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ABSTRACT

Study results and design for an Educational Technology Assessment Model (ETAM) are outlined, and conclusions and recommendations of the study are summarized. An eight-task procedure is provided to guide the assessor of a training innovation through the required data collection and analysis steps leading to a decision to accept, reject, or continue to study the innovation. Step-by-step application of the ETAM procedures also is given. Proposed portions of the ETAM amenable to computerization are identified, and validation results are given. A review of relevant literature is included. (SK)

# TAEG

TRAINING
ANALYSIS
AND
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GROUP

TAEG REPORT
NO. 12-3

# DESIGN OF TRAINING SYSTEMS
# PHASE II-A REPORT

AN EDUCATIONAL TECHNOLOGY ASSESSMENT MODEL (ETAM)

FOCUS
ON
THE
TRAINED
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13. ABSTRACT


This single volume final report outlines the study results and design for an Educational Technology Assessment Model. The primary report feature is an eight task procedure in Section III intended to guide the assessor of a training innovation through the required data collection and analysis steps leading to a decision to accept, reject, or continue to study the innovation. Scenarios in Section V describe the step by step application of the ETAM procedures to the assessment of an innovation.

A summary of conclusions and recommendations is included in the Overview, Section I. Other sections of the report include: 1) a review of relevant literature (Section II); 2) proposed portions of ETAM amenable to computerization (Section IV); and 3) validation results (Section VI).

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TAEG Report No. 12-3

# AN EDUCATIONAL TECHNOLOGY ASSESSMENT MODEL (ETAM)

Robert B. Miller
Larry R. Duffy



This Study was Performed by
International Business Machines Corporation

for the

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July 1975



Alfred F. Smode

ALFRED F. SMODE, Ph.D., Director
Training Analysis & Evaluation Group

# FOREWORD

This report presents the final results in the design of an Educational Technology Assessment Model (ETAM), a training management tool for assessing the long-term effects of introducing an innovative technological change into the existing or planned training environment. This represents the final output of Phase II-A which is part of a multiphase effort called "Design of Training Systems," undertaken in consonance with the requirements of Advanced Development Objective 43-03X, "Education and Training."

Sincere thanks is expressed for the cooperation of the Director and members of the Training Analysis and Evaluation Group for making available certain documentation and in providing assistance in various areas of the project. Especially helpful was the TECEP report, which included training cost model algorithms, made available by TAEG. The assistance provided by Dr. William Giauque, Naval Postgraduate School, was extremely helpful in finalizing the decision analytic components of the procedure. Special acknowledgement is given Prof. Robert M. Gagne, Florida State University, who served as project consultant.

The ETAM procedural approach was developed by Dr. R. B. Miller and Mr. L. R. Duffy. Mr. R. E. Hallman provided management for the project; Mrs. L. Girard, Mrs. C. Latham and Mrs. S. Goodell provided secretarial and editorial services.

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# EDUCATIONAL TECHNOLOGY ASSESSMENT MODEL OVERVIEW

## PROBLEM

Rapid changes are coming about in the demands put on education and training, but there are also extensions being made continuously to educational and training technology. The decision to adopt, reject, postpone, or further study a proposed innovation should be a rational choice based upon the relationship of the costs to introduce and maintain the innovation, balanced against the range and magnitude of the benefits to be derived from the innovation. It is important to identify, as precisely as possible, the range of applicability of the innovation in order to appreciate the economies of scale in realizing the benefits, while avoiding the costs of error in misapplying the innovation to training situations and other conditions where the innovation is irrevelant or contra-indicated.

The training enterprise is a system of interlocking activities where a given change may be reflected in a large pattern of consequences. Thus, if something is made "easier to learn," the outcome can be a reduction in the aptitude requirements of the student, a reduction of training time, or a higher level of capability of the trained student for a given amount of training time. The choice of which variable to exploit as an advantage can depend on the relative cost advantage to the personnel subsystem in terms of available recruits, or to the training establishment in terms of costs per graduating student, or to operations in terms of skill level. The assessment technique leading to decisions should enable the analysis leading to these choices.

Instructional technology embraces a wide variety of elements. These range from costs and capabilities of dozens of types of vehicles, from human instructor and blackboard to flight simulator. The technology also applies to instructional techniques and learning controls, student incentives and motivations, transfer of training facilitations, methods of providing practice in knowledge and skill learning, the organization of instructional sequence and content, and a host of other factors in the efficiency and effectiveness of the teaching-learning process. Instructional technology also extends to the technical and administrative operations by which job task requirements are identified, training objectives specified, instructional vehicles are programmed for instruction, and student performances measured and interpreted. All of these factors interact with benefits and costs associated with where specific training will be conducted, when it will be taught, and under what conditions. The total benefit and cost model to which a substantive innovation is to be applied is very complex.

At this point the reader may have only a vague concept for the term "innovation" as used in the ETAM context. Early in Section III, characteristics and examples of training innovations are discussed in detail. However, here it should be sufficient to state that innovation is a constant or enduring change that can be purposely planned for and evaluated on the basis of known criteria. Thus, while "change" may be the unplanned evolution from one state to another, innovation implies that the state change can and is planned and evaluated.

But the introduction of an innovation can have remote effects which cannot be readily anticipated. Its outcomes are only partly predictable, even by knowledgeable experts, so that the decision to accept or reject an innovation at a given time is based on probabilities of success and perceived magnitudes of risk. Rational choices should objectify, as far as possible, these uncertainties, probabilities, and risks when the potential benefits and costs of the innovation are compared with alternatives. One alternative is not to make the change but continue as is with respect to the proposed innovation. But the risks of this conservative policy should also be made explicit.

The objective of this procedure for evaluating innovations or changes proposed for the instructional enterprise is to formalize as extensively as possible, the dimensions and elements of potential applicability of the innovation, and to structure the benefit variables and cost variables that are relevant to it. The outcome should be a presentation to the executive decision maker of the profile of expected pattern of potential benefits and cost advantages, the estimated probabilities of achieving the advantages, the major liabilities that confront their achievement, and, where choice or rejection may not be clear-cut, the most critical data to next obtain for making that decision. The decision maker may then be in a position to evaluate a variety of innovation proposals that compete for an inevitably limited budget, so that maximum returns on investment can be realized.

A secondary and dependent objective is to develop a descriptive and analytic terminology that can be applied to data base descriptions of instructional vehicles and their relevant properties, job tasks and their important attributes, and training courses and content within training courses. By attaching relevant descriptors to identify the entire domain of variables in the training enterprise, it becomes possible to use the computer for making automatic searches for relevant entities in courses, and in instructional vehicles, after an innovation has been described by appropriate descriptors from the descriptor list. These descriptor sets may also structure cost models for categorizing and accessing empirical cost data. These objectives do not assume that the final decision to accept or reject will be based solely upon the items turned up by computer search; rather, all ultimate decisions of this kind will be made by human experts.

## APPROACH

The entire ETAM procedure is aimed at supporting human judgment and reducing or simplifying the exercise of human judgment, but not of replacing it by automatic operations of selection and calculation. The large number of loose interactions in the development and administration of training, in the learning process, and between the learning process and the characteristics of the student, demand informed human judgmental processes for decisions and outcome monitoring. The procedures are intended to extend and support human judgments by offering structure, reference definitions, and concepts, and in general, by trying to get the most use of information available to the assessor, either within his head or external to it.

Even where a set of automatic operations combines and integrates assessment data in executing the algorithms of the assessment model, the constituent data are also displayed to the decision maker for his inspection. There is every opportunity for making commonsense checks against "black box" operations.

The procedural approach has also aimed at maximum consistency with Navy concepts and terminology, compatible with the practical requirements of making the assessment. It has been necessary, however, to formulate an organized picture of instructional functions, of the learning process as related to defined task structures, and of generalized differences in instructional requirements for different classes of job tasks. The intent in creating these taxonomic structures has been to compromise between academic precision and practical simplicity. Every term is defined at one or more levels in readily identified contexts.

It must, therefore, be stipulated that the use of ETAM in the assessment of innovations requires persons with extensive background knowledge in Navy training operations, who have had at least a number of days study of the ETAM procedures and the referenced material which defines the application of the terminology.

An attempt has been made to safeguard and offset both of the following types of errors from being grossly manifest:

a. Accepting an innovation because its benefits have been overgeneralized, or its costs and liabilities have been incompletely recognized.

b. Rejecting an innovation because the range of its benefits has been too narrowly perceived, or because its costs have been too narrowly prorated, or because its liabilities have not been presented in ways that enable their overcoming to be feasible.

CONCLUSIONS

ETAM exists as a preliminary design and, as such, it has been concluded that:

- A systematic procedural methodology for assessing innovation and change in training can be described.

- The following of a procedural model can lead to a more effective analysis of a proposed innovation.

- A decision structure can be organized that permits a systematic assessment of both tangible and intangible benefits.

- A decision sequence can be developed which makes effective use of efficiently gathered information.

- A taxonomic structure can be used strategically to search out the full range of application of any innovation or change within the instructional enterprise.

- ETAM, as a totally manual procedure, demands an impractical amount of time and effort for exploring multiple alternatives, variations, and conditions.

- However, many components of ETAM demand human (expert) judgments which can be supported but not replaced with automated procedures.

RECOMMENDATIONS

It was concluded that the ETAM design provides a logical basis for evaluating an innovation; however, the manual aspects of the procedure cause it to be unworkable for anything beyond an analysis involving just a few alternatives, variations, and conditions. It is recommended that automated procedures be developed to facilitate more complex analyses and that this development effort be supported to include the following:

- A study of the scaling procedures for expressing the relative "importance" of benefits and the probabilities of success, as a refinement of the cost-benefits assessment process.

- Development of the indexing procedures for translating the ETAM nomenclature into descriptions of courses, tasks, and instructional vehicle attributes. This would include translation rules and guidelines for assigning data base search descriptors.

- A study of the human factors requirements and the development of a procedural interface for an assessor to interact with a graphic terminal linked to a computer in performing information retrieval, contextual manipulation of decision data, and user data entry.

- The specification of an information flow model for the functions outlined in the Development and Administrative Management of Training (Section III, Subtask 05.24), to produce a more tightly coupled system for predicting training/job effects from changes in these functions.

- Development of a series of integrated programs, based upon the computer applications outlined in Section IV, which will accept user generated input, interact with the user to obtain refined data, and will provide a set of output reports to aid the decision-making process.

# SECTION II

# REVIEW OF RELEVANT LITERATURE

## REVIEW OF THE LITERATURE ON TASK TAXONOMIES AND DECISION ANALYSIS

The taxonomic structures offered in Task 5 in the ETAM procedures deal with the determination of the potential range-of-effect in a proposed innovation. The classifications in that section are based mainly on a sequence of developments by R. B. Miller that began in the early 1950's with his outline for the description and analysis of military tasks, primarily in the operation and maintenance of equipments. These techniques were best organized and presented in his 1963 article. This article also contained the classification of task elements or task functions which are substantially retained in ETAM. The structure for Stages of Learning was contained in his Handbook on Training and Training Equipment Design (1953), which was extended to include the concepts of Task Formats in his monograph on A Method for Determining Task Strategies (1974). His 1972 publication on the design of Duty Modules proposes a systematic method for the organizing of tasks into entities useful for training, operations, skills descriptions, and transfer of training or assignment purposes.

The literature on task taxonomies tends to be more extensive than illuminating, if one is concerned with practical utility. It is outside the scope of relevance here to review the range of approaches, arguments, and findings. Miller's 1975 paper contains such a general review with critiques. The same document which contains Miller's review, also contains the taxonomic positions of Gagné (1975) and Fleishman (1975), respectively. All three articles point to extensive reference bibliographies on taxonomic questions.

In summary, taxonomic positions and aspirations have been based on three quite different starting assumptions. Miller summarized two of these three positions in 1967. One major school of taxonomic development is dedicated to the empirical discovery of taxonomic elements in behavior or performance. (Some theorists hold that behavior should be treated differently in this context than performance, others hold that the distinction is meaningless at best, misleading at worst.) Fleishman is the most systematic and articulate holder of this position. It is believed that whatever performance components are revealed, essentially by factor analytic studies, are structural entities (abilities) which are independent of the instructional technique or other influences on the learner's experiences which become manifest in a skill.

According to Miller (1967, 1971A, 1971B), the second point of view is that behavioral "functions" are inevitably ambiguous in their definition and specification except in the denotable instance; but this is not a taxonomic occasion which should be a generalization of instances. Furthermore, Miller insists, a large variety of quite different learning experiences may become associated in the expression of a skilled performance. He believes, therefore, that task taxonomies are invented and have as their criterion not some natural structures that can be independently validated, but that their test is in practical utility. Thus, it is useful to distinguish between something called "scan and detect" and something called "interpret" because one can be

efficiently learned by different presentations and experiences than the other, and each generalizes differently than the other. Miller would say that if a categorization does not serve a useful design or decision purpose, it should be abandoned for one that does. In this position, he treats task taxonomies as a branch of technology, whereas Fleishman (and many of his colleagues) treats task taxonomy development as a branch of science.

Gagné represents a third position. In his Conditions of Learning (1970), he confines his interest to cognitive tasks. He identifies layers of building-block learning elements, where a more complex level of competence is achieved by putting together simpler building blocks, which are conceived as prerequisites. He thus distinguishes categories of human performance which, on the one hand, imply the existence of different human capabilities, and on the other, require different sets of conditions for their learning. In later work (Gagné and Briggs, 1974), this point of view is expanded to encompass additional categories of human competence including knowledge and motor skills.

The literature on task analysis is largely methodological and intersects little with theory and concepts of practice in learning and behavior organization. Miller (1962) has proposed a differentiation between task description, which is an objective statement of what a performance should do, and task analysis, which deals primarily with the psychological conditions for effective performance. In its broad application, task analyses of different kinds support varied purposes in the personnel subsystem: job and task design, human factors engineering, job aids, training, assessment of skills, skills identification, assignment, and selection. Task descriptions appropriate for one objective may be inadequate for other of these purposes. Task descriptions, as the basis for the development of training content, have become almost standard doctrine in the Navy, as well as the Air Force and Army. A variety of formats have been proposed, but most of them follow the structure of "stimulus situation-action-consequence of action" as the paradigm for the unit of description. In general, however, formats for capturing problem solving activities, such as fault localization, have been inadequate as direct input to instructional design. Miller (1974) has attempted to remedy some of these inadequacies.

Rundquist (1970) has laid out the most practical and comprehensive pattern of procedural steps known to this reviewer for describing duties and job tasks, and for proceeding from these descriptions to the specifications of courses and detailed course objectives. It is especially effective in topics about which many guides are deficient; i.e., the determination of the range of input situations and conditions with which the job incumbent must cope, and, therefore, to which he should be exposed, on an appropriate sampling basis, during training. The guidance contains many insights about the psychology of learning that should be applied to the instructional process. While it is procedurally comprehensive, both in range and depth, for developing and converting job information into training specifications and operations, the guide is not concerned with taxonomic issues, and indeed they are irrelevant to its purposes. Rundquist's procedures are being widely applied in the Navy. This job-skill oriented approach to the identification and specification of training objectives should facilitate the application of the ETAM taxonomies. At present, this seems a reasonable conjecture rather than a confirmed demonstration.

An excellent reference to a complete list of types and training devices is contained in a preliminary U. S. Navy Training Analysis and Evaluation Group report entitled, "A Technique for Choosing Cost-Effective Instructional Media." An extremely useful set of guidelines for the choice of training equipment and media applications is also contained in this report.

The literature on decision theory has grown extensively over the past few years. A major part of this literature deals with a "decision science" approach to combining subjective probabilities and multi-dimensional utility patterns. Schlaifer (1959) introduces some of the basic concepts for obtaining the expected value of utility patterns. Rather separate components of the decision process are being combined to bring more sophisticated methods to bear upon the solution of complex problems. A Handbook for Decision Analysis (1973), developed as an outgrowth of a contract with the Office of Naval Research (ONR), treats a number of the major concepts and techniques in decision analysis. It contains numerous examples of their application to practical problems. The basis for the information obtained in the examples is a consultant interacting with a knowledgeable person on the problem characteristics. The consultant elicits responses which provide the information folded into a general decision framework.

A later ONR contract on Adaptive Computer Aiding in Dynamic Decision Processes takes the prior work a step further by automating the ability to track the responses of the decision maker in real time in order to learn the decision strategy, and then to assist the decision maker in optimizing the process. This report contains a number of bibliographic references (many of them ONR reports).

The estimation of subjective probabilities, in a sense, is almost a separate subject, and is a critical component of the entire decision process. The present Educational Technology Assessment Model uses a very simplified method in requesting three estimates of the variable; the most likely magnitude of the variable, the most pessimistic estimate, and the most optimistic estimate. The assumption is that almost 100% of probability density function is contained in the interval, and that a Beta distribution approximating the normal, results. Hahn and Shapiro (1967) indicate this distribution as applicable to variables bounded at both ends. The PERT methodology for estimating project completion times uses this distribution and, for the interested reader, is discussed in Battersby (1964). ETAM provides similar caveats as are contained in the literature, cautioning the use of probabilities derived in this manner. Several methods for improving subjective estimates are discussed by Huber (1974) and are also contained in the Handbook for Decision Analysis. The scaling procedures and the estimation of points on a continuum that bring about agreement of the model variables with reality, are crucial to the validity of model results. Further work is proposed in this area and is outlined in Section VII of this report.

The economic analysis section of the model is straightforward and is based upon widely accepted techniques for handling investment type decisions. SECNAV INSTRUCTION 7000.14A served as a basis for a portion of the output specifications for the results of the economic analysis. No further literature references are considered necessary here, although several are contained in the bibliography for the interested reader.

In conclusion, this overview, while brief, has maintained relevance to the key issues appropriate to the project. One is to establish a basis of awareness of the range of extant literature potentially relevant to the solution of the problems tackled here. It seems clear that no systematic attempt has been previously published to encompass the objectives posed by projecting the potential implications of any kind of innovation in instructional technology, nor the acquisition of a data base indexed to cope with the search aspects of such a task. But the reader is pointed to the literature which may be at least tangentially related to this enterprise, if an inquiry to alternatives may be considered desirable. The bibliography presented at the end of this chapter, while small, points to extensive bibliographies contained in the references.

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# SECTION III

## EDUCATIONAL TECHNOLOGY ASSESSMENT MODEL PROCEDURES

The Educational Technology Assessment Model (ETAM) is a series of tasks supported by subtasks and detailed procedures intended to provide guidance to persons assessing the value of a proposed "educational innovation." The value will be determined by systematically considering the benefits and liabilities (including savings and costs), attendant risks from both internal and environmental influences, the potential range of applicability, and its worth in terms of certain economic measures. A major determinant of true value is related to the range of application identified for the innovation. The model outlines a comprehensive pattern of taxonomic elements based upon psychological learning principles and instructional economics which provide the assessor with procedural guidance in establishing the innovation range of application. The general model structure, the major analytic and decision components, the documentation features, and basic user guidance are outlined in this introductory section.

### APPLICATION AND COMMON SENSE

The reader may be initially intimidated by the bulk of this manual. But, like an unabridged dictionary, only very limited sections may be applicable to a given problem. One reason for bulk is its ability to respond to a very large variety of problems. Another reason for its bulk is that it is not only a structured classification system, it is also a condensed text description of the technology of education, training, and learning. The text is essential for clarifying the concepts that give useful meanings to the terms used in the classification. The text itself is an instructional document. A technology which, in application, results in the spending of tens of billions of dollars a year in this country, deserves careful exposition, and perhaps especially to those getting the data for making decisions on the funding of projects having such financial and social significance.

The reader who is a potential assessor of an innovation may furthermore be intimidated by the apparent length and complexity of procedures for collecting and analysing data for decision making. But there is no compulsion to follow through all stages and levels of data collection and analysis. The following imaginary examples fit ETAM structure.

1. <u>Teaching sleeping students</u>

Innovator: My machine can teach students while they sleep.

Assessor: What skills can it teach?

Innovator: Anything that can be learned by hearing spoken words.

Assessor: How much does it cost?

Innovator: Including R&D costs, procurement and maintenance, $20 per student per night, assuming 10,000 student nights per year.

Assessor: What's the sleep loss effect?

Innovator: Eight hours sleep with learning becomes equivalent to seven hours sleep without it.

Assessor: If the student were awake, how long would it take him to learn what he is taught in a night's sleep?

Innovator: Awake, it would take him ten to fifteen minutes to learn what he learned overnight in sleep.

Decision maker (who overheard the conversation): Forget it!

2. <u>Brain-Coupled Learning: The Engram Transmitter</u>

Innovator: This is an electronic device that enables me to link, by electrodes, the brain activities of a skilled performer of a task to the brain of a student. When the skilled performer is doing the job, the impulses transmit to the student who actually learns while the instructor performs. The student can then immediately perform the same thing at the same skill level as his instructor.

Assessor: What tasks have you actually taught this way?

Innovator: Bicycle riding, pursuit tracking on an oscilloscope, and celestial navigation. I also taught TV troubleshooting with the Engram Transmitter but it took quite a few sample exercises to do it.

Assessor: Any difficulties in matching student and teacher?

Innovator: Yes, great variability in both. Out of a hundred would-be teachers and a hundred would-be students, only about five pairs can work out.

Assessor: What's the saving in student training time over normal times to teach and learn the same tasks?

Innovator: It ranges from 50% to 90% savings in terms of student practice hours. I can't explain yet why it doesn't work with all teacher-student pairs. You understand, the teacher is not teaching, he is just doing his job while his brain "teaches."

Assessor: How many dollars and time of R&D would be needed for production prototypes to be developed, with a 90% level of successful matching of student and teacher?

Innovator: I see about $50 million in R&D and ten years of study and development. We still don't really understand the phenomenon at work here.

Decision maker: There is half a million in my budget for a high risk, high payoff venture, especially if it's in an entirely new area of exploration. Do you want to take that and solve the problem of matching the student and teacher at levels that approximate our present aptitude requirements for the same job? I can't use a rare-bird phenomenon, no matter how good it is.

3. Training in Handgun Firing

Innovator: I have a device and procedure to teach accuracy in firing handguns. Controlled experiments show my method gets the same level of accuracy with 5,000 rounds fired as your training methods get with 7,500 rounds. I need no more instructors than you do, and no more student time than you use. Accuracy is measured by all your present criteria. With 7,500 rounds fired by my method, average accuracy of my trainees is 30% superior to yours, plus or minus 10%, covering ninety percent of the cases. Skill retention over six months without practice is better by 30%.

Assessor: Does your method apply to other aiming operations such as rifles, bazookas, mortars, automatic rifles?

Innovator: I don't know if it can be adapted to them, but I don't think so.

Assessor: What does your training cost?

Innovator: About 25% of your savings in the cost of the ammunition alone. The increase in skill and retention over your method of training is a bonus.

Decision maker: If it does what he says it does, let's use it. We can find out later if it can be adapted to other weapons.

If one is familiar with the procedures and philosophy of ETAM, there is nothing inconsistent between these scenarios and those procedures. The innovator and the assessor quickly got to the essential point of each decision: no go; study it further; or accept. In the first example, it was quickly evident that the costs overwhelmed even a potential benefit, and in any event the benefit was trivial.

In the Engram Transmitter, the potential value of the innovation could be enormous as evidenced by the savings in training time, but the key risk factor was in its range of applicability to pairings of teacher and student. No doubt additional studies on what could and could not be learned this way would also need to be done before further large commitments. In the handgun trainer, the ratio of costs to benefits is clear, and the range of applicability, although highly limited, is sufficiently important to justify an acceptance decision.

The ETAM procedures emphasize that investigation can be halted when information is adequate for the human decision maker to accept, reject, or study further the proposed innovation. Extensive assessment examination is justified to the degree that:

1. The economic and social commitment is very large.
2. There is large uncertainty and risk in the success of the proposed innovation as an enterprise.
3. The advantage of benefits to costs is marginal or dubious, or many of the benefits are intangibles.
4. The training objective is extremely important and no technical alternative seems to be available.

CHARACTERISTICS AND EXAMPLES OF TRAINING INNOVATIONS

WHAT IS AN INNOVATION IN TRAINING AND EDUCATION? An innovation is a relatively constant or enduring change in the procedures, objects, or functions used in any aspect of the instructional process, which may be viewed as a benefit (or a liability) and has associated costs. Thus, an innovation may be a technical invention or extrapolation from an invention, or a structural modification to the setting of instruction, such as classroom to on-the-job.

The following are general classes of factors within and among which innovations can be introduced.

1. Change in <u>content</u> of instruction for a given set of terminal objectives.
2. Change in <u>media</u> or <u>device</u> used as a vehicle for delivering instruction.
3. Modifications in delivering instructional or learning process <u>functions</u>.
4. Shift in the <u>environment</u> in which a given phase of instruction is given.
5. Shift in the <u>characteristics of input students</u> to one or a set of courses.
6. Shift in <u>policy</u> between student performance objectives to be acquired at school and those acquired on the job.
7. Change in <u>criterion levels of performance</u> required to complete a course, or to graduate from a school.
8. Change in technique for <u>presentation of content</u> for more efficient learning and transfer of a given class of material.
9. Modification of processes for <u>generating training requirements</u> and objectives and for converting this information into instructional content and test criteria.

10. Change in the organization of instructional modules as elements in programs of instruction.

11. Change in selecting, training, and assigning of instructors.

Any list of things about which innovation is possible must be incomplete. The preceding list is no exception.

EXAMPLES OF TRAINING INNOVATIONS. The following are some specific examples of innovations. It is immaterial that some are hypothetical proposals.

Static Rehearsal of Complex Skills. Experienced pilots had learned in a simulator, space vehicle approaches and landings under instrument and visual conditions. The innovation, consisting of techniques of self-imposed verbal rehearsals of the procedures in these maneuvers, showed as much retraining benefit as the control subjects who practiced the retraining in a simulator.

Systems Effectiveness Analyzer (SEA). SEA utilizes existing equipment, plus computer-based software, to enhance existing AMRL capabilities to evaluate weapon system performance. It assesses the setup and other conditions of the system as the human operates it procedurally, and also assesses the performance of the human operator by round-by-round probability of kill, and the resulting target's probability of survival. Human performance is evaluated in the context of system performance.

Scan and Detect Training. Although the radar screen is the primary target for this proposal, any task that emphasizes the scanning of a perceptual field and the detection of a class of signal within a context of clutter is a candidate. The sequence of training is as follows: the student is presented with the signal to be detected in a field without background noise; immediately thereafter, the same signal is presented in a series of increasingly heavy background noise or disturbance; the type of noise is varied. The student learns not merely to detect the signal in ideal (and unrealistic) conditions, but rather to read through noise. The noise introduced becomes greater than encountered most of the time, so the student becomes "overtrained" in reading through noise, leading to a high level of skill and reliable performance in reading through "moderate" noise levels. Reading through noise for a given class of signal in a given sensory modality, is presumed to be generalizable as a skill. The psychological principle is that of learning quickly to suppress perceptual ground irrelevance as a "format" for the perceptual tasks. This is applicable to auditory as well as visual tasks.

Student Participation in Learning Route. When a student enters his first orientation course for training in a career specialty, he is given a flow chart or critical path structure (with alternative branch points) that will lead him through training to a full-fledged competence. The student can see where he is on this path, and what lies ahead. He can interrogate points along the path for one or more levels of conceptual presentation of the subject matter and skills he is to learn -- and these skills are shown manifest in job situations. The student, therefore, can see the outcomes of his learning efforts for what he has yet to learn and this, in turn, to its meaning in job operations. This presentation of critical path in training

should also enable the student to access at any point, further levels of detail of job information (or job-training information), either for review or as "advance organizers" of future learning. The outcome should, for most students, be increased motivation to learn as manifest in (a) more rapid learning of course content; (b) better retention of course content over periods of time; (c) better transfer of material learned in previous courses to new courses; and (d) higher performance levels on performance tests.

The psychological principle used as the rationale here is that the student is an active participant in his learning process, has greater mnemonic richness while learning (with effects in learning rate, retention, and recall), and, ultimately, more motivation on the job.

Predicting Student Performance Levels from Types of Learning Errors. A technique is devised for capturing and using the kinds of errors (as well as their relative frequencies) made by students in the process of learning. Error measurement is begun on their first day in any class, and is cumulative in building a profile. Some kinds of error are highly predictive of success in a given kind of duty, depending on where in the course of learning they occur. Others are predictive of failure in a given kind of performance expectation, but may predict success in other tasks or performance expectations. Still other kinds of errors have no predictive value. Error data are combined with learning data.

The error analysis technique, therefore, predicts washouts, and more or less precisely where the washout will occur in training (or on the job). Thus, it can predict the student's ceiling in a class of activity. The error data also predict the kinds of tasks which the student may be expected to learn to do well -- thus, it is a selection procedure and may result in more precise student guidance. It should be emphasized that the appearance of large amounts of given error data early in learning a given task, may be predictive of more eventual success on that task than fewer errors of that kind.

Error analysis depends, in part, on strategy in designing tests and learning situations for the test. It does not add to overall training time in the traditional form of instruction. It does add perhaps 5% to the cost of preparing training materials in terms of specialized instructor time. It also adds costs to the assessment process during training.

The technique is derived from learning theory and lab data that show different aptitudes coming into dominance at different stages of learning. But aptitudes interact with task content and with method of training and learning.

Key Personnel Identification and Special Training. Considerable attention and resource is given in formal education to the slow learner. But some individuals entering training are far more likely than others to become "key persons" within (or even outside) their trained skill specialties in their operating organizations, and training adapted to their discovery and early cultivation can have high payoff. Factors in addition to, or other than, ordinary technical skills lead to key roles. Early training may include identifiers for these student properties, and lead these students through special pathways that enhance their ability to assume key roles quickly when on the job, rather than depend on extensive proving and

on-the-job training experiences. The key person may actually show up more poorly in the learning of some classroom materials and subtasks than many individuals who turn out mediocre on the job.

The learning strategy is not fast-track, but a different track and style of instruction. It would need to be individualized or taught through small group coaching; have minimized criteria on the "mechanics" content of training; and emphasize individual initiative in learning what is situationally needed; and in planning, organizing, and evaluating objectives.

The training costs for these students will be high, and the benefits will not show up in standard performance tests, but only in job behaviors in the field. The washout and dropout rate may be high. It is estimated that about 5% of an ordinary class of trainees have key person potential, and out of every 10 key persons selected, only 8 will achieve key competence.

General Comment. The structuring of a technology that both articulates and integrates functional entities may, in itself, be a source of invention and innovation. Even though ideas may be serendipitous, they may be developed and tested systematically. It also becomes feasible to fit research findings into application frameworks, and to extrapolate the significance of an engineering development, such as low-cost microelectronics and display technologies, to instructional functions long before specific applications are designed with them. Thus, an accelerating tempo of cost-effective innovation can be achieved.

For example, the adaptation of computer technologies to education and training is a costly undertaking and can generally be cost justified only when there is sufficient scale of utilization. The application must achieve a "critical mass" of usefulness to a wide-range of students with a wide-range of practical task-learning, through a wide-range of levels of skill acquisition, before the payoffs can mount up dramatically. This is one example of the need for systematization of a technology in order to optimize the full potential range of resources within that technology for coping with the objectives of the large enterprise.

## MODEL STRUCTURE

The model consists of eight distinct tasks to guide the assessor in creating a comprehensive description of the proposed educational innovation, in identifying potentially more cost-effective alternatives, in determining the full range of application for the innovation, in assessing the risks, benefits, and liabilities associated with the implementation and use of the innovation, and in preparing a coherent presentation of the analytic results for review by the ultimate decision maker. The individual tasks and their interrelationships are shown in Figure III-1. The tasks are designed and sequenced to accomplish two primary objectives.

- First is to provide a means to determine the true value of the innovation if it is applied to the training situation.
- Second is to find the full range of potential applications for the innovation in the training environment.

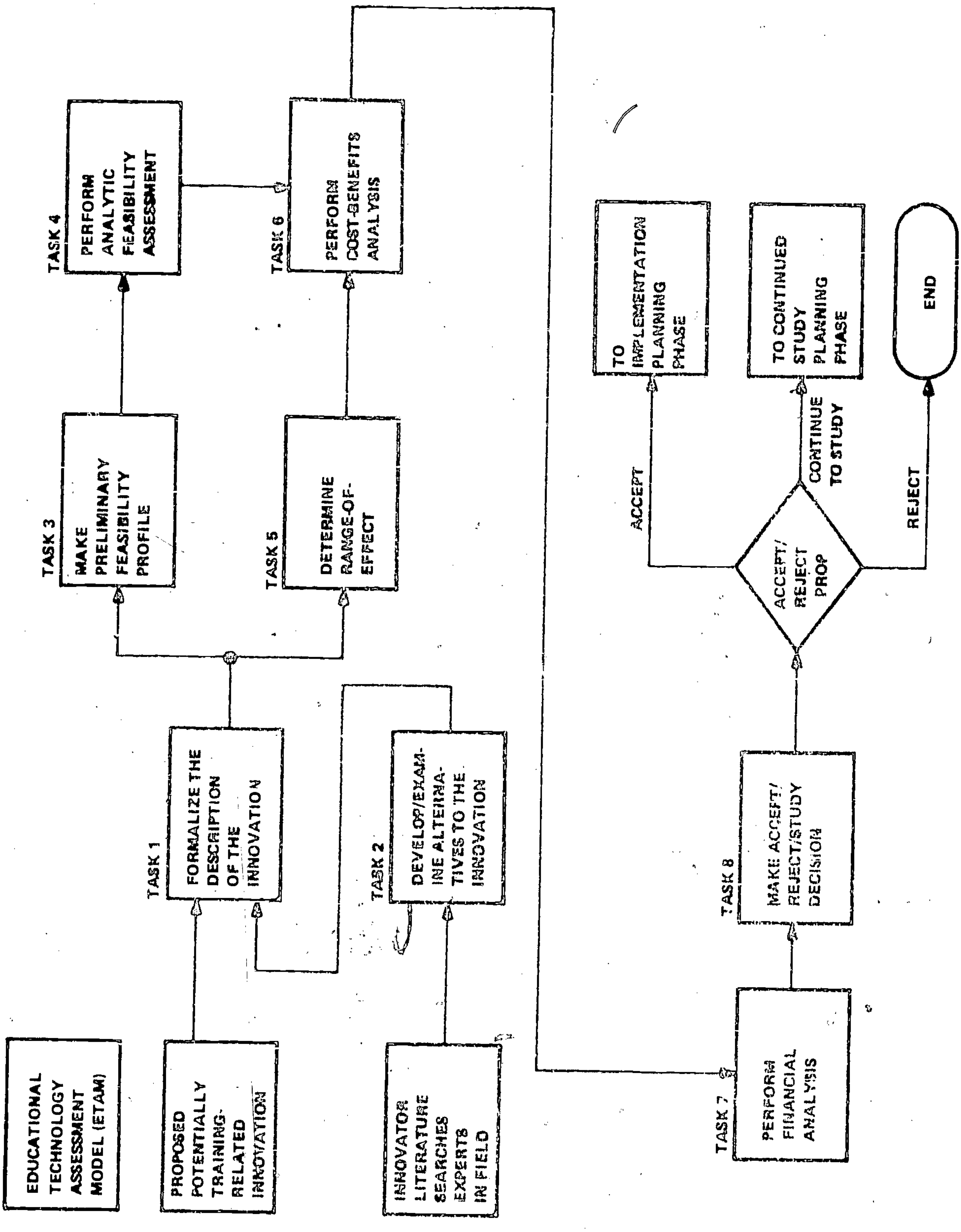



FIGURE III-1. ETAM TASK FLOW

In meeting these two objectives, the ETAM procedures can be envisioned as having two major components. The first consists of those activities which permit expansion of the innovators view as to how and where the innovation might be applied. This type of "divergent activity" takes place at the beginning of the procedural process by means of the expanded description of the innovation and through the range-of-effect analysis. Once the full potential for applying the innovation has been explored, the second, or "convergent activity," deals with assessing all aspects of the innovation across this full range of application. The second objective is to converge to the decision to accept or reject the innovation. This conceptual view of the ETAM procedures is shown in Figure III-2.

Each of the tasks comprising the Educational Technology Assessment Model is briefly described below:

- Task 1 - Formalize the Description of the Innovation. The innovator is provided with a number of categories for systematically expanding the descriptive information on the innovation. The objective of the innovation, target applications, and the results of empirical studies involving limited application of the innovation are among the categories to be completed.

- Task 2 - Develop/Examine Alternatives to the Innovation. In this task the innovator is requested to consider possible alternatives to the proposed innovation which may require a lesser level of investment funding, and possibly be more cost-effective.

- Task 3 - Make Preliminary Feasibility Profile. The formal assessment procedure begins at this point with a consideration of potential risks in the implementation and application of the innovation, due to such factors as organizational incompatibilities, goals/policies incompatibilities, technological requirements, technical support requirements, funding constraints, and problems in attitudinal acceptance by users.

- Task 4 - Perform Analytic Feasibility Assessment. The results of Task 3 are analyzed in greater depth, and risk reduction studies and projects are defined. Risk assessments are made in view of these studies and projects, and a preliminary decision tree is structured for providing initial guidance as to whether the innovation should be accepted outright, accepted with the additional expenditures for the risk reduction projects, or rejected.

- Task 5 - Determine Range-of-Effect The prior tasks have been concerned with the assessment of the innovation over a limited range of application. Initially, it was with the target applications identified by the innovator; in Task 4 a preliminary extended range of application

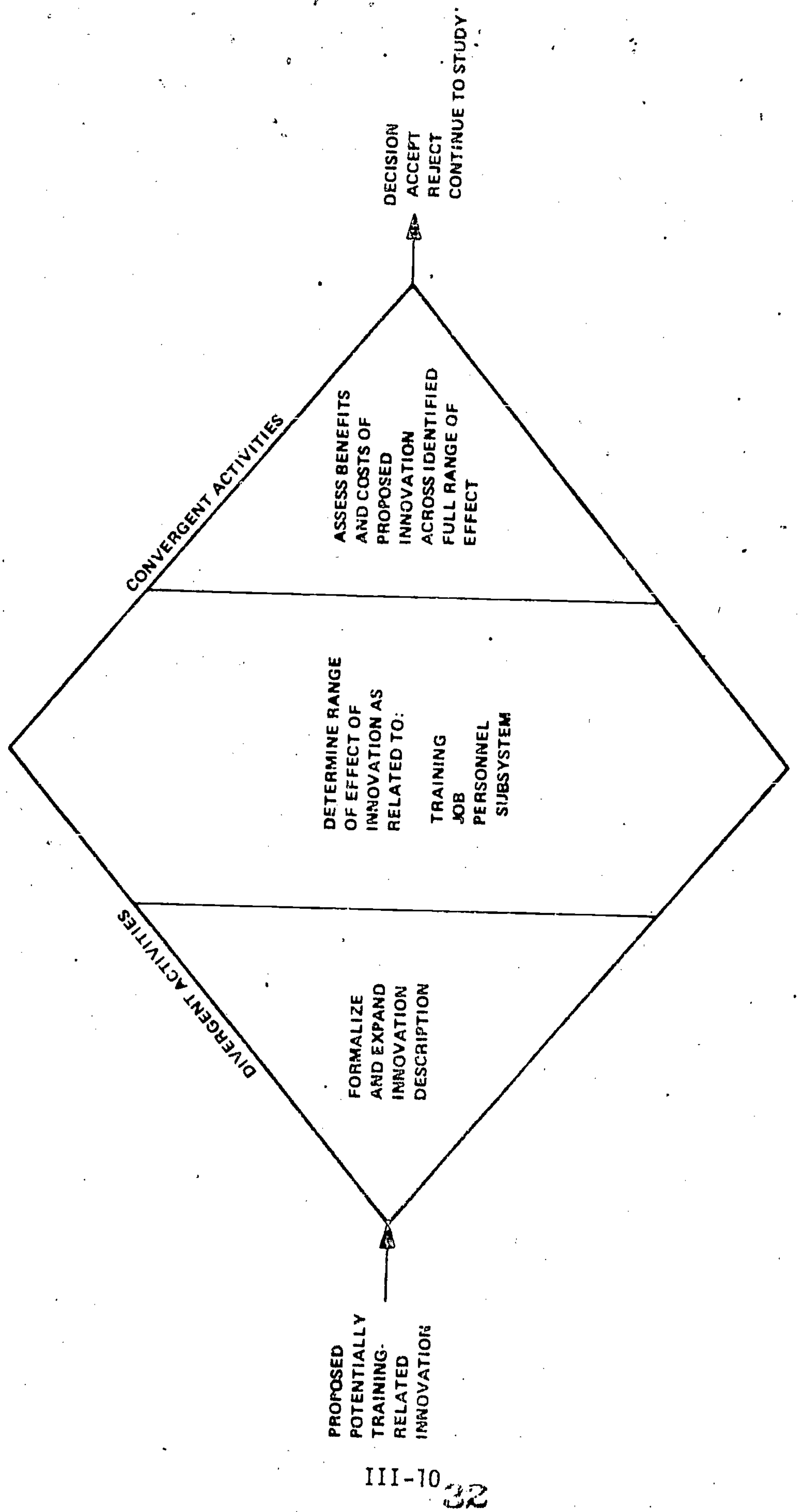



FIGURE III-2. ETAM CONCEPTUAL OVERVIEW

was considered. Task 5 contains a number of classification structures to which the innovation is related. Each structure may result in the assignment of one or more descriptors applicable to the innovation. These descriptors will serve as search parameters in finding the full range of courses, jobs, or equipments to which the innovation may potentially be applicable. Task 5 also deals with describing the benefit pattern which may be expected of the innovation when generally applied.

- Task 6 - Perform Cost-Benefits Analysis. The decision tree developed in Task 4 is refined to include more precise costs and savings derived from processing the tangible benefits through cost models. In addition, the intangible benefits are so analyzed that they are expressed in "equivalent dollars," so that the various decision paths can be more easily evaluated. Equivalent dollars is a utility expression rather than a literal dollar value. Probabilities of implementation success and user acceptance with and without the risk reduction projects are refined, and the decision variables are recalculated.

- Task 7 - Perform Financial Analysis. This task is concerned with assessing the tangible benefits and liabilities (those expressable in real dollars) in terms of certain economic measures. The investment costs and the annual costs and savings are calculated over a planning period extending a number of years into the future. Rates-of-return on the invested dollars are determined for the incremental effect of each alternative compared to every other alternative. Alternatives consist of the proposed innovation, the existing system, and any other approaches defined in Task 2 which were considered reasonable candidates for further assessment. This assessment process provides a separate, distinct view of the value of the innovation as was gained from the decision tree assessment in Task 6. Both are inputs to the decision maker.

- Task 8 - Make Accept/Reject/Study Decision. The decision information and formats have been addressed throughout the assessment process. This task provides guidance to the presenter of the analytic data to the ultimate decision maker.

The model is structured so that the outputs of each task will permit a decision as to whether the assessment process should be continued. The level of effort associated with the carrying out of any task should be consistent with the potential value of the innovation indicated at that point.

## ANALYTIC AND DECISION COMPONENTS

The model design provides a hierarchical analytic approach and a sequential decision structure. The analysis proceeds from judgmental inspection of

descriptive data to the application of more sophisticated quantitative techniques intended to provide the decision maker with a more extensive understanding of the innovation's potential value. Each analytic step in the assessment process expands the knowledge base for decision making, and should provide a higher level of confidence in any decision indicated. At the same time, the process provides an increasing awareness of the uncertainties inherent in information to be presented to the decision maker. Both the expanded knowledge base and the increased awareness of uncertainty become essential components of the information provided the decision maker. There is no requirement, however, that all of the tasks be carried out before sufficient information is available for a decision. The tasks are sequenced so that an accept/reject decision can potentially be made at any point in the procedure.

ANALYTIC FEATURES. The initial analysis centers around the formalized description of the innovation. The objective, assumption, target applications, and empirical data can be examined to determine whether further efforts should be applied to the assessment of the proposed innovation. Obvious risks in the implementation and use of the innovation which might prevent intrinsic benefits from being realized are next considered in the analytic process. The opinions of experts are sought in obtaining estimates of success probabilities for implementation and user acceptance. A decision tree provides this framework.

If unusually high levels of risk result from this preliminary feasibility profile, possible approaches for reducing the level of risk are then identified. These will introduce additional costs which must be considered in the overall cost analysis. At the same time, an expanded range of application for the innovation is considered in assigning costs and savings to the decision tree. The next step in the analysis is to determine more precisely where the proposed innovation might be applied. Taxonomic structures are used to classify the innovation so that a search of various data bases containing target applications indexed with the same taxonomic descriptors, will result in identification of a potentially wide range of uses for the innovation. This analytic process provides a systematic technique for generalizing the use of the innovation in order to complete the assessment process in its full potential. A detailed cost analysis is now conducted for the full range of courses, jobs, equipments, etc., to which the innovation might be applied. Important benefits and liabilities are introduced into this phase of the analysis by assigning them equivalent dollar values. The benefits and liabilities quantified in this manner are combined with the actual savings and costs. Equivalent dollar values are identified for each possible outcome on the decision tree so that the analytic framework permits calculation of decision variables which express a more comprehensive measure of the utility or value of a particular decision. This level of analysis is complemented with an financial analysis of the proposed innovation and possible alternatives. Measures of financial value are developed as a part of this analytic process. The full range of analysis discussed above has a number of decision points interposed in order that subsequent analysis at more in-depth levels will be justified by any decision to proceed beyond that point.

DECISION FEATURES. From the preceding discussion, the sequential nature of the decision structure should be more or less obvious.

The expanded description of the innovation assists in deciding to continue or abandon the assessment process at that point. The risk analysis identifies any serious obstacles to the successful implementation and use of the innovation; this occurs early in the assessment process, prior to the gathering of extensive range-of-effect and cost data. The decision tree framework forces the assessor to consider the implications of a number of possible outcomes in the decision process. For example, the effects of successfully implementing the innovation only to have it fail to gain adequate user acceptance may be so serious (excessive recovery costs, inadequately trained personnel, long-term potential for rejecting subsequent innovations which might have otherwise been successful, etc.) that, considering the success probabilities, the decision to accept may be judged too risky at this point in the evaluation. Identification of the full range of application for the innovation permits decisions and planning efforts to be performed more realistically at the beginning, even though a resulting decision may be to implement in phases. Two independent views of the innovation's value are made available to the decision maker in the decision tree framework and in the economic analysis. The decision tree is refined to assist the decision maker to select the path with the highest payoff, taking into account both tangible and intangible benefits and liabilities. The decision path resulting from this stage of analysis becomes the basis for the comparative analysis of the proposed innovation against the existing system, and also against any reasonable alternatives. The economic analysis satisfies the requirement of the financial component in the decision process by ensuring that potential alternatives for investment of scarce resources have been fully explored, and each has been subjected to evaluation to determine the respective returns on invested capital. The final decision documentation is organized so that the decision maker obtains a clear picture of the merits and shortcomings of the innovation, and also a sound understanding of the validity of the data used in the assessment and of the degree of uncertainty associated with the total range of decision information.

MODEL DOCUMENTATION

The entire procedural model for assessment of educational technology has been designed with several unique documentation features to enhance both its usage and its maintenance.

TASK PROCEDURAL HIERARCHY. An overall task flow of the model has been presented in this section of the model documentation. This is intended for those interested only in an overview of the model structure. Each task, in turn, has been documented at several levels of detail. The top level consists of flows showing the subtasks to be undertaken by the assessor at that phase of the assessment. The sequential or parallel accomplishment of the subtasks can be determined by referring to this level of documentation. Also, the task flows show decision points internal to the task which direct the assessor to alternate subtasks. Following the task flow is an overall task description containing a list of the subtasks within that task category. Task, subtask, and page references are provided to permit rapid access to procedural information. This referencing scheme also permits pointing the assessor to a procedure contained within another task, thus eliminating the need for redocumenting common procedures. The most detailed level of documentation is the actual procedure for accomplishing the subtask. A description section is optional in introducing the sub-

task procedure which will contain one or more steps outlining how the subtask should be accomplished. Comments are inserted within the procedural steps when it is felt a clarification or further reference is necessary. An optional section is available for a discussion of the rationale for undertaking the subtask. This will be used when the reason for the procedure may not be apparent to the user.

NUMBERING OF TASKS AND SUBTASKS. ETAM consists of eight distinct tasks numbered 1 through 8. Within a task, the subtasks are numbered sequentially. The reference to Task 5, Subtask 11, would be 05.11. Each page within a subtask is numbered sequentially, so the reference to Task 6, Subtask 2, page 3, would be 06.02.03. The introductory flows and task descriptions containing a list of the subtasks, are identified as Subtask 0, therefore, the reference to the overall flow for Task 4 would be 04.00.

The overall flows are not given a figure number; however, an individual figure within the procedural sequences is numbered to correspond with the numbering of the subtask in which it appears. Therefore, the third figure to appear within Task 6, Subtask 7, would be labeled Figure 6.7.3. All figures within a subtask procedure are placed after the procedural steps. Certain figures may be duplicated without the figure number designation. This is to permit the figure to be copied for use by the assessor in documenting some aspect of the assessment process.

It must be underscored, however, that the task flows are generalized conceptual sequences. Practical factors can justify departures from the sequence expressed in the conceptual model when actual assessment procedures are performed. The conceptual map should not be treated as a procedural straightjacket.

The documentation design is intended to allow ease in updating and maintaining the document. Changes can be made with minimal impact upon other sections. As additional information is obtained through the use of the model, it can be inserted at the appropriate point.

USER GUIDANCE

The use of ETAM procedures requires an expert of the consultant type to relate the formalized description of the innovation -- and any data available about it -- to the full range of instructional devices, courses, and course objectives, jobs and job tasks, and student characteristics. The classification system that guides the assessor is a comprehensive, procedurally-oriented taxonomic structure of processes and products in the economics of instruction and in the psychology of learning. The analytic techniques require a degree of understanding of decision theory, statistical techniques, and financial and economic analysis. In general, therefore, the use of ETAM is not intended for either the trainer or the training officer. However, a sound understanding of the ETAM process by training personnel, interfacing with an assessor-consultant, in evaluating an innovation is essential.

The ETAM procedures have been documented at several levels of detail, as previously discussed, so that, initially, the assessor will have available step-by-step procedures for accomplishing the assessment. As competency is gained in the use of the procedures, succeeding assessment exercises may require reference only to the higher level task descriptions or task flows.

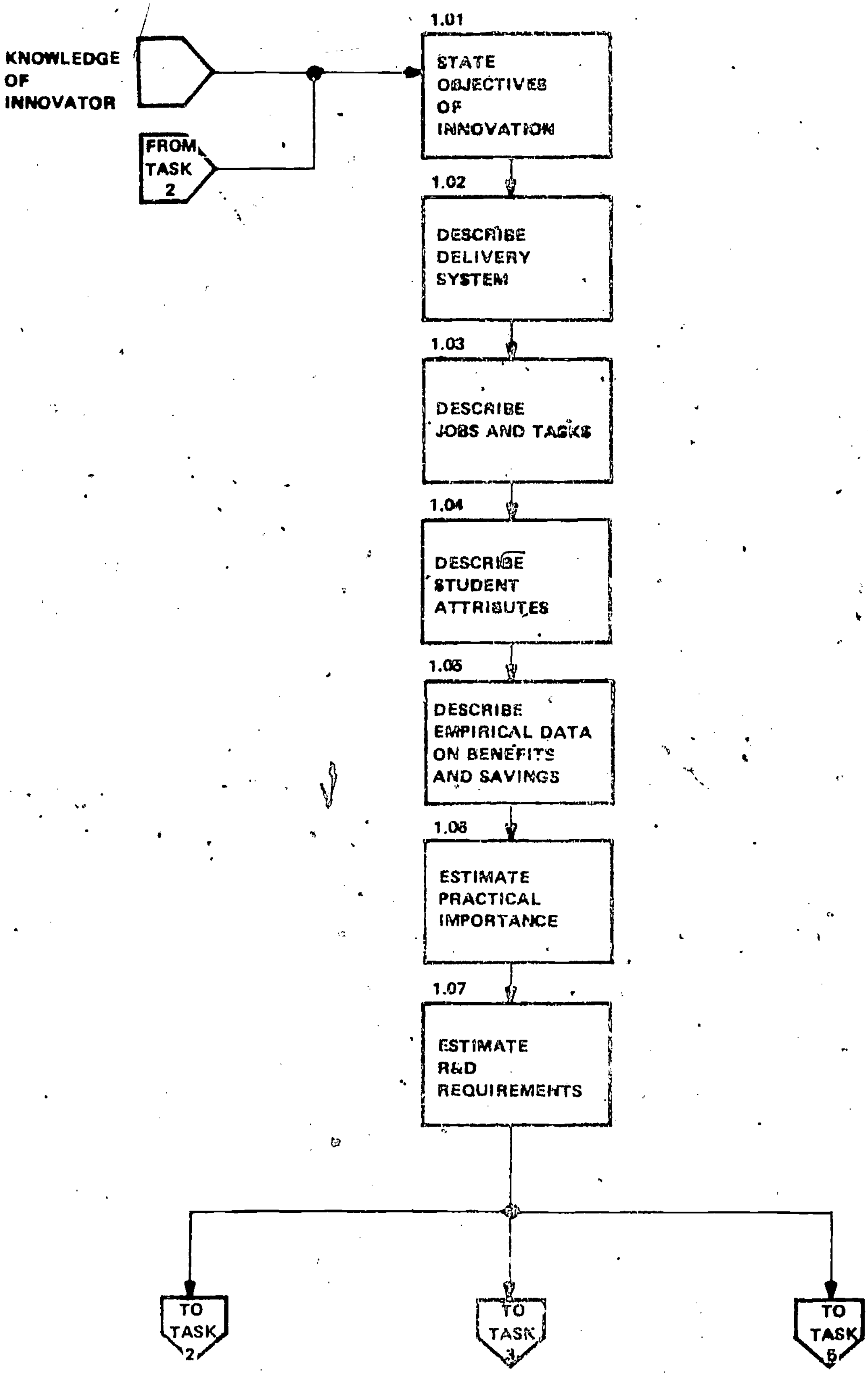
The tasks within ETAM suggest a form of project management, including the creation and maintenance of a project file. As each task is completed, its outputs should be retained in the project file since, in many cases, subsequent tasks build upon or refine the results of prior tasks.

While systematic procedures and formal quantification techniques may seemingly enhance the credibility of outputs, the innovator, the assessor, reviewers, and decision makers are cautioned here that the analytic results are no better than data used in producing the results. In fact, the systematic processing of bad data may produce outputs which are totally incongruous with sound intuitive judgment. All data estimates should be continually subjected to tests of reasonableness, as should interim model outputs. Data sources should be documented in all cases and verified for reliability.

The final note to the user concerns the general application of the procedures to the assessment process. Each task, subtask, and procedure represents only an approximate methodology for conducting the evaluation. Different innovations will require variations in the application of certain procedures. Additional procedural techniques may have to be created by the assessor. For example, a general decision tree model has been suggested for use; however, as is pointed out within the text of the model, other decision tree structures may need to be created to handle some types of assessment problems. Also, the assessor has a wide latitude as to the depth to which any particular assessment step is pursued. This will be a function of need, interest, potential value, risk, and the time and resources available for assessment. At each step in the procedure the assessor should ask the following questions: 1) Do I have sufficient information to reasonably recommend rejection of the innovation and halting of further analysis, and 2) can this particular step be simplified or bypassed, or is a more in-depth analysis than is outlined suggested?

A last explicit caveat. An assessment team with a broad technical knowledge base and penetrating insights can use ETAM as a tool, develop a wider base of alternatives to the innovation, and an awareness of range of benefits and liabilities than will an assessment team which lacks these capacities for creative insight. There is no guarantee, for example, that a given training aid will also be perceived by an assessor as a job aid having a performance benefit, as well as a training benefit. ETAM is a structure for guiding the collection and organization of descriptive and evaluative information by the assessment team, but it cannot generate that information. The ETAM category structure does, however, guarantee at least a lowest common denominator of inquiry and data adequacy for assessment purposes without inhibiting higher levels of competence.

| | TASK | SUBTASK | PAGE |
|---|---|---|---|
| TASK: FORMALIZE THE DESCRIPTION OF THE INNOVATION | 01 | 00 | 01 |



| TASK | SUBTASK | PAGE |
|---|---|---|
| 01 | 00 | 02 |

TASK: FORMALIZE THE DESCRIPTION OF THE INNOVATION

The description achieved by means of this step will lead to the selection of the appropriate decision format for determining the ultimate "range-of-effect" or relevance of the innovation. The description is intended to get as much information about the intent and application of the innovation, as well as background data and empirical data, direct and indirect, that the innovator has developed. Wherever the following format is incomplete, the innovator should improvise or add commentary.

One justification in attempting, in general, to follow the classification outline is to simplify entering and retrieving the innovation into a data bank for cross-referencing purposes.

Descriptions of what is known about each of the following items should be entered under the designated headings that are applicable.

| SUBTASK | REFERENCE |
|---|---|
| 1. State the objectives and a summary of the innovation. | 01.01.01 |
| 2. Describe delivery system or training vehicle. | 01.02.01 |
| 3. Describe jobs and tasks applicable to the innovation. | 01.03.01 |
| 4. Describe relevant student attributes. | 01.04.01 |
| 5. Describe empirical data on benefits and savings. | 01.05.01 |
| 6. Estimate the practical importance of the training product resulting from the innovation. | 01.06.01 |
| 7. Estimate resource requirements needed for further study and implementation of the innovation. | 01.07.01 |

RATIONALE

All of the information available to and used by the innovator should be captured and set down. The structure offered here will guide the assessment process, even though some of the information offered in this section may have to be modified in the course of the assessment process. The format for obtaining and setting down information in Task 1 is a highly condensed version of the complete procedural format for obtaining assessment data. Even though the innovation may, for various reasons, be rejected early in the assessment process for adoption, the complete record of the innovator as represented in this task can be retained in archives suitably indexed for specialized search and retrieval operations in the event that future developments warrant reconsideration, either on the basis of other technical developments or on the basis of a changing need.

| TASK | SUBTASK | PAGE |
|---|---|---|
| 01 | 01 | 01 |

TASK: FORMALIZE THE DESCRIPTION OF THE INNOVATION

SUBTASK: STATE THE OBJECTIVES AND A SUMMARY OF THE INNOVATION

PROCEDURE

1. The formal description of the innovation should be preceded by a brief statement on its major objectives. This should be followed by a one or two page summary or abstract that describes the innovation in general terms and its intended effect(s). The summary should be completed with a list of keyword descriptors for describing the innovation as a retrievable item by subject content in a data base directory.

COMMENT: This set of descriptors may be modified during and after analysis of the innovation's range-of-effect.

TASK: FORMALIZE THE DESCRIPTION OF THE INNOVATION

SUBTASK: DESCRIBE THE DELIVERY SYSTEM OR TRAINING VEHICLE

DESCRIPTION

The innovation may be directed towards the functional improvement or cost reduction of methods of instructional delivery or of instructional media. Or it may deal with the process of developing course materials or the instructional process, either generally or specifically, to a course or type of course. Whether the effects may be direct or indirect, any information relevant to these factors known to the innovator should be identified here.

PROCEDURE

1. Describe what information is relevant to any one or more of the following topics.

   - Program or Course Design. Does the innovation deal with the process of developing individual courses, or for a program of courses leading to the knowledge and skill of a duty or rating, or the design of an entire curriculum structure? The emphasis here is technique for the development and design of training or for the organization and modularity of training content.

   - Instructional Process. Is the innovation aimed at instructional technique, either through the design of improved or added functions in the instructional vehicle, or the design and presentation of content? Is a means made available for teaching new levels or kinds of skills or accelerating the rate at which knowledge or skill is acquired or transferred to real-work environments? Does the innovation enable different locales for instruction to be used, or specialization of the content of the instruction to the individual student and his particular needs and capabilities? (This function will be repeated in the item below.) This list is not exhaustive. Where an item is applicable, identify it by name and describe the relevant characteristics of the innovation.

   - Target Courses. Was the innovation intended to apply principally to one course, or related type of course? Identify the course and the specific course content including, where possible, the name of the knowledge or skill to which it applies.

| TASK | SUBTASK | PAGE |
|---|---|---|
| 01 | 03 | 01 |

TASK: FORMALIZE THE DESCRIPTION OF THE INNOVATION

SUBTASK: DESCRIBE JOBS AND TASKS APPLICABLE TO THE INNOVATION

DESCRIPTION

In this section, try to identify: (1) the specific job or task in the operational environment for which the innovation is intended; and (2) by implication, the range of jobs and tasks to which the innovation applies.

PROCEDURE

1. Use the following terms and definitions to help identify the jobs and tasks to which the innovation applies.

   - Equipment Orientation. Does the innovation apply to training in the operation or servicing of equipment? If so, is it a specific item of equipment, or a class of equipment? Identify all particulars.

   - Work Function Dealing with Equipment. Does the innovation deal with the operation or the maintenance or service and support tasks on the equipment identified in the preceding item? In whatever case, specify the applicable tasks within the identified work function. Where feasible use the Navy's Manual of Qualifications for Advancement as a guide for identification and terminology of specific knowledge or practical factors.

   - Operational Environments. External operational environments may be shipboard, dock, bad weather, landing operations, etc. Internal environments may be described by stress, fatigue, pain, or other distress. An innovation may be directed towards a class of external or internal environment.

   - Target Job (Rating, Billet, NEC, NOBC, etc.). Where possible, specify the applicable jobs targeted by the innovation in terms of Navy nomenclature; i.e., general rates, ratings, etc.

TASK: FORMALIZE THE DESCRIPTION OF THE INNOVATION

SUBTASK: DESCRIBE RELEVANT STUDENT ATTRIBUTES

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DESCRIPTION

The innovation may be directed primarily to the enhancement of desirable student attributes or individual differences, or to the minimizing of liabilities. These should be identified in this subtask.

PROCEDURE

1. Use the following terms and definitions to help identify the student attributes that may be relevant to the innovation. Do not feel restricted to these terms or concepts if others serve to clarify the idea.

   - Prior Training or Experience. Does the innovation enhance, in training or performance, previous training and experiences or, conversely, is it intended to compensate for deficiencies in previous training and experience? These may be done by improved assessment procedures or training techniques or a combination of both. The training may be accomplished so as to facilitate its transfer, plus job experience, to new or extended training.

   - Attitudes and Motivations. The innovation may be directed towards increasing the student's will to learn, interest, attentiveness, and participation in the learning process. These factors should be differentiated from those that may be successful in recruiting candidates for a given course of instruction. It should be understood that the normal by-products of effective instruction are positive student attitudes and motivations. An innovation may be conceived, however, that seeks motivational enhancement by specific planned actions for that particular purpose, although they may be embedded in normal instructional actions.

   - Aptitudes. The target of the innovation may primarily be that of changing aptitude levels or mixes while holding the objectives of training and training costs constant. Such targets can be identified, named, and usually quantified.

   - Social Factors. Social environments of some students may create impediments to the learning process and the learned product. They may also affect the social climate in the training environment and later the operational environment. An innovation may be aimed at

overcoming general or specific social handicaps of entrants to training, or students, with the objective of changing acceptance patterns of candidates to training and, both efficiency and effectiveness of the training administered.

- Washouts and Dropouts. The innovation may aim at the reclamation of actual and potential washouts and dropouts from training programs.

- Student Evaluation. Procedures for capturing, organizing, interpreting, and using various means of assessing student performance, during and at the end of training, for purposes other than directly concerned with the training process itself.

TASK: FORMALIZE THE DESCRIPTION OF THE INNOVATION

SUBTASK: DESCRIBE EMPIRICAL DATA ON BENEFITS AND SAVINGS

DESCRIPTION

The innovation may have been subjected to pilot testing with live subjects under experimental or demonstration conditions. Presumably, the study has been written according to the usual requirements for replicability of what was done. All reports dealing with data obtained from the innovation in any kind of use or investigatory tryout should be included as part of this subtask documentation.

If the innovation is directed principally to a cost reduction in a type of instructional vehicle or medium, or to an instructional function, cost data based on eventual procurement costs, plus operation and maintenance costs, should be obtained as part of the present documentation.

PROCEDURE

1. Obtain and set down data from the studies that show quantitative benefits in the learning process, or products of learning as characterized in Subtasks 01.02, 01.03, and 01.04. Note any qualifications that should be applied to these benefits such as the distributions of scores around mean results, special conditions under which the study was performed, size and nature of the sample of subjects, and so on. These benefits should be compared with respect to control conditions that represent a current practice, or that can be related to a current training practice. The generalizations made in the conclusions reported about the study should be carefully checked against the actual conditions and samplings in the study.

   - Criterion Variables for Measuring Training Effectiveness. If the innovation is directed primarily to a student performance benefit, the experimental conditions may enable the benefit to be characterized by one or more of the following.

     a. Parsimony in what is learned, with respect to a given level and range of acceptable task performance, or its equivalent in the expression of "knowledge." This is the minimum range and level of learning that enables reliability and competence in all criteria of effective job task performance. Thus, it is one measure of the efficiency of training; only that which contributes to a performance criterion is learned.

b. Validity and completeness in level of proficiency. The innovation may be directed towards increasing the job task relevance of what is learned, or to higher levels of proficiency than is practicable with current training practices.

c. Completeness in range of what is learned. The innovation may enable kinds of skill to be acquired that heretofore were not feasible other than in operational situations; or the innovation may identify skill requirements heretofore neglected in training, but which contribute to overall job effectiveness.

d. Extensibility of skill in degree or in kind. If the innovation enables the student to increase his skill level more effectively by on-the-job experiences as a function of the kind of training he gets, the innovation would be classified under this rubric rather than b. above. The innovation may, however, demonstrably facilitate the acquisition of associated skills relative to the incumbent's assigned job, or related jobs, as in cross-training, or for a higher level job.

e. Work motivation. The innovation may have a primary thrust in the increase of the student's motivation to do the work, do it well, or be willing to perform effectively in potentially incapacitating stress conditions. This motivation should be differentiated from willingness to accept a given billet or job position.

2. Obtain and set down the quantitative costs reported in the studies (or based on further inquiry) as measured by the relevant input conditions. Costs may be expressed in comparative practice time or exposure time, or in dollar cost per unit of learning per student if the innovation is primarily an instructional vehicle function. In the latter case, determine or estimate the eventual unit procurement cost plus estimated costs of operation and maintenance (per year) of the device or medium. Set down any factors that may qualify these estimates.

3. Estimate the magnitudes of benefits and savings under actual conditions in the Navy context. This is the translation of the findings in the study to values in benefits and savings, or both, in actual training environments and performance environments. This translation is a judgmental process. The rationale for extrapolating magnitudes in kind and amount from the study to real life should be made explicit. The data derived in this step should be identified and differentiated from the data reported in step 2.

TASK: FORMALIZE THE DESCRIPTION OF THE INNOVATION

SUBTASK: ESTIMATE THE PRACTICAL IMPORTANCE OF THE TRAINING PRODUCT RESULTING FROM THE INNOVATION

## DESCRIPTION

The innovator may have performed or referenced inquiry into the importance of the instructional objectives towards which the innovation is directed. Such information can assist in evaluating the potential contribution of the innovation.

## PROCEDURE

1. Describe or estimate the practical importance of the training product which results from the effects of the innovation. This may be a gross estimate of the importance and centrality of the knowledge or skill to effective job performance as a contribution to the success of the Navy mission. The training outcome to which the innovation is relevant may be critical, important, potentially useful, or irrelevant to mission effectiveness - that is, in the mainstream of job actions such as landing an aircraft, or peripheral to the mainstream such as the legibility of handwriting in filing a flight report. If actual on the job data are available (such as accident reports, specific kinds of failures in diagnostic operations, procedural inadequacies, and so on) that can focus and quantify the deficiency towards which the innovation is aimed, such data can materially assist the evaluation.

2. The empirical benefits plus the practical importance of the innovation may be sufficiently clear-cut to justify going directly to Task 6 (Cost-Benefits Analysis), and an acceptance decision.

TASK: FORMALIZE THE DESCRIPTION OF THE INNOVATION

SUBTASK: ESTIMATE RESOURCE REQUIREMENTS NEEDED FOR FURTHER STUDY AND IMPLEMENTATION OF THE INNOVATION

DESCRIPTION

This task is performed on the assumption that further research and development activity may be required to bring the innovation to a state of implementation on a practical scale and in real training situations. It may also be assumed as background for this step that further testing of the effectiveness of the innovation, such as in experiments in various settings with various samples of conditions and subjects, may be necessary or at least desirable for making firm commitment about the benefits and range of benefits to be derived from the innovation, as well as to expose its liabilities.

PROCEDURE

1. Provide a breakdown estimate in dollars, time, and human talent of the resources expended thus far in developing the innovation and in testing its effectiveness.

2. With step 1 as a reference, prepare an estimate in dollars, time, and human talent for:

   a. Further research and development effort required to bring the innovation to level of development where it can be introduced and used effectively on the scale and in the contexts of practical application.

   b. Further tryout testing and empirical data collection on the magnitude and range of effectiveness of the innovation that can assure better than a 90% probability that the projected benefits will be achieved and the projected liabilities kept within their estimated bounds.

| TASK | SUBTASK | PAGE |
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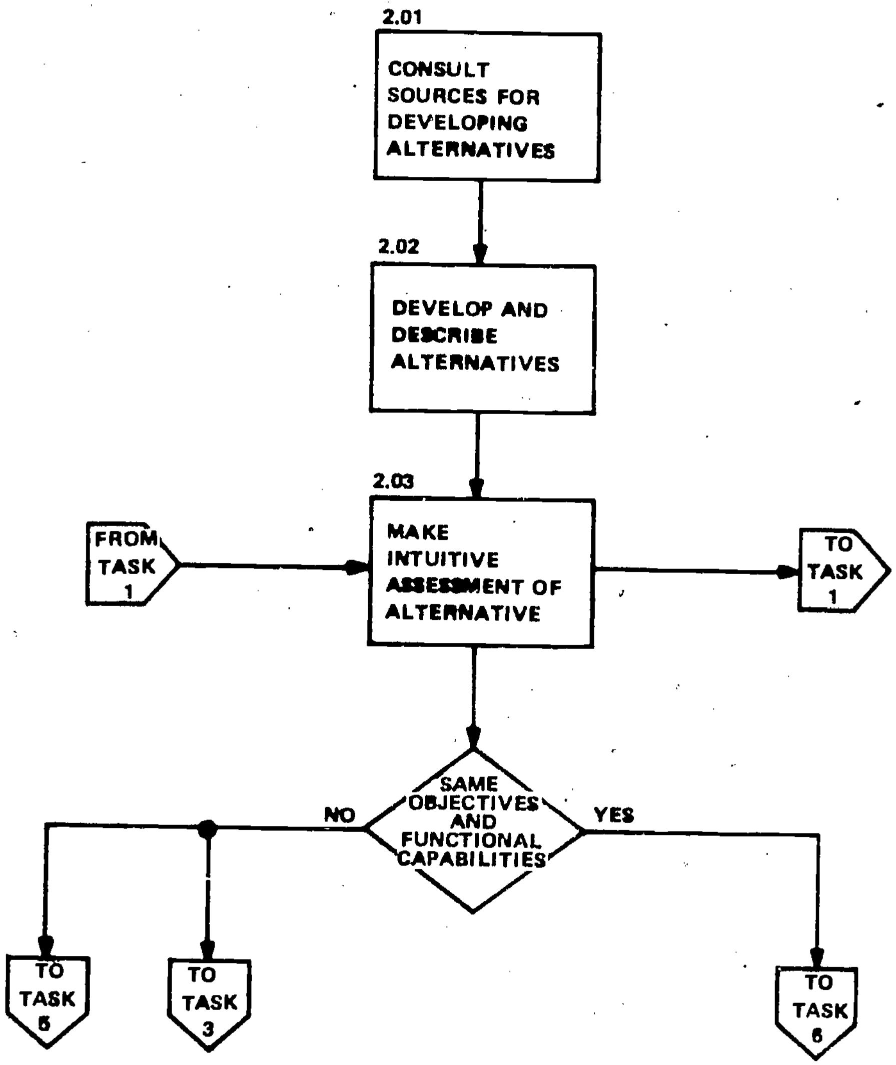
| 02 | 00 | 01 |

TASK: DEVELOP/EXAMINE ALTERNATIVES TO THE INNOVATION



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| 02 | 00 | 02 |

TASK: DEVELOP/EXAMINE ALTERNATIVES TO THE INNOVATION

The first embodiment of an innovation may incorporate the concept but lack implementation know-how. A few hours of directed effort in a selected group of experts can result in alternative embodiments that may sacrifice little of the benefits of the innovation but achieve them at costs greatly below those implied by the original embodiment. It may also turn out that the innovation is not an innovation in fact but only in its form of presentation, and that the concept has been previously rejected in fact and in principle, or that it is embodied in existing practices but with a different name and appearance. The search for alternative embodiments does imply that the functional principle and objectives contained in the innovative concept are understood and transmitted.

Alternatives may also be found by searching the literature or by redirecting the expertise of the innovator.

General knowledge in the subject field, plus common sense, may direct efforts at gross cost reduction on the more cost-sensitive variables. A cost-sensitive variable is one that has a large multiplier factor; it can also be a cost factor with many cost dependencies.

The level of human expertise required to effectively implement the innovation in training practices can be a crucial cost factor, not readily translated into dollars but central to the practicality of the innovation. This is especially true if any exercise of the innovation in the real world depends on a high level of creative or logical talent.

On the other hand, an innovation that may be impractical at one time or in one context may be highly serviceable in other contexts. Failure history should, therefore, be examined for its relevance to current or projected needs and opportunities. For example, a simulation function that was impractical for analog computers may be trivial in cost on a contemporary digital computer.

A commonsense search for functional alternatives and their evaluation may save extensive time and effort in putting the original statement of the innovation through the assessment mill. A potential source of alternatives can be the archives of innovations that were proposed in the past but rejected for various reasons applicable at the time but no longer applicable.

Any alternative to the innovation as it was originally proposed should be described in the same format that was used to describe the original proposal (Task 1).

| TASK | SUBTASK | PAGE |
|---|---|---|
| 02 | 00 | 03 |

| SUBTASK | REFERENCE |
|---|---|
| 1. Consult sources for developing alternatives to the innovation. | 02.01.01 |
| 2. Develop and describe alternatives to the innovation. | 02.02.01 |
| 3. Make an intuitive assessment of the alternative. | 02.03.01 |

| TASK | SUBTASK | PAGE |
|---|---|---|
| 02 | 01 | 01 |

TASK: DEVELOP/EXAMINE ALTERNATIVES TO THE INNOVATION

SUBTASK: CONSULT SOURCES FOR DEVELOPING ALTERNATIVES TO THE INNOVATION

PROCEDURE

1. Consult available sources of information and ideas leading to the development of alternatives to the innovation that may be potentially more feasible, practical, or otherwise have more benefits and fewer liabilities than the innovation as proposed.

   Potential sources for alternatives may be found in the following ways:

   - Understanding the objectives of the innovation so clearly that some aspects of the innovator's implementation become recognized as non-essential or irrelevant to the central objective of the innovation. Stripping off the appurtenances from the innovation as originally proposed may make it more practical and feasible to accomplish.
   - Reviewing the literature on the topic with which the innovation deals. Alternatives may already exist, and data may be available about them.
   - Finding experts on the topic and consulting with them, getting their suggestions about alternatives to the innovation as proposed. Experts may also be used to make preliminary reviews and technical assessments of alternatives to the innovation when these alternatives are developed.

TASK: DEVELOP/EXAMINE ALTERNATIVES TO THE INNOVATION

SUBTASK: DEVELOP AND DESCRIBE ALTERNATIVES TO THE INNOVATION

DESCRIPTION

This process should be no more formal or time-consuming than is dictated by common sense applied to the alternatives. Some ideas as alternatives can be evaluated and dismissed in the course of casual conversation. Others may justify no more than a few notes of description that may be sufficient to find a key weakness that eliminates the alternative from further examination. An alternative that survives the incubation and early critical processes, should be set down in sufficient detail so that if it fails in later stages of even informal assessment, it can be put into the data base of "innovations."

PROCEDURE

1. Prepare a description of the alternative to the innovation as proposed by the innovator. The description should be formatted according to the outline in Task 1. Go no further in detail than seems justified by the apparent quality of the alternative.

2. If, as a consequence of interplay between the inventive, descriptive, and critical processes in the development of the alternative, it becomes a promising candidate for competing with the innovation as proposed, a formal description should be made of it. Follow the format described in Task 1.

TASK: DEVELOP/EXAMINE ALTERNATIVES TO THE INNOVATION

SUBTASK: MAKE AN INTUITIVE ASSESSMENT OF THE ALTERNATIVE

DESCRIPTION

The formal description of the alternative may make apparent some difficulties that were obscure before that description. The formal description also enables the assessor and his associates to back off from the statement of the alternative as they did from the original description of the innovation by the innovator. The question can be asked, globally and analytically; "Does this thing make sense? Where's the fundamental flaw in assumption or procedure? Does the proposed implementation really lead to the objective stated? Is the objective itself stated operationally enough that one could tell whether it was met or not met?" and so forth.

PROCEDURE

1. Make an intuitive assessment of the description of the alternative.

2. If the result of the intuitive assessment is favorable, complete the formal description of the alternative. It should then be put through the ETAM procedural model; Tasks 3 through 8. If the result is unfavorable, put the description and the assessment into the archives.

3. The alternative to the original innovation may not have equivalent objectives and functional capabilities. If so, the alternative must have its own analysis made, not only through Tasks 3 and 4, but also through the range-of-effect and benefits/liabilities assessments in Task 5. It is unnecessary for the alternative to have objectives equivalent to the innovation in order for it to be subject to comparative analysis.

| TASK | SUBTASK | PAGE |
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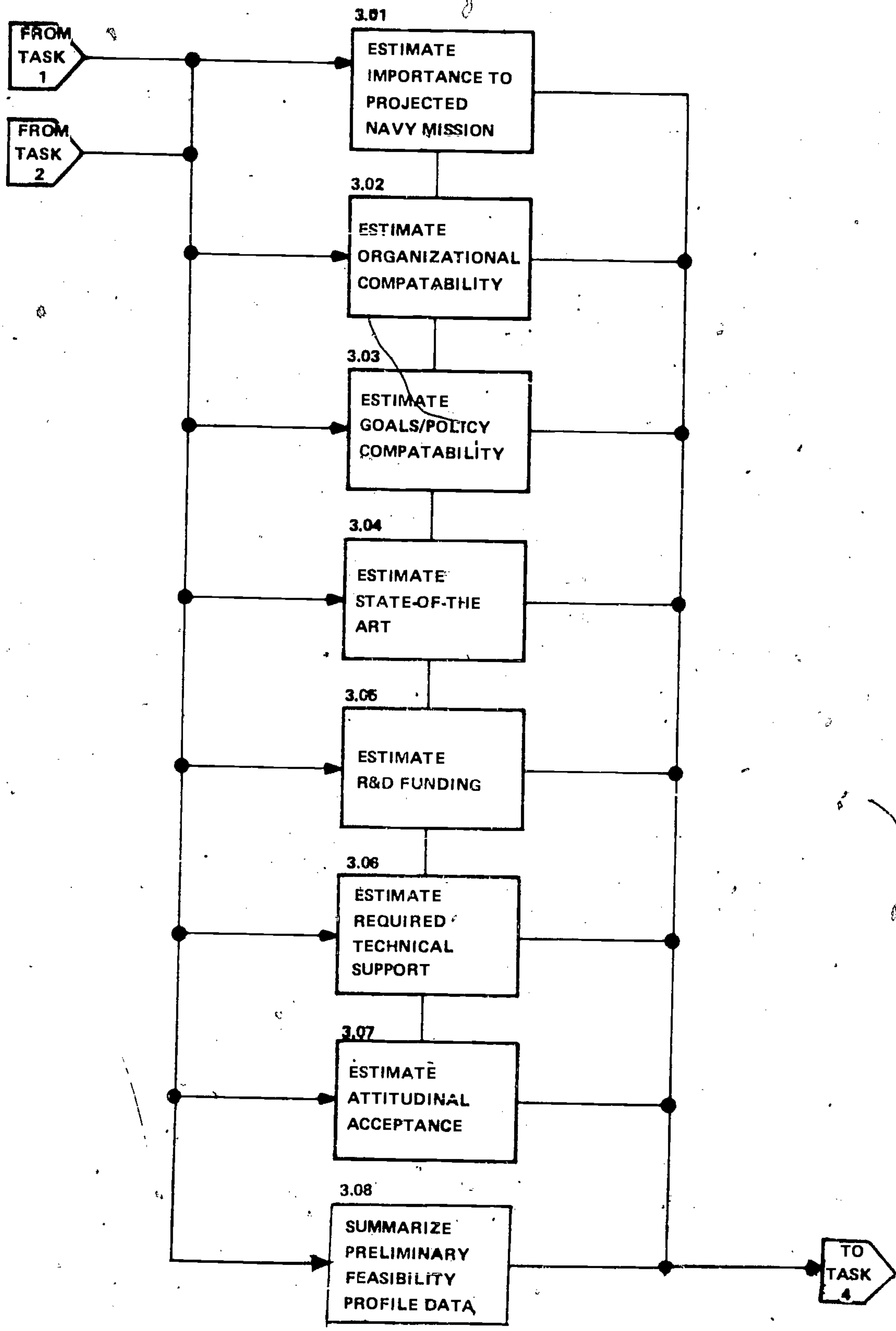
TASK: MAKE PRELIMINARY FEASIBILITY PROFILE



| TASK | SUBTASK | PAGE |
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| 03 | 00 | 02 |

TASK: MAKE PRELIMINARY FEASIBILITY PROFILE

The assessment and decision process relative to the educational innovation and identified alternatives began in Tasks 1 and 2 with rather macro-type judgments. Task 3 begins the more formal aspect of the assessment and decision process which is further refined in Task 4 (Perform Analytic Feasibility Assessment). The outputs of these tasks become the basis for making the in-depth assessment outlined in Task 6 (Perform Cost-Benefits Analysis) and in Task 7 (Perform Financial Analysis).

The assessment process must consider the proposed innovation and alternatives in two contexts. The first is in terms of its intrinsic benefits. Improved training performance, decreased course length, reduced costs, etc., are typical examples of intrinsic benefits resulting from application of the innovation. Quantification and aggregation of these benefits will be a major part of the total assessment procedure. The second context, however, relates to more global concerns that may impact the development, implementation, or ultimate acceptance by the using system. Organizational compatibility, funding availability, attitudinal acceptance, etc., are typical factors with which the assessor is concerned at this point in the assessment process. A framework for viewing these two assessment contexts can be seen by referring to the decision tree in Figure 3.0.1. The intrinsic benefits are aggregated for each of the important outcomes, A through D. The second group of factors, and the ones to be considered here and in Task 4, will be used to establish the probabilities at points U through Z. The overall procedure will be detailed in Task 4; however, at this point the intent is to check the innovation for reasonability in the context of the factors which may affect the probability estimates of implementation success and using system's acceptance.

| SUBTASK | REFERENCE |
|---|---|
| 1. Importance of the Innovation to the Projected Navy Mission. Make a gross estimate of the potential contribution of the innovation (if successfully implemented) to the support of specific, identified elements in the Navy mission. These elements may lie within the training mission, in the operational mission, or in a relationship between the training and operational missions. | 03.01.01 |
| 2. Organizational Compatability. Estimate the degree to which the effects of the innovation fit in with command and career organizational structures of jobs and duties and policies for the use of personnel. | 03.02.01 |
| 3. Goals/Policy Compatability. Estimate the degree to which the proposed innovation fits with existing goals and policies within the training and other personnel organizations where implementation is expected to take place. | 03.03.01 |

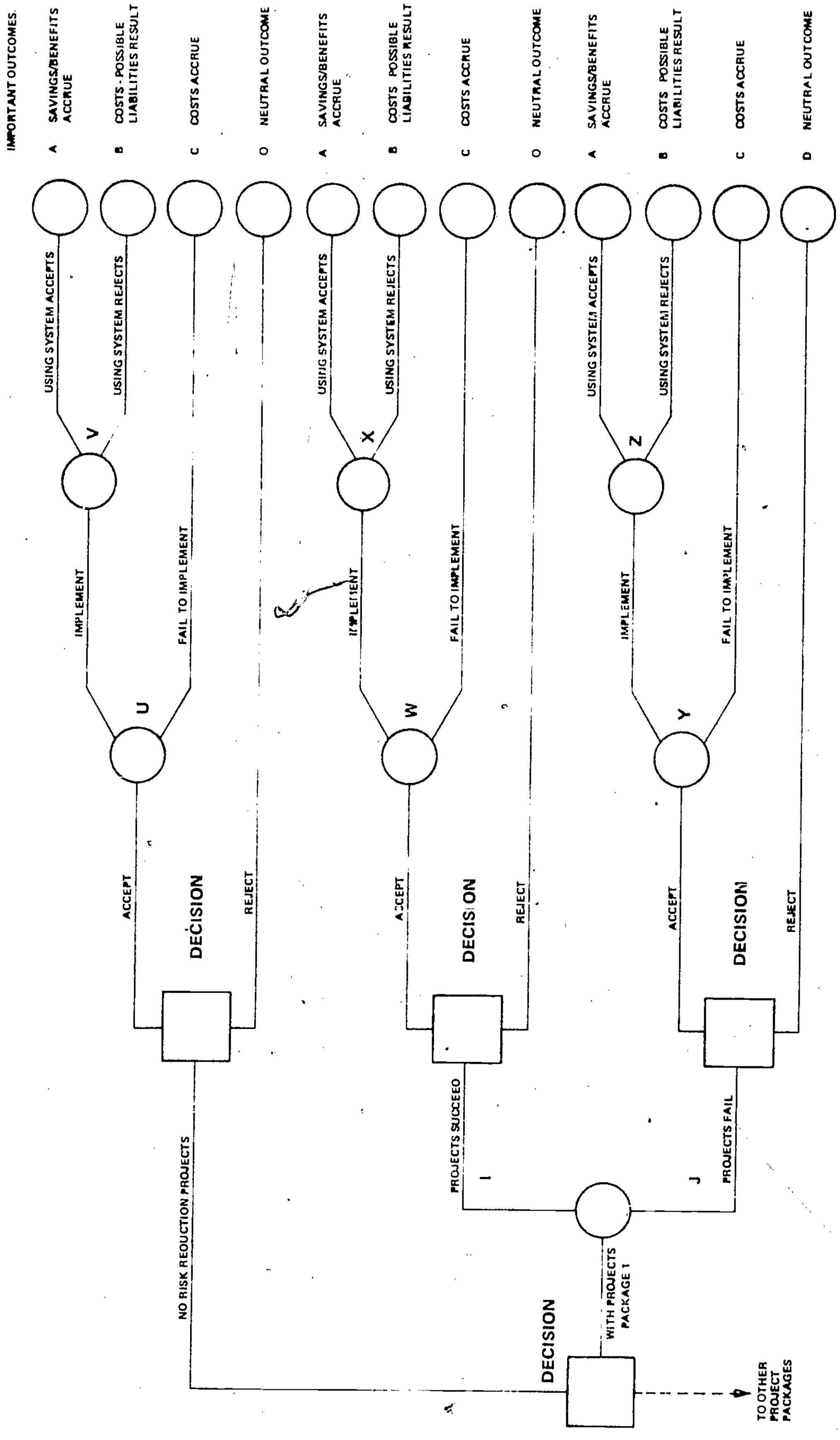


FIGURE 3.0.1. DECISION TREE — A FRAMEWORK FOR ASSESSING TRAINING INNOVATIONS



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REFERENCE

4. State-of-the-Art. Make an estimate of the technical feasibility of implementing the proposed innovation on the scale necessary for practical application. Consider any unique technical requirements that need extensive R&D effort to accomplish. 03.04.01

5. Funding. Make an estimate of the magnitude of dollar support for further R&D effort in bringing the proposed innovation to the point of actual operational introduction and application. These costs should include those to be spent in modifying existing facilities and practices in order to accept the innovation, and costs from retraining persons required to implement the innovation. 03.05.01

6. Technical Support. Estimate the extent to which qualified personnel of whatever kinds are needed can be made available to support further R&D or implementation of the innovation or maintenance of the innovation in practice. High levels of specialized, generalized, or creative talent (especially the latter) are hard to find, and many demands compete for their services. 03.06.01

7. Attitudinal Acceptance. Estimate the degree to which the instructional community and/or the students will accept the device or function as desirable, meaningful, and appropriate to their sense of role and self-image. 03.07.01

8. Summarize the Preliminary Feasibility Profile Data. Identify risk by category, numbers of risk reduction projects, and estimated costs for these projects. 03.08.01

RATIONALE

The innovation may, at this stage, show up so many major impediments that the assessor feels justified in recommending a rejection of the proposal to the decision maker without further analysis. If this is not the case, the data developed here will feed into Task 4 (Perform Analytic Feasibility Assessment) and later into Task 6 (Perform Cost-Benefits Analysis) and Task 8 (Make Accept/Reject/Study Decision).

COMMENT

The assessor is cautioned here on a decision to reject without an explicit or intuitive understanding of the range of applications for the innovation. Because virtually every major innovation at its inception has presented almost insuperable obstacles, shortsightedness or conservatism at this point may cause premature rejection of a potentially valuable enhancement to training.

| TASK | SUBTASK | PAGE |
|---|---|---|
| 03 | 01 | 01 |

TASK: MAKE PRELIMINARY FEASIBILITY PROFILE

SUBTASK: ESTIMATE THE IMPORTANCE OF THE INNOVATION TO THE PROJECTED NAVY MISSION

PROCEDURE

1. Estimate the overall significance of the innovation and its implications for the goals and mission of the Navy. These may consist of the mission of training, operations, or of the relationship between the two. The estimate should take into account future trends and demands and restrictions that may be placed on Navy institutions in terms of student and instructor input, turnaround time in preparing and administering training, flexibility, and similar issues. The potential cost advantages of the innovation should be treated as secondary in arriving at a judgment of the functional importance of the innovation.

2. Select the statement below which best describes the estimated importance of the innovation if it were implemented and widely applied to its potential range of usefulness.

   ( ) The innovation would have an effect of little or trivial importance to the overall training and operational missions of the Navy.

   ( ) It would have an effect of moderate importance.

   ( ) Its effect would be substantial and important.

   ( ) Its effect would be highly important and possibly crucial to training and/or operational missions of the Navy.

3. Decide if the innovation has important enough application within the Navy to justify pursuing the analysis. This consideration should be extended into future years where the possibility of changing missions may change the importance estimate.

| TASK | SUBTASK | PAGE |
|---|---|---|
| 03 | 02 | 01 |

TASK: MAKE PRELIMINARY FEASIBILITY PROFILE

SUBTASK: ESTIMATE OF ORGANIZATIONAL COMPATABILITY

PROCEDURE

1. Consider the degree to which the effects that may be produced by the innovation, or that may be involved in its use, conflict with or fit into command and career organizational structures of jobs and duties and policies for the use of personnel. This judgment should not be affected by whether the assessor believes the outcome from the innovation would be desirable or undesirable.

2. Select the statement below which best fits. The innovation would lead to consequences that would be:

   ( ) Incompatible and inconsistent with Navy command and career structures as they exist or are planned.

   ( ) Somewhat inconsistent with Navy command and career structures.

   ( ) Irrelevant to Navy command and career structures.

   ( ) Supportive of Navy command and career structures.

3. Decide whether the risks are so high that no viable set of implementation projects could be described to reduce them to an acceptable level. If this is the case, then rejection should be considered at this point. If potentially high risks exist, then thought should be given at this time to risk reduction projects to be detailed in Task 4. If the projected project cost seems unreasonably high in relation to the benefits associated with the reduction of risk, then this is perhaps another reason for rejection at this time.

| TASK | SUBTASK | PAGE |
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| 03 | 03 | 01 |

TASK: MAKE PRELIMINARY FEASIBILITY PROFILE

SUBTASK: ESTIMATE OF GOALS/POLICY COMPATIBILITY

PROCEDURE

1. Consider the degree to which the proposed innovation fits with existing goals and policies within the training and other personnel organizations, where implementation is expected to take place. Thus, for example, the goal of the training establishment could be the training of the person not only for a specific military job or position, but for any of a family of jobs, or for a counterpart in the civilian specialty as well as the military job. It is assumed that the assessor is familiar with those goals and policies that could be applicable to the innovation.

2. Select the statement below which best fits the case. The innovation would lead to:

   ( ) Substantial conflicts with existing goals and policies of one or more training and other personnel organizations.

   ( ) Minor conflicts with those policies.

   ( ) No conflicts.

   ( ) Support, in general, of existing goals and policies.

3. As in the preceding procedure, an assessment of risks, risk reduction projects, and the apparent cost-benefits of these projects should be made to determine if the innovation should be rejected at this time.

| TASK | SUBTASK | PAGE |
|---|---|---|
| 03 | 04 | 01 |

TASK: MAKE PRELIMINARY FEASIBILITY PROFILE

SUBTASK: ESTIMATE OF THE STATE-OF-THE-ART APPLICABLE TO THE INNOVATION

PROCEDURE

1. Consider the technical feasibility of the proposed innovation in terms of the scope and scale that would make its implementation practical. Take into account unique technical requirements that might need extensive R&D effort to accomplish, in order to develop and integrate the innovation into an instructional or operational system.

2. Select the statement below which best fits the case. The innovation has:

   ( ) Low probability of success in overcoming technical difficulties, even with substantial continued R&D effort.

   ( ) Moderate probability of technical success with some continued R&D effort.

   ( ) High probability of success with at least moderate R&D support.

   ( ) Amply demonstrated technical feasibility at this time.

3. Decide whether the risks are so high that no viable set of implementation projects could be described to reduce them to an acceptable level. If this is the case, then rejection should be considered at this point. If potentially high risks exist, then thought should be given at this time to risk reduction projects to be detailed in Task 4. If the projected project cost seems unreasonably high in relation to the benefits associated with the reduction of risk, then this is perhaps another reason for rejection at this time.

TASK: MAKE PRELIMINARY FEASIBILITY PROFILE

SUBTASK: ESTIMATE FURTHER R&D FUNDING

PROCEDURE

1. Examine the number and kinds of R&D effort still required to be completed in order to bring the innovation to completion -- that is, to actual operational introduction and application. The R&D may be in terms of systems design, hardware, software, communications, and other factors. (See Task 5, Determine Range-of-Effect, Subtask 2, Develop Background for Instructional Vehicle Analysis, for a list of potentially relevant usage properties.) The costs of technical and operational debugging of new technologies should not be underestimated. Costs required to modify existing facilities and practices in order to accept the innovation should be included, as well as costs from retraining persons required to implement the innovation. It may be sufficient to make gross estimates of potential costs for various elements of the expected R&D effort.

2. Estimate the relative magnitude of the expected R&D costs. This estimate should reference the available or expected overall R&D budget of the Navy for training. Select the statement which best fits the case.

   If a comparison is made with the typical size of funding for an R&D objective in Navy education and training, the R&D expenditure realistically to be expected in order to bring the proposed innovation into operational implementation will be:

   ( ) Large to very large to bring the innovation to an operational level of implementation.

   ( ) Moderate.

   ( ) Readily integrated into existing planned programs of expenditures for training R&D.

   ( ) An immediate and relatively direct savings to the R&D budget for training.

3. Decide whether the costs are so high to preclude obtaining adequate funding. Alternative approaches at a lesser level of funding should be considered at this point. If potentially high risks exist, then thought should be given at this time to possible rejection. If the projected R&D cost seems unreasonably high in relation to the benefits associated with the reduction of risk, then this is perhaps another reason for rejection at this time.

4. Retain any estimates of actual dollar costs that were developed in this subtask. Document these data in the project file.

| TASK | SUBTASK | PAGE |
|---|---|---|
| 03 | 06 | 01 |

TASK: MAKE PRELIMINARY FEASIBILITY PROFILE

SUBTASK: ESTIMATE REQUIRED TECHNICAL SUPPORT

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PROCEDURE

1. Examine the various kinds of skills and abilities that will be needed in order to bring the proposed innovation into service. These may require those skills needed for the R&D work and also those skills that will be necessary to maintain and apply the innovation, assuming it has been implemented. Then, assess the ease or difficulty in finding people with these skills and skill levels in the quantity that may be needed. It should be recognized that novel creative skills are always in short supply and heavy demand, especially when various technical constraints may be placed upon their talent.

2. Select the statement below which best fits the estimate of level of technical support that will be required to develop and maintain, in practice, the innovation:

   ( ) Extremely rare kinds of talent will be required to (1) continue the R&D or; (2) to implement the innovation in practice or; both (1) and (2) apply.

   ( ) Some difficulty should be expected in finding the kind of talent needed to complete the R&D work and to implement the innovation in practice.

   ( ) Adequate talent is available or can be made available for bringing the innovation to practical and realistic implementation in training.

   ( ) Adopting the innovation will actually reduce the level of talent now required for performing the function intended for the innovation in the training subsystem.

3. Decide whether the risks are so high that no viable set of implementation projects could be described to reduce them to an acceptable level. If this is the case, then rejection should be considered at this point. If potentially high risks exist, then thought should be given at this time to risk reduction projects to be detailed in Task 4. If the projected project cost seems unreasonably high in relation to the benefits associated with the reduction of risk, then this is perhaps another reason for rejection at this time.

| TASK | SUBTASK | PAGE |
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| 03 | 07 | 01 |

TASK: MAKE PRELIMINARY FEASIBILITY PROFILE

SUBTASK: ESTIMATE ATTITUDINAL ACCEPTANCE

PROCEDURE

1. On the basis of historical precedents or current expressions of attitude about issues represented by the innovation, determine the degree to which users of the innovation are likely to accept the innovation as desirable, meaningful, and appropriate to their sense of role and of self-image. General experience has shown that if the instructor rejects the instructional device, function, or role, he will transmit this attitude to most of his students. This does not mean that the converse occurs, namely that instructor acceptance is tantamount to student acceptance. The assessor should recognize that some resistance may be either transient or a deep and long-lasting resentment.

2. Select the statement below which best describes the kind of attitudinal acceptance to be expected if the innovation is introduced:

   ( ) The instructional community will almost certainly respond to the innovation with sustained hostility.

   ( ) The instructional community will probably respond with some moderate but temporary resistance to the innovation.

   ( ) The innovation can be introduced to the instructional community with little or no feeling about it, one way or the other.

   ( ) On the main, the instructional community will welcome the innovation, especially after its realistic values have been experienced.

3. Decide whether the risks are so high that no viable set of implementation projects could be described to reduce them to an acceptable level. If this is the case, then rejection should be considered at this point. If potentially high risks exist, then thought should be given at this time to risk reduction projects to be detailed in Task 4. If the projected project cost seems unreasonably high in relation to the benefits associated with the reduction of risk, then this is perhaps another reason for rejection at this time.

| TASK | SUBTASK | PAGE |
|---|---|---|
| 03 | 08 | 01 |

TASK: MAKE PRELIMINARY FEASIBILITY PROFILE

SUBTASK: SUMMARIZE PRELIMINARY FEASIBILITY PROFILE DATA

PROCEDURE

1. Assemble the data from Task 3, Subtasks 1 through 7 into the format suggested in Figure 3.8.1. Check the level of risk and importance without considering additional risk reduction projects.

2. Indicate the number of risk reduction projects required and identified for each risk category.

3. Estimate the approximate total cost for risk reduction projects in each category.

4. Summarize the risk data with an overall risk assessment, total for risk reduction projects, and estimated total cost for the projects.

5. An extremely useful exercise at this point would be to reevaluate the individual risk levels considering successful completion of all the identified risk reduction projects.

COMMENT

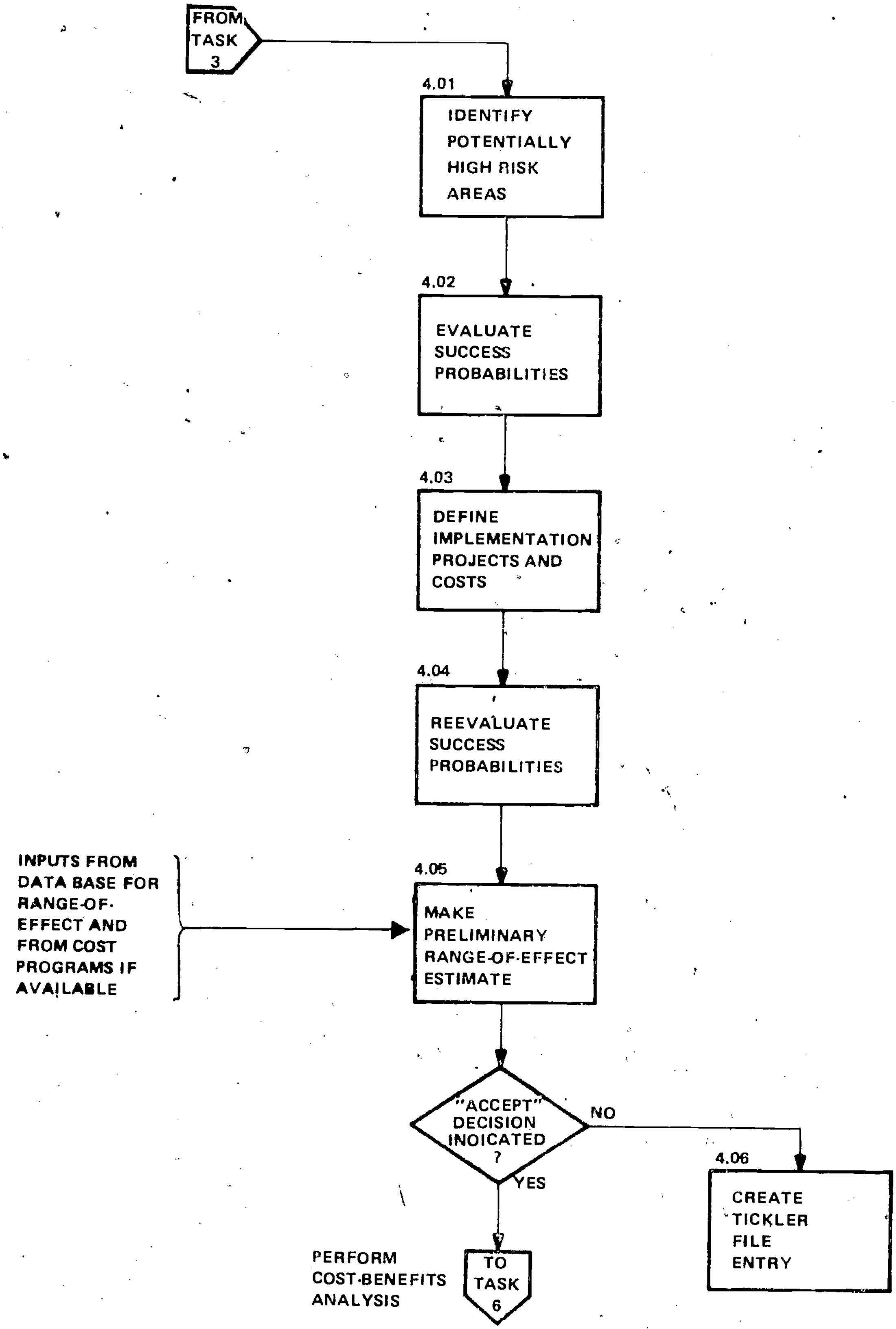
The data summarized here may prompt a rejection decision at this point, however, whether a rejection occurs or analysis continues, the data will be a valuable input to the management decision process.

| SUBTASK | RISK ITEM / RISK DEGREE | UNACCEPTABLY HIGH RISK OR OF TRIVIAL IMPORTANCE | MODERATE RISK OR OF MODERATE IMPORTANCE | NO RISK OR OF SUBSTANTIAL IMPORTANCE | SUPPORTIVE OR OF HIGH OR CRUCIAL IMPORTANCE | COMMENTS, NATURE OF RISK, ETC. | NUMBER OF RISK REDUCTION PROJECTS REQ'D AND IDENTIFIED | ESTMATED PROJECT COSTS |
|---|---|---|---|---|---|---|---|---|
| 01 | IMPORTANCE TO PROJECTED NAVY MISSION | | | | | | | |
| 02 | ORGANIZATIONAL COMPATIBILITY | | | | | | | |
| 03 | GOALS/POLICY COMPATIBILITY | | | | | | | |
| 04 | STATE-OF-THE-ART | | | | | | | |
| 05 | R&D FUNDING REQUIREMENTS | | | | | | | |
| 06 | TECHNICAL SUPPORT REQUIREMENT | | | | | | | |
| 07 | ATTITUDINAL ACCEPTANCE | | | | | | | |
| | OVERALL PROFILE AND TOTAL PROJECTS AND DOLLARS | | | | | | | |

FIGURE 3.8.1. SUMMARIZED PRELIMINARY FEASIBILITY PROFILE

TASK: PERFORM ANALYTIC FEASIBILITY ASSESSMENT

| TASK | SUBTASK | PAGE |
|---|---|---|
| 04 | 00 | 01 |



| TASK | SUBTASK | PAGE |
|---|---|---|
| 04 | 00 | 02 |

TASK: PERFORM ANALYTIC FEASIBILITY ASSESSMENT

Having decided as the result of Task 3 that there are no insurmountable obstacles in achieving the benefits of the proposed innovation, more rigorous application of the factors outlined in Task 3 will be made at this stage of the assessment process. This task has a two-fold purpose. First is to refine the analysis of Task 3 in developing success probabilities for inclusion in the decision tree. Second is to further define implementation projects targeted at reducing the risk from any of the factors considered in Task 3. Once risk reduction programs have been defined, the success probabilities are reestimated and used along with the original probability estimates to complete the decision tree. If no major problem areas were identified, then Task 4 would be bypassed; although the factors considered in the analysis of Task 3 should be reassessed after Task 5 (Determine Range-of-Effect) has been completed, since a broadened application of the innovation may expose new problems.

| SUBTASK: | | REFERENCE |
|---|---|---|
| 1. | Identify the factors from Task 3 that represent potentially high risks in the implementation and use of the proposed innovation. (This and the following subtasks are also applied to each alternative resulting from the analysis in Task 2.) | 04.01.01 |
| 2. | Evaluate the probabilities that the innovation can be successfully implemented and used considering the identified risks. | 04.02.01 |
| 3. | Define projects and associated costs intended to reduce risks to a reasonable level. | 04.03.01 |
| 4. | Reevaluate the probabilities of successful implementation and use considering achievement of project results. | 04.04.01 |
| 5. | Make preliminary estimate of potential scope of application (range-of-effect) required for project payoff. | 04.05.01 |
| 6. | Create tickler file entry identifying criteria for reassessment of innovation if, at this point, the proposal does not appear feasible. | 04.06.01 |

| TASK | SUBTASK | PAGE |
|---|---|---|
| 04 | 01 | 01 |

TASK: PERFORM ANALYTIC FEASIBILITY ASSESSMENT

SUBTASK: IDENTIFY POTENTIALLY HIGH RISK AREAS

PROCEDURE

1. Refer to the output of Task 3 which identifies risks which may impact the projected implementation or use of the proposed innovation in the following topical categories.

   - Importance of innovation to projected Navy mission
   - Organizational compatibility
   - Goals/policy compatibility
   - State-of-art (Technological feasibility)
   - Funding constraints
   - Technical support capability
   - Attitudinal acceptance.

2. Develop further detail for each risk statement which describes the specific obstacle to be overcome (the potential problem envisioned in implementing and/or using the innovation). The detail should suggest R&D studies or projects which can be undertaken to reduce the overall risk in each major category. More than one approach to reducing the risks may be identified and each reasonable alternative should be described and carried through the subsequent analysis.

3. Document results of analysis and incorporate into project file.

TASK: PERFORM ANALYTIC FEASIBILITY ASSESSMENT

SUBTASK: EVALUATE SUCCESS PROBABILITIES

DESCRIPTION

Evaluation of success probability is performed with respect to implementation of the innovation as well as in relation to its acceptance by the using system. Some of the risk categories from the preceding subtask will affect implementation; e.g., state-of-art, others will affect innovation use; e.g., funding constraints. In this procedure the risk items are separated so that an independent evaluation can be made for each category. The process outlined in this procedure may require several iterations using judgmental inputs from a number of experts in the specific problem areas. Also, since the impacts may not be independent; e.g., the resolution of an organizational incompatibility may change the probability for a technical support type problem; the interrelationships and conditional probabilities may have to be worked out using extended decision tree diagrams or some form of cross-impact tables*. The basic decision tree format discussed in Task 3 and shown in Figure 4.2.1 will be used as a starting point.

PROCEDURE

1. Classify the risk statements from 04.01 into:

   a. Those that will create problems in the implementation of the innovation.

   b. Those that will interfere with the successful use of the innovation once it has been implemented.

2. Given no specific project action is undertaken to resolve any of the problem areas (other than a continuing level of awareness that the problem exists), estimate the probability that:

   a. Successful implementation (includes any development and installation activities) can be achieved (U in Figure 4.2.1).

   b. The user will accept the application of the innovation as planned (V in Figure 4.2.1). User in this context refers to the using system; i.e., organization, function, environment, etc.

COMMENT: Composite probabilities where the problem areas are not independent may require more complex analysis than is suggested here.

*Paper on DELPHI Techniques and Cross Impact Analysis - Author unknown.

3. For each of the above two estimates, provide an interval estimate where the one end of the range is the probability of success under the most favorable conditions and the other end of the range is the probability of success under the most adverse conditions.

4. Document results of these estimates for incorporation into the project file.

RATIONALE

The probability estimates and confidence intervals developed in this subtask will be part of the data used to determine the relative value of the decision to either:

a. Reject the proposed innovation outright.

b. Accept it without additional study.

c. Accept it and conduct continued studies considering their associated costs.

The confidence intervals will be used in conjunction with sensitivity analyses to determine if additional information should be acquired in order to improve the confidence in the estimate.

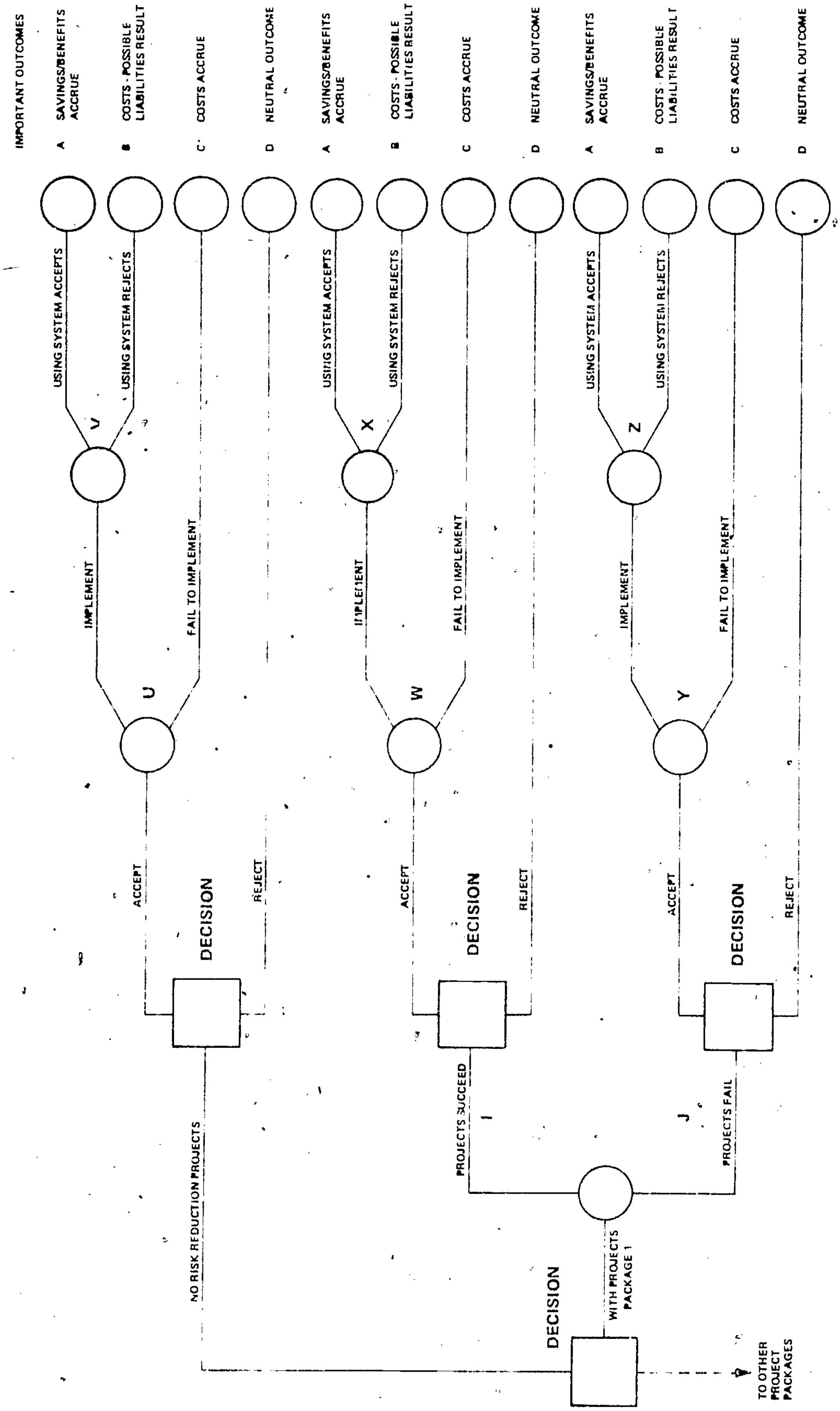



FIGURE 4.2.1. DECISION TREE FOR ASSESSMENT OF TRAINING INNOVATION

| TASK | SUBTASK | PAGE |
|---|---|---|
| 04 | 03 | 01 |

TASK: PERFORM ANALYTIC FEASIBILITY ASSESSMENT

SUBTASK: DEFINE IMPLEMENTATION PROJECTS AND COSTS

DESCRIPTION

The assessor must decide whether the level of risk identified is potentially too high to be acceptable. This general reference resulted in the previously identified risk statements. The task, at this point, is to define specific projects targeted at overcoming some of the problems which create the potentially high level of risk, and to cost out these projects for inclusion in the decision tree outcomes resulting from the decision to carry out the projects. The preliminary cost estimates performed in Task 3 will be refined at this point.

PROCEDURE

1. Prepare a project description for each R&D effort, study, experiment, etc., which should be considered in reducing a specific problem or group of problems to a reasonable level of risk.

2. Identify resource requirements and approximate time schedule for accomplishing each project.

3. Prepare a detailed cost analysis of each project. A sample form for documenting cost data is shown in Figure 4.3.1.

4. Group projects into one or more packages, each of which is intended to reduce the overall risk to a reasonable level. Where alternative approaches to reducing risk have been defined, groupings of projects can be structured to include the various alternatives. Different cost/benefit patterns will undoubtedly result from the alternative risk reduction packages and the effect upon the decision variable will be determined when the decision tree is folded back as outlined in Subtask 04.05.

5. Document results of project definition and costing for incorporation into the project file.

PRELIMINARY
COST ESTIMATE

NEW ☐ REVISED ☐

| PROJECT | PROJECT NAME | PROJECT NO. | DATE |
|---|---|---|---|
| | | | |

**PERSONNEL**

| JOB | MAN MONTHS | COST/MAN MONTH | JOB COST | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | $ |

**EQUIPMENT**

| DESCRIPTION | QUANTITY | UNIT COST | COST | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | $ |

**SPACE**

| REASON | SQUARE FEET | COST/SQ. FT. | COST | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | $ |

**TRAVEL (NON-STUDENT)**

| FROM - TO - REASON | NO. OF TRIPS | COST/TRIP | COST | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | $ |

**STUDENTS**

| NO. OF STUDENTS - REASON | NO. OF DAYS | COST/STUDENT DAY | COST | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | $ |

**OTHER**

| DESCRIPTION | MAN MONTHS/QTY. | UNIT COST | COST | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | $ |

| | |
|---|---|
| **TOTAL PROJECT COSTS** | $ |

FIGURE 4.3.1. COST/SAVINGS DATA SHEET

TASK: PERFORM ANALYTIC FEASIBILITY ASSESSMENT

SUBTASK: REEVALUATE SUCCESS PROBABILITIES

---

DESCRIPTION

This involves procedures similar to those outlined in Subtask 04.02.

PROCEDURE

1. Given that the specified risk reduction projects are undertaken for each grouping or package of risk reduction projects, reestimate the probability that the projects will succeed. The values resulting from the estimates will be assigned to the "projects succeed" leg on the decision tree (I for project package 1 in Figure 4.2.1). The value for "projects fail" (1-I) is also entered on the decision tree. If more than one project package has been defined, similar entries will be made for each additional package.

2. Given that the projects succeed, for each project package estimate the probability that:

   a. Successful implementation can be achieved (W in Figure 4.2.1).

   b. The user will accept the application of the innovation as planned (X in Figure 4.2.1).

3. Similarly, given that the projects fail, for each project package estimate the probability that:

   a. Successful implementation can be achieved (Y in Figure 4.2.1).

   b. The user will accept the application of the innovation as planned (Z in Figure 4.2.1).

COMMENT: In this reassessment of risk, consideration shall be given to the time required to complete identified projects from the standpoint that a change in implementation date could in itself modify the probabilities of success. Where a number of interrelated projects are being planned, some level of project scheduling may be required using PERT, CPM, etc., before reasonable estimates may be made.

4. For each of the above estimates, provide an expression of confidence by estimating in each case an optimistic value given the most favorable conditions occur, and a pessimistic value considering the most adverse conditions come about.

5. Document results of these estimates for incorporation into the project file.

| TASK | SUBTASK | PAGE |
|---|---|---|
| 04 | 05 | 01 |

TASK: PERFORM ANALYTIC FEASIBILITY ASSESSMENT

SUBTASK: MAKE PRELIMINARY "RANGE-OF-EFFECT" ESTIMATE

DESCRIPTION

If the process of describing the innovation and conducting the preliminary feasibility analysis has not provided a clear basis for a decision regarding the innovation, this subtask will provide an initial quantitative basis for the selection of a decision route.

PROCEDURE

1. Using the target applications for the innovation from Task 1; i.e., course, jobs, equipments, students, etc., make a preliminary estimate of the extended range of courses, jobs, etc., over which the proposed innovation might apply.

COMMENT: If data bases are available for searching, preliminary search parameters may be defined without the full analysis required by Task 5 (Determine Range-of-Effect).

2. Identify the appropriate cost categories impacted by the innovation. A further subdivision of costs between development/implementation and recurring operational costs should be maintained so that costs can be related to the specific outcomes of the decision tree. For example, one class of costs may be expended in the process of attempting to implement, and even though the implementation was unsuccessful, these costs will be incurred and identified in outcome C of the decision tree shown in Figure 4.2.1. Shutdown costs in case of failure should be considered.

3. Prepare gross cost/savings estimates for each cost category considering each outcome of the decision tree in Figure 4.2.1.

COMMENT: If a cost model is available, input parameters should be specified and the model run to determine preliminary costs/savings.

4. Enter costs on the decision tree for outcomes A through D and specify the probabilities (most likely) at points U through Z. An example of a completed decision tree is shown in Figure 4.5.1.

5. Fold back the decision tree to obtain the preliminary value of each of the three decision paths. The steps in the foldback process are illustrated in Figure 4.5.2.

6. Select preliminary decision path. The highest positive value on legs 1, 2, etc., would be an indication of the best preliminary decision. If all of these values are zero, based on this preliminary assessment the proposed innovation should be rejected. It is possible, however, that the identification of alternative risk reduction projects which produce revised success probabilities could change this preliminary result. Also, a revised range-of-effect analysis may expand savings beyond cost to create a more favorable decision outcome.

7. Document results of decision tree analysis for incorporation into the project file.

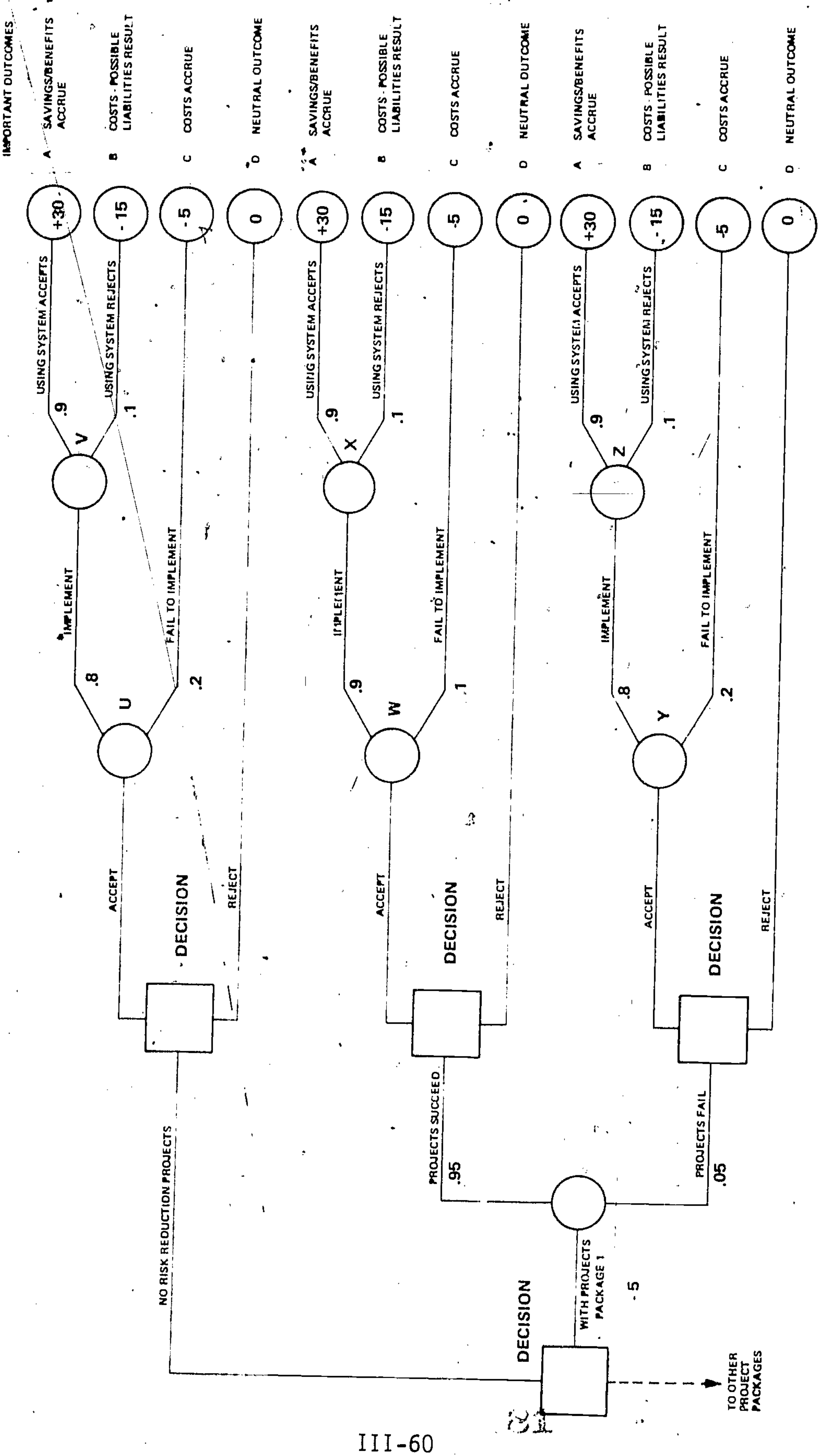



FIGURE 4.5.1. DECISION TREE FOR ASSESSMENT OF TRAINING INNOVATION (EXAMPLE OF FORM COMPLETED WITH INITIAL OUTCOME VALUES AND PROBABILITIES)

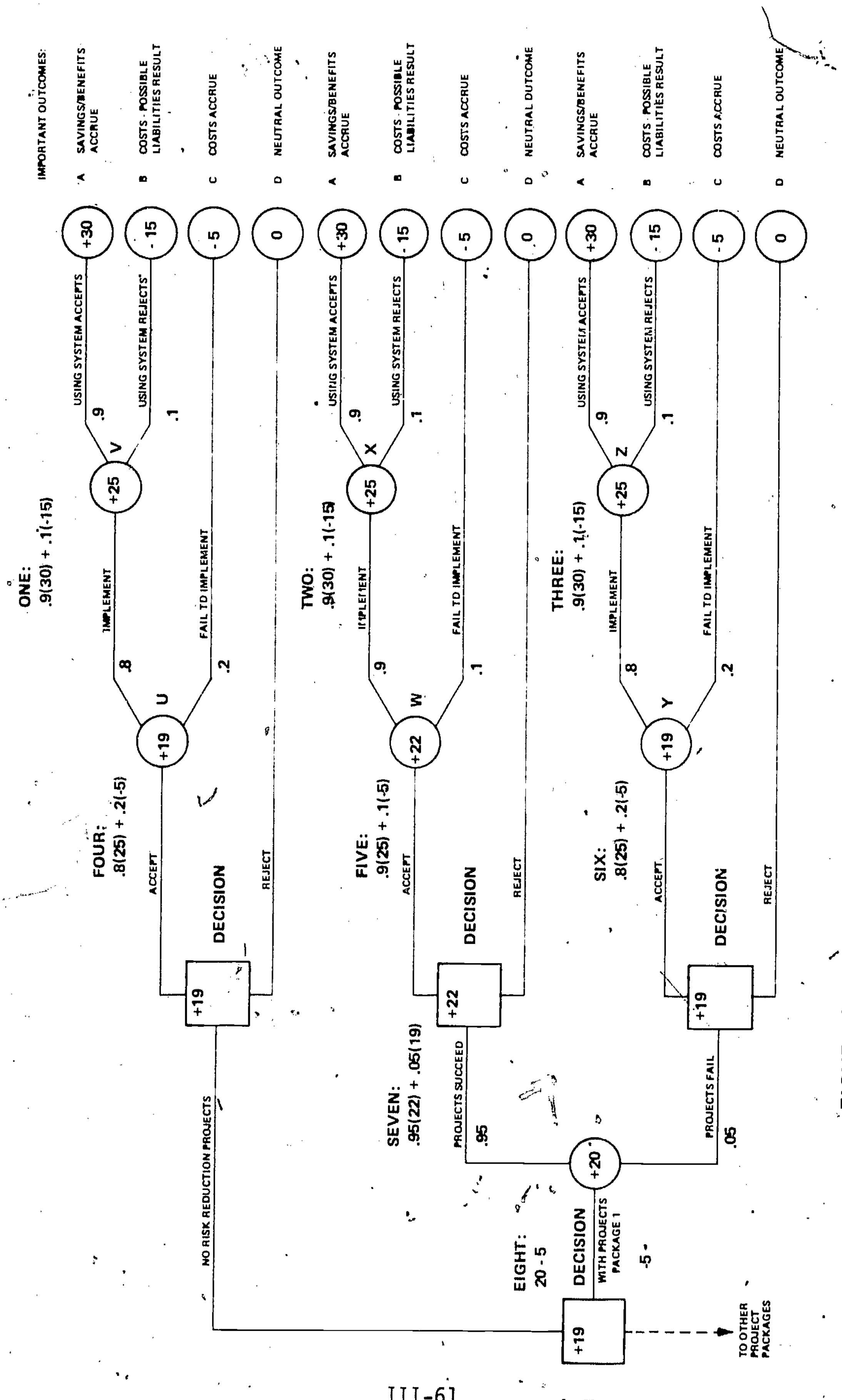



FIGURE 4.5.2. DECISION TREE FOR ASSESSMENT OF TRAINING INNOVATION (EXAMPLE OF FOLDING BACK PROCESS)

TASK: PERFORM ANALYTIC FEASIBILITY ASSESSMENT

SUBTASK: CREATE TICKLER FILE ENTRY

PROCEDURE

1. If a decision is made at this time not to proceed, the problem areas should be reanalyzed to establish the basis upon which the innovation might be reactivated. For example:

   - When might presently insufficient funding be available.
   - When will an appropriate level of technical support be available.
   - When might existing organizational constraints be modified.
   - When might attitudinal acceptance on the part of the user population be improved to bring about a more acceptable level of risk.
   - When might a particular technological breakthrough occur.

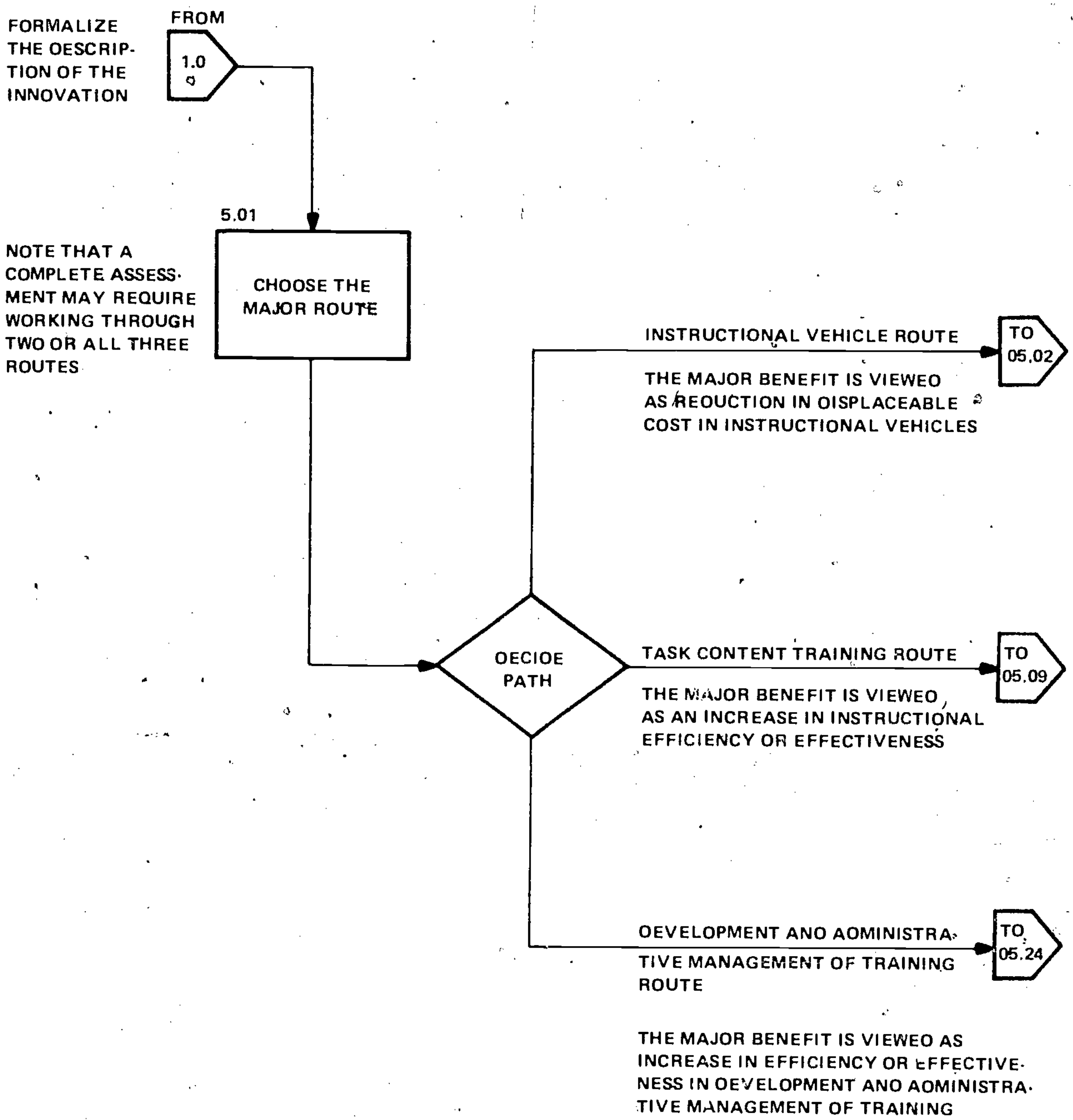
2. Create a tickler file entry which reflects an estimated date where risk from identified problem areas may be reduced so that the proposed innovation may now be acceptable.

RATIONALE

One of the objectives of the ETAM procedure is that information not be lost either because of summarization exercises or due to a gap in evaluation or implementation of the proposed innovation. Changing conditions may create conditions where application of the innovation appears more reasonable. It is important that a system of estimating the time at which these conditions may occur, and a system of forcing visibility of the proposal at that time, be instituted. This procedure, while seemingly trivial, is intended to prevent loss of perhaps valuable data.

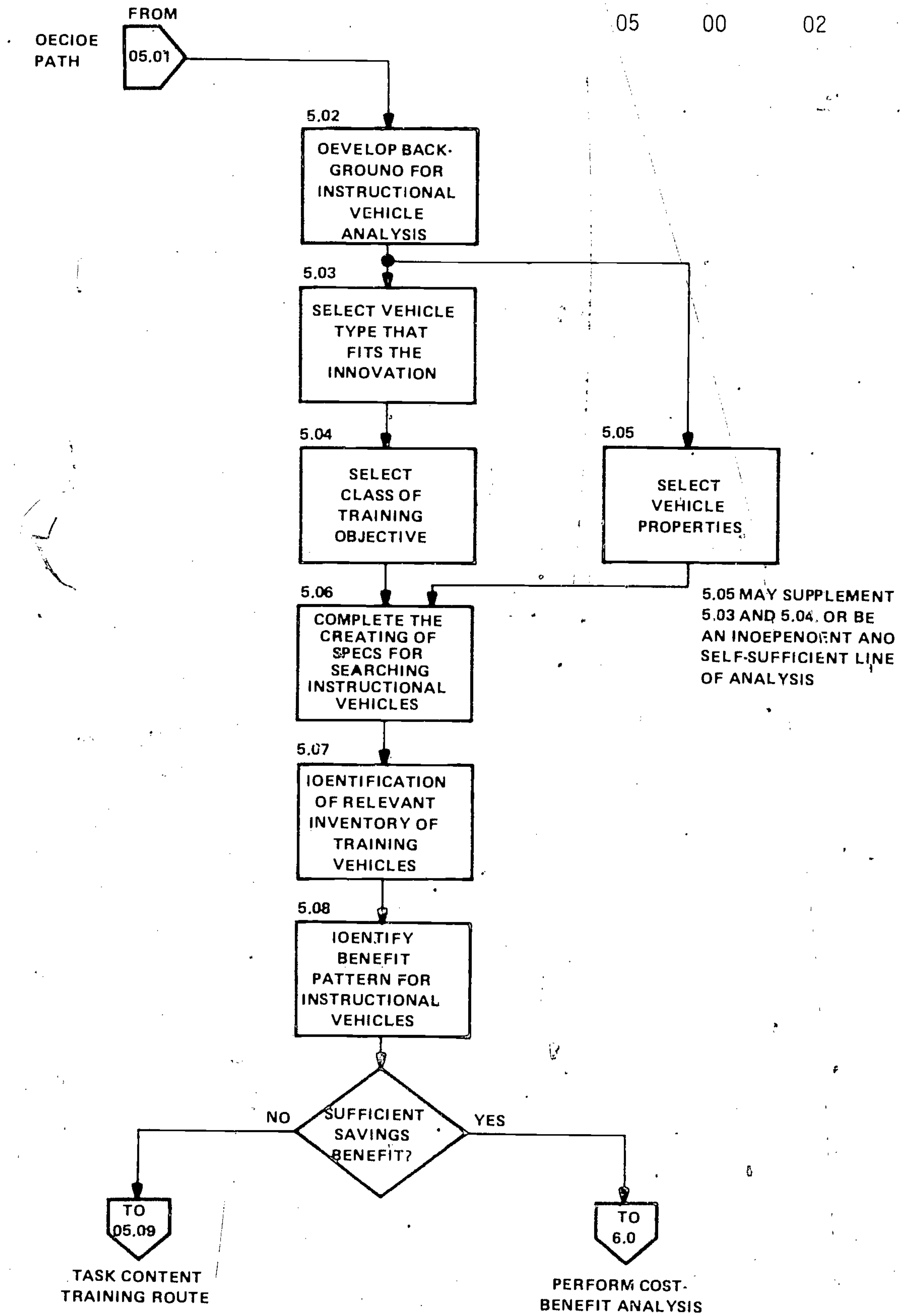
TASK: DETERMINE RANGE-OF-EFFECT

| TASK | SUBTASK | PAGE |
|---|---|---|
| 05 | 00 | 01 |



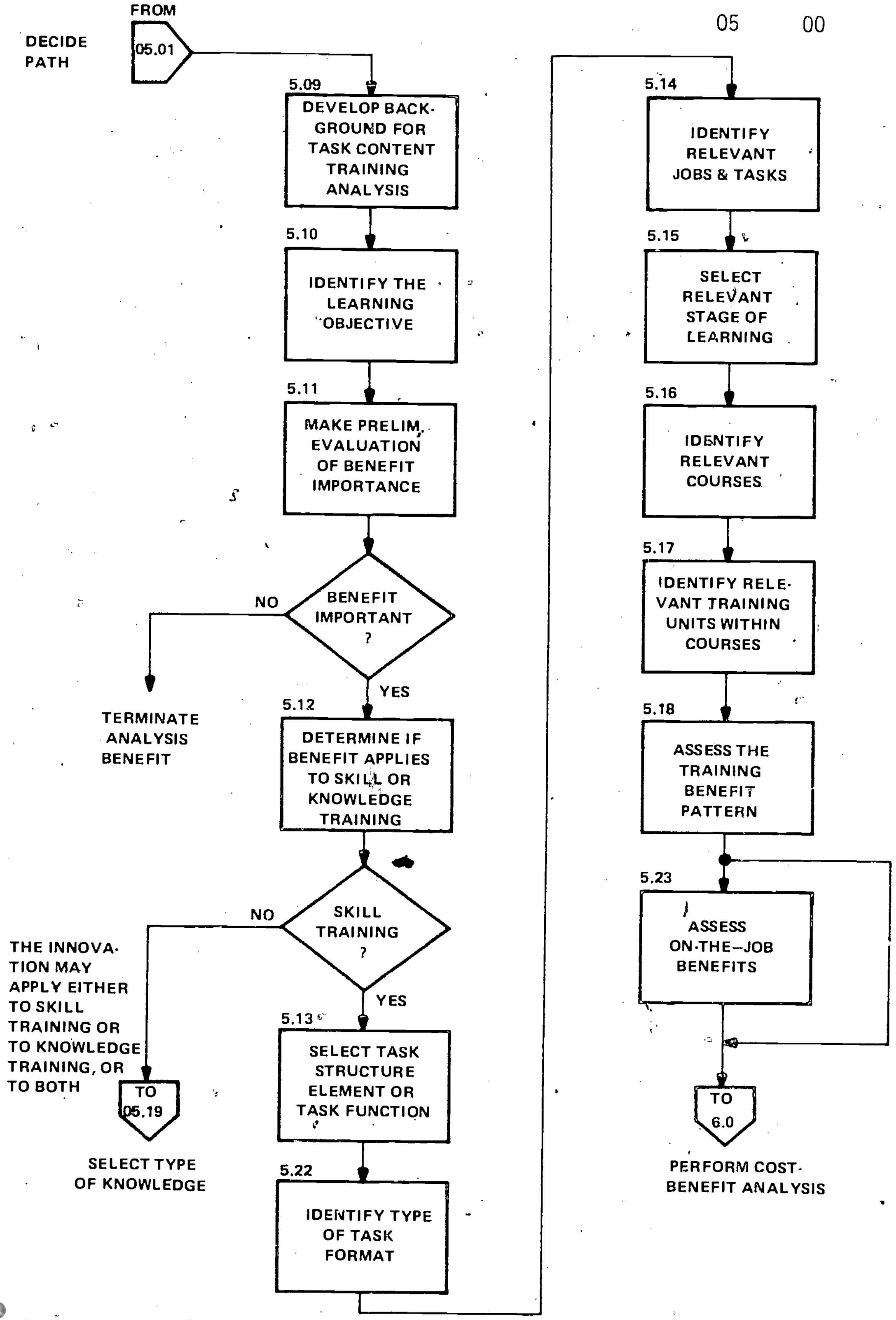
INSTRUCTIONAL VEHICLE ROUTE

| TASK | SUBTASK | PAGE |
|---|---|---|
| 05 | 00 | 02 |



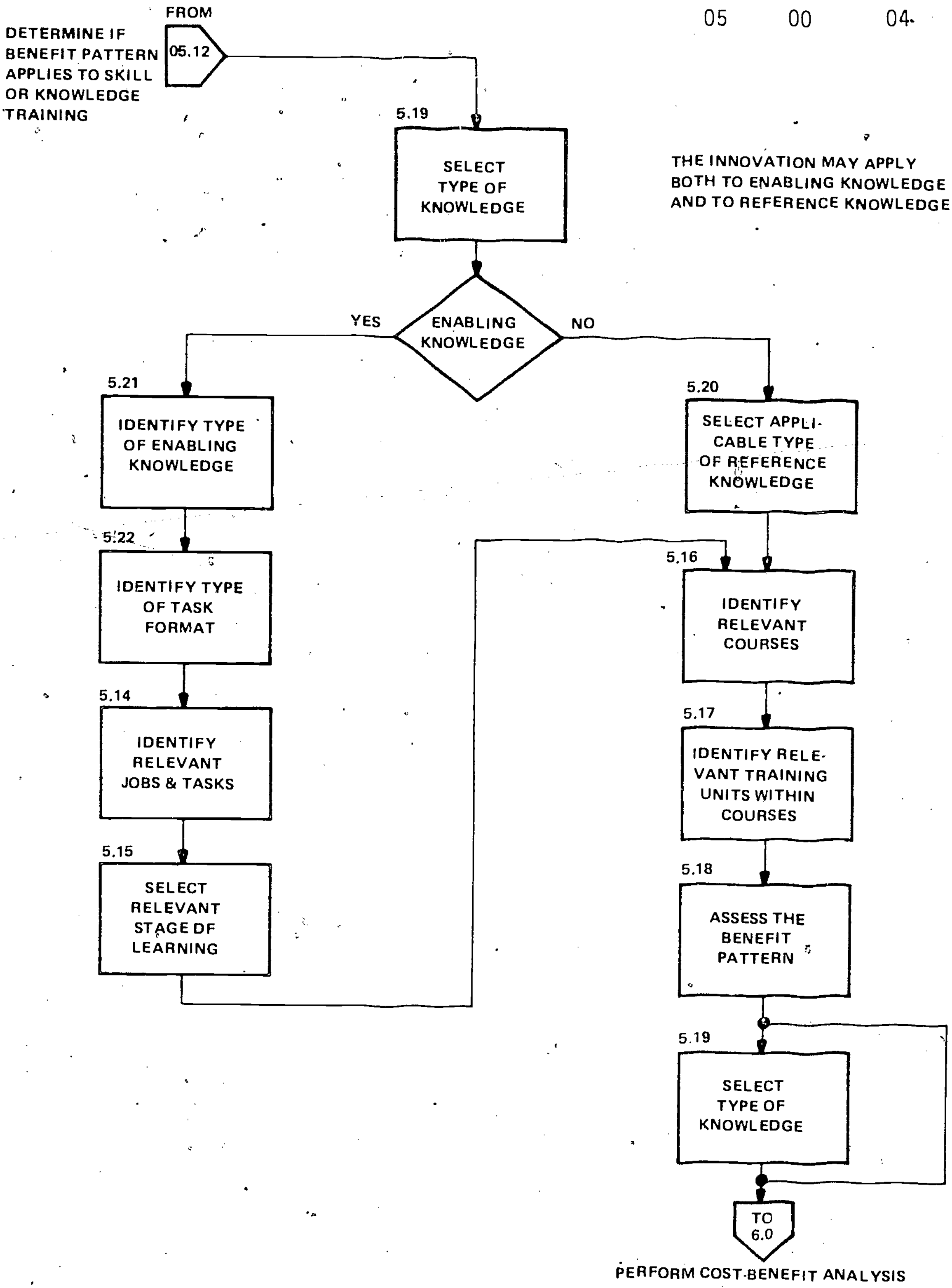
TASK CONTENT TRAINING ANALYSIS ROUTE: SKILLS

| TASK | SUBTASK | PAGE |
|---|---|---|
| 05 | 00 | 03 |



TASK CONTENT TRAINING ANALYSIS: KNOWLEDGE

| TASK | SUBTASK | PAGE |
|---|---|---|
| 05 | 00 | 04 |

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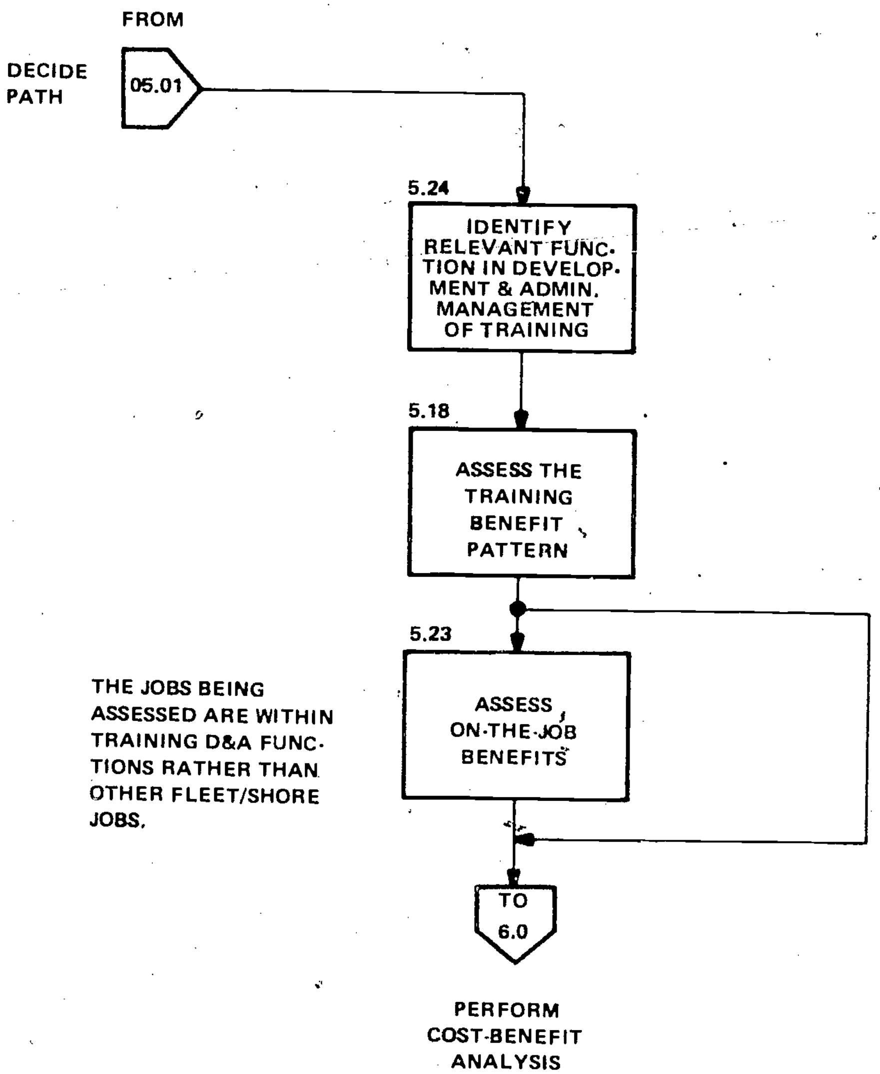
DEVELOPMENT AND ADMINISTRATIVE MANAGEMENT OF TRAINING ROUTE

| TASK | SUBTASK | PAGE |
|---|---|---|
| 05 | 00 | 05 |



TASK: DETERMINE RANGE-OF-EFFECT

This is likely to be the most important and difficult task in the entire procedure. Its general purpose is to determine the full range of potential applicability of an innovation in training, operations, and in the personnel subsystem. These effects may consist of job performance and training objectives for which "benefits" are yielded. The effects may also be potential savings of displaceable dollars, time, level of talent required for instructional function, or other cost element. The latter will be called "costs and cost analysis". Where possible a benefit in achieving a training objective (a knowledge or skill) will be translated into training cost savings.

The scope of range-of-effect consists of many factors, concepts and operations. Simplifying maps may be misleading if taken literally or as complete in themselves. Nevertheless, the reader is given several levels of abstraction for Task 5:

The schematic diagram of major procedural functions that is presented at the head of this chapter.

The listing of subtask names which immediately follows these introductory paragraphs.

The listing of subtasks and variables and categories within each subtask: this list follows the subtask name listing.

The explanatory descriptions of subtasks and categories within subtasks that make up the body of Task 5.

An Appendix A which treats in analytic detail some of the key characterizations in the main text of Task 5.

The reader is not advised to use the contents of the first three items above as self-sufficient either for critiquing or for using the Range-of-Effect procedures.

The quantitative objectives in determining range-of-effect in the results of training can be expressed in student training hours to achieve a training objective, minimum levels of student aptitude requirements, attrition rate, and level of student performance. These variables are not independent of each other, so assumptions must be made as to which will be fixed, and which will be varied for assessment purposes. By determining the range of jobs and tasks relevant to the innovation, the range of courses and numbers of students can be identified.

A second class of quantitative objective is the determination of displaceable costs which the innovation might achieve in the Navy's inventory of instructional vehicles, including instructors, or to displaceable costs in training development and management functions.

The range-of-effect procedures consist of two major parts. One part consists of classificatory terms from which the assessor can select descriptors which fit the innovation, and which can be used to search the data base of jobs and job tasks, courses and course objectives, instructional vehicles, and their properties. The results of the data base searches, when checked by the assessor, represent the full pattern of students, courses, instructional operations, vehicles of delivery, and other elements to which the benefits and cost advantages, if any, of the innovation could appropriately apply.

Note that the "data base" may exist in the head of the assessor and his associates, on paper documents, or in computerized files for selective access.

Subject matter search terms are never completely exhaustive or unambiguous. Human judgment finally determines whether the search operation has indeed made a useful match between the two entities described; the properties of the innovation and the properties of the entity to be matched with it. Even though two descriptions may match each other, the objects denoted by the search may, when examined in their fuller contexts, have important differences that override their similarities. The user should be aware of the limitations of words in describing things.

After identifying the list of entities to which the innovation has potential relevance (courses, job tasks, aptitudes or instructional vehicles, or training development and administrative functions), the second major activity for the assessor is to assign magnitudes of benefit likely to be conferred by the innovation. He also indicates the likelihood of achieving the benefit by giving an expression of confidence to his magnitude estimate. If the innovation offers several kinds of benefit, he rates the relative importance of each. The assessor also identifies and evaluates secondary benefits to be expected of the innovation, and liabilities which its adoption might bring about.

The formats on which the assessor develops all of the information in this task are intended to serve as procedural aids to him. They also transmit the data he generates into the cost analysis and business assessment operations that lead to an assessment outcome.

Because the assessor must select his pathway through range-of-effect analysis by knowing what is ahead of given choice points of route, he must have a good working knowledge of the entire classificatory scheme in this task. Arriving at a description of the application potential of the innovation is inductive and insightful as well as deductive. For this reason, some major subtasks consist of activity called "orientation" which is the learning of information context necessary to select other subtasks.

| SUBTASK | REFERENCE |
|---|---|
| 1. Choose the major route for determining range-of-effect | 05.01.01 |
| 2. Develop background for instructional vehicle analysis | 05.02.01 |

| | | REFERENCE |
|---|---|---|
| 3. | Select vehicle type that fits the innovation | 05.03.01 |
| 4. | Select class of training objective | 05.04.01 |
| 5. | Select vehicle properties | 05.05.01 |
| 6. | Complete the creating of specifications for searching the instructional vehicle inventory | 05.06.01 |
| 7. | Identification of relevant inventory of training vehicles | 05.07.01 |
| 8. | Identify benefit pattern for instructional vehicles | 05.08.01 |
| 9. | Develop background for task content training analysis | 05.09.01 |
| 10. | Identify the learning objective | 05.10.01 |
| 11. | Make preliminary evaluation of benefit importance | 05.11.01 |
| 12. | Determine if the benefit applies to skill or knowledge training | 05.12.01 |
| 13. | Select task structure element or task "function" | 05.13.01 |
| 14. | Identify relevant jobs and tasks | 05.14.01 |
| 15. | Select relevant stage of learning | 05.15.01 |
| 16. | Identify relevant courses | 05.16.01 |
| 17. | Identify relevant training units within courses | 05.17.01 |
| 18. | Assess the training benefit pattern | 05.18.01 |
| 19. | Select type of knowledge | 05.19.01 |
| 20. | Select applicable type of reference knowledge | 05.20.01 |
| 21. | Identify type of enabling knowledge | 05.21.01 |
| 22. | Identify type of task format | 05.22.01 |
| 23. | Assess on-the-job benefits | 05.23.01 |
| 24. | Identify relevant function in development and administrative management of training | 05.24.01 |

TOPICAL OUTLINE OF RANGE-OF-EFFECT

This listing should serve as a topical guide to the content of Task 5, and after knowledge of the item definitions and descriptions in the main text which follows, as a kind of checklist. The subtasks are sequenced by logical order rather than by procedural order so as to avoid redundancies.

05.01 Choose the major route for determining range of effect

Instructional vehicles
Task content training
Development and administrative management of training

INSTRUCTIONAL VEHICLES

05.03 Vehicle types

Instructor
Static graphics
Animated graphics
Static physical models
Procedural trainers

Symbolic
Physical mockup

Task simulators

05.04 Class of training objective

Reference knowledge
Knowledge -- task specific and enabling
Task-skill formats
Skill training

05.05 Vehicle properties

Instructional functions:

Type of stimulus presented to student

visual
auditory
kinesthetic
tactile

Type of content displayed

text-verbal
diagrammatic
representational

abstracted pictorial representation
pictorial representations
physical representations

Type of presentational sequence

library of frames or items
presentation sequence not applicable
fixed sequential frames or items
random selection of frame sequences
dynamic change of content within frame

Selection source for sequencing

internal program
instructor
student choice
student performance
combinations of the above

Type of external control operated by student

not applicable directly
artificial or symbolic response by student
representational response by student

by symbolic selection
by dummy control activation

task-manipulative response

non-dynamic in time and force
dynamic and interactive

Feedback presentation logic

not applicable
selects next stimulus item or sequence
gives evaluation of preceding response
selects and presents guidance information

Response evaluation logic

not internal -- depends on instructor evaluation
evaluation limited to student's immediate response
evaluation extended to a set of student responses
tolerance limits on acceptable student response

fixed
variable

Utilization functions:

Programmability, and control of device operation
Portability, including storage
Multiple usage
Set up and operating simplification
Maintenance simplification; dependability
Updatability in instructional function
Combining instructional functions
Modularization of training content
Direct translatability from a requirement to training decisions and programming of training content

Supplemental training functions

Extended range of control of learning conditions
Extended range of subject matter for practice
Extended range of task functions trained
Instructor roles facilitated

TASK CONTENT TRAINING

05.13 Task structure element or task function

Goal projection
Scan-detect
Identify
Interpret
Procedure following
Decide
Construct-plan
Track
Motor performance
Interpersonal interaction
Recall task-cycle information
Recall enabling information

05.14 Relevant Jobs and Tasks

Gross job categories

Operations
Maintenance
Service
Command

Objective task variables

Equipment and objects used
Environments in which is task performed
Tools used
Reference information used in performing task
Task operations ("task structure elements")
Criteria of task performance

05.15 Stage of Learning

Orientation and familiarization
Task nomenclature (identifications, locations and names, facts, rules)
Task formats at the conceptual level
Procedures learned at the verbal level only
Performing task components with guidance
Doing the entire task/job procedurally: barely acceptable mastery
Highly proficient task/job performance in work context
Unusual task conditions
Performing job/tasks at key man level
Refresher learning

05.19 Type of knowledge

Reference
Enabling

05.20 Reference knowledge

System purposes
Organizational roles
Contexts of operation
Organizational rules and constraints
Non-work directed content

05.21 Enabling knowledge

Operational goal criteria
Nomenclature, identification and location of work objects
Procedure descriptions
Job relevant facts

05.22 Type of task format

Procedure formats
Decision formats
Construction formats

05.18 Benefit pattern in training: variables

Training time reduced
Aptitude level reduced
Attrition level reduced
Performance level increased, extended

05.23 Benefit pattern on-the-job

Greater flexibility in assignment
Less on-the-job training to acceptable performance
Higher productivity levels, and better quality, fewer errors
Greater range in work competence
Willingness under stress
Higher level of self-initiated and self-directed activity

DEVELOPMENT AND ADMINISTRATIVE MANAGEMENT OF TRAINING

05.24 Development and Administrative Management of Training

Capture and description of skill and knowledge requirements
Matching the skill requirement with descriptions of available resources in skills, aptitudes to learn
Matching the skill requirements with available training resources
Developing training requirements from skill requirements descriptions
Selecting the training environments
Slow vs. fast-paced development of training material
Selection or devising of training modules
Selection of instructional vehicles and media
Designing the content of instruction
Devising selection procedures for students
Assessment of the student
Assignment of graduates to job positions
Evaluation on the job
Career development
Administrative planning and control
Evaluation of learning or entropy of the training system

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: CHOOSE THE MAJOR ROUTE FOR DETERMINING RANGE-OF-EFFECT

There are three major routes to be followed for the assessment of the innovation. Following one route does not exclude the possibility of using elements in another route. The alternatives are:

- Instructional Vehicles. The basis for choosing this alternative is that the innovation aims primarily at reducing a cost in the development or use of an instructional vehicle while maintaining a level of function equivalent to the vehicle (or vehicle property) displaced by the innovation. The choice of this route leads to Subtask 05.02, Develop Background for Instructional Vehicle Analysis.
- Task Content Training. This analytic route is chosen if the innovation is directed primarily at increasing the effectiveness or efficiency of instructional processes that may result in shorter training time to achieve a type of training objective, lower aptitude requirement, lower attrition rates, or a higher level of learned performance. The choice of this route leads to Subtask 05.09, Develop Background for Task Content Training Analysis.
- Development and Administrative Management of Training. These are functions that deal with the information interfaces to and from training, such as training requirements input or graduate competence descriptions as output. Others deal with such factors as space; selection of instructional media, development of training course content, and administrative control. At the present stage of formatting these processes, an innovation dealing with any one or more functions must be restricted to showing one or more kinds of cost advantage compared with the reference conditions against which the innovation is to be evaluated. This choice leads to Subtask 05.24, Identify Relevant Function in Development and Administrative Management of Training.

PROCEDURE

1. On the basis of applying the description of the innovation prepared in Task 1 to the considerations above, select at least tentatively, the route for assessment of potential benefits from the alternatives:

    Instructional Vehicles
    Task Content Training
    Development and Administrative Management of Training.

2. If the information provided in Subtask 05.01 is insufficient for making this choice, the assessor should study the descriptive and analytic content in all subtasks in Task 5, and then make his choice of route for analysis.

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: DEVELOP BACKGROUND FOR INSTRUCTIONAL VEHICLE ANALYSIS

DESCRIPTION

Instructional vehicles range from a printed page of instructions through human instructors and to the actual work objects and tools -- combined with the learner and the work environment. This range defies any simple classification of instructional vehicle types, purposes, functions, or characteristics.

Determining range-of-effect of an innovation through the route of instructional vehicle characteristics should be based primarily on the following condition: the innovation is intended to reduce or displace existing or expected costs on an existing or planned inventory of instructional vehicles. The cost reduction assumes no loss in training benefit, and is not to be evaluated primarily on an increase in the training benefit. Thus, the substitution of digital computers for analog computers in complex simulators is likely to be based primarily on cost comparisons and cost generalizations rather than on training outcome benefits. When the innovation is directed primarily to an increased training benefit, the assessor should generally choose the Task Content Training Route (05.09) for determining the innovation's range-of-effect.

The purpose to be served by a classificatory system for instructional vehicles is to provide a set of descriptors for linking the innovation to the appropriate subset of training vehicles in the entire Navy inventory of training vehicles. Thus, if a grossly cheaper way of programming dynamic three-dimensional representations on two-dimensional displays is the proposed innovation, one wants to identify all items in the inventory that have visual displays that present or simulate three-dimensional motion. Potentially relevant vehicles may not be restricted to complex training simulators; they could also apply to knowledge trainers that instruct in principles of mechanical motion, or to perceptual trainers for the scanning, detection, and identification of terrain information.

The assessor has two major routes for identifying the relevant training vehicle inventory. He should look ahead beyond the choice point and see if any descriptors in either of the routes make a good first order fit. If so, that is the direction he should take, at least at the start.

PROCEDURE

1. Become familiar with the conditions for selecting the instructional vehicles route for determining the range-of-effect for the innovation.

2. Read the description of the innovation given in Task 1.

3. Examine the terms in the listings under Subtasks 05.03, Select Vehicle Type, and 05.05, Select Vehicle Properties. Some one or combination of these terms may suggest a direct way of describing the innovation for searching the instructional vehicle inventory.

4. Do not be limited to the description of the vehicle by any terminology, however. If there are other terms which can more quickly and comprehensively identify the inventory items, use them.

5. If the innovation is, <u>without doubt</u>, limited to an already identified piece of equipment, or a medium used in a given way, it is unnecessary to go through an elaborate search operation. Go directly to Subtask 05.05, Select Vehicle Properties. It is possible, however, that the innovation, either as a device or as a construction principle, may be applicable to a class of vehicles with which the assessor is not familiar. The data base search on selected descriptors would then be a safe bet.

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: SELECT VEHICLE TYPE THAT FITS THE INNOVATION

DESCRIPTION

A vehicle is anything that performs instructional functions; for purposes of the present analysis, this includes the instructor. The innovation may apply more of less equally to all members of a given type of instructional vehicle; for example, interpersonal skills in instructors, or a device for creating, storing, and indexing microfiche and other images. The fastest means of locating the relevant inventory is to use the broadest name that covers the range, subsetting with qualifying terms if the preliminary results of the data base search yield too many irrelevant hits.

The names in the list of vehicle types cited below should be understood in terms of the definitions cited in the text under PROCEDURE. Each of the terms cited may have somewhat different meanings outside of the present context. Many of the distinctions made here among the types are primarily derived from the set of "Instructional Functions" listed under Subtask 05.05, Select Vehicle Properties.

The major vehicle types consist of:

- Instructor
- Static graphics
- Animated graphics
- Static physical models
- Procedural trainers
    - Symbolic
    - Physical mockup
- Task simulators.

PROCEDURE

1. If the innovation has to do with all members, or a large subset of members, of any one of the following types of instructional vehicles, select the term to which the innovation applies.

    - The Instructor. Innovations may be directed towards improvements in the selection, training, assignment, motivation, and turnover of instructors. The "improvement" should be assessable in terms of reductions of the norms against which the innovation is targeted. Less training time to achieve a given instructional competence is directly measurable. An innovation

that enables, with the normal training time and cost, an instructor to teach a greater variety of courses must be more indirectly assessed in terms of probable dollar value of the capability in the expected training environment. If instructor versatility is expected to reduce instructor turnover rates, the expected reduction of rate (and its probability) will have to balance against the tangible values in reducing that rate.

The assessment picture may include estimates of intangible factors such as "instructor satisfaction" or "instructor interest in what he is teaching", but should be identified as intangibles -- not because that makes them unimportant, but to identify their intangibility.

The instructor is, or should be, the key instructional vehicle in the entire training establishment. He, therefore, justifies large efforts to make him effective in his varied teacher roles. But he may also be the target of many well-meaning, poorly worked-through and inadequately tested innovations which, had they been assessed on tough-minded criteria, would quickly have been disregarded. It is because the instructor is vulnerable to many "innovative" influences, most of which may be distractors to him, that assessment screenings can be useful to him as well as to the establishment.

The instructor presents information by words, chalkboard diagrams, gestures, and sometimes by demonstrating task performance literally or symbolically. In the classroom he is effective primarily in teaching concepts, principles, strategies, and aspiration goals. He is comparatively inefficient in drill on material learned by repetitive practice (rote), such as facts, rules, nomenclature, perceptual discriminations, and classifications. When teaching task skills he may have limited instructional value as a model to copy or emulate in performing the task. He may have great value in responding to individual differences among students (if he has this sensitivity) and tailoring aspirations and practice content for the student. He may focus or expand student attention while engaged in task practice, provide supplementary task cues, and supplement normal task feedback with interpretive feedback -- relating specifics of what the student did or failed to do that resulted in a good or a poor outcome.

Both his efficiency and effectiveness as an instructor depend on the goodness of his implicit process model of the task, his awareness of the kinds and stages of learning, and knowledge of the individual learning characteristics of the student. The instructor can serve as a human model in the establishment of positive attitudes.

- Static Graphics. A static graphic is a display on a page or screen of a content that does not move. Text, pictures, diagrams, maps, and lists fall into this category. Books, charts, foils and overlays, slide projectors, and microfiche, are devices in this category.

The training objectives for these devices tend to be limited to the acquisition of reference knowledge and in some cases to enabling knowledge. The latter is true where the target skill is symbolic, such as interpreting the symbols on a terrain map, but in these cases there must be supplemental instructional functions brought to bear.

Developmental and production cost for graphic aids is notoriously high at ordinary commercial rates. For example, an invention that would enable individuals, after a few minutes of training, to create the content and control the process for generating an ordinary colored slide would have an average $30 to $40 commercial cost per slide as a displaceable target.

Other cost factors on static graphics include storage and retrieval. An instructor may often prefer to make a new graphic rather than spend the time and effort required to find an existing one that might have served the purpose.

- Animated Graphics. These are graphics that present the appearance of motion in the content displayed. Television, the motion picture and the computer-generated display are examples. (There is an important sense in which the image being drawn by the instructor on a blackboard is an "animated graphic", although its completion makes it a static graphic.)

  Animated graphics may transmit concepts of serial dependencies, process sequences, and time dependencies. As such, they may contribute to reference knowledge. They may be task-specific and enabling if they provide a mnemonic structure for the later learning of task procedures, or for the generalizing of task procedures to a variety of work situations not immediately apparent to the student. In order to be useful, the mnemonic structure must parallel the structure of what is to be learned as a task skill.

  Animated graphics may be pictorial or diagrammatic. Both are commercially expensive to create, the diagrammatic ones far more so than the pictorial. Computers have been programmed to develop graphic sequences on a display tube that may be less expensive than sequences developed manually. The Walt Disney studios have an extensive technology for creating animation effects.

- Static Physical Models. A physical model is a three-dimensional representation of objects. Such representations are often called mock-ups. Their demonstration effect as a value to training may be questioned, although they may offer a kind of reference knowledge. A demonstration model of a variety of fighter airplane cockpits may present similarities and differences among them. Three-dimensional representations need not be life size.

A physical model may be used to teach a "task-specific enabling knowledge" by providing instruction on nomenclature and locations of work objects.

These devices are generally expensive to build, costly to store, and used only briefly in the student's learning scenario.

- Procedural Trainers. Procedural trainers not only present the student with a display of information, but enable him to make (1) actual or (2) simulated task responses with the device with a feedback representation. Procedural trainers may provide direct practice in a cognitive skill. An example would be training in the cognitive aspects of troubleshooting, or in the planning of a military action. The procedural trainer may instruct in the symbolic representation of a nontracking perceptual-motor task, such as the verbal sequence that describes the actions to take in shutting down a particular type of power plant in a vessel. The latter would be an example of instruction in a task-skill format as represented by the student's ability to give a verbal description of the procedure, or to simulate the steps in the procedure in the physical task environment.

Procedure trainers may be physical representations of the task environment. The controls operated by the student may simulate actual functions, or act merely as dummy controls, or have a variety of feedback cues that range between these extremes. There is some growing evidence, and psychological theory, which shows that the physical fidelity of control response in the learning and generalization of most procedures may be very low, at least through the early and middle levels of task learning where extensive practice is required for "learning what to do next" with a high degree of reliability.

Where performance data are collected, the large percentage of human errors are always assigned to "failure to follow standard operating procedure". These findings imply, among other things, inadequate practice by students on procedures as such, and inadequate practice of procedures in full work context if the latter may interfere with recall.

The kinds and amounts of physical fidelity that are necessary and sufficient for various classes of procedure training are poorly understood, and practices used in designing training vehicles for procedure training is largely ad hoc. But because the costs of physical fidelity are high, and because students should have massive amounts of practice in order to acquire reliable procedural skills, the opportunities for innovations leading to large cost reductions in overall training are perhaps greater in this field than any other except in the determination of what is relevant to teach and learn.

Evaluations of innovations in procedural trainers should take into account the Stages of Learning analysis (Subtask 05.15).

Factors applicable to most procedural trainers are identified under Select Vehicle Properties (Subtask 05.05), which may be used to further refine the relevant description of the innovation.

- Simulators of Operational Devices. These devices have "realistic" physical or psychological fidelity to the work task situation. The controls used by the operator, and control feedback and other features, are intended to make the student respond as if he were performing in the real-life situation. The device may also contain a variety of sensors and interpreters of student response for evaluation and control of exercise content presented to the student.

Because simulators are expensive devices to develop, program and operate, there are many opportunities for displaceable dollars. The relationship of kind and degree of fidelity of physical simulation to transfer of training is a key cost factor. Fidelity of stimulus input is an especially sensitive cost which is understood abstractly, but in the specific case must generally be solved by ad hoc inquiry and expensive experimentation.

Unfortunately, the high cost of simulators tends to restrict the number of practice hours it is feasible to give individual students. Some attention has been directed towards the use of less costly "part task trainers" to achieve part skills and lower learning levels of skills. A major innovation would consist of a systematic set of practical guidelines that would specify criteria of minimum physical simulation requirements for given classes of tasks, stages of learning, and degree of task integration. The formulation of such guidelines would necessarily rest on a theory of transfer of training at varying levels of learning in various perceptual, cognitive, and perceptual-motor tasks.

Simulators are also used to evaluate and check out the competence of students who are at or near operational levels of performance. It is unclear whether a simulator that is used for evaluation requires any properties that differ from those needed for high level training. It is assumed that the purpose of the evaluation here is that of qualifying or disqualifying the student from readiness to perform on operational equipment.

The assessment of innovations in this class of device should take realistic account of the effect of training management, instructors, and students on the training effectiveness of the device. It is well known that if an instructor dislikes the training device he is required to use, the student will also tend to dislike or distrust it, with a corresponding inadequacy in its potency for learning. This could mean that a productive innovation might consist of a means of inducing favorable attitudes towards effective training devices that may fail to evoke favorable attitudes from teacher and student.

All of the vehicle properties listed in Subtask 05.05 apply to simulators. After identifying that the innovation applies roughly to simulators, use the vehicle properties listings to further refine the characterization.

2. If the vehicle type appropriate to the innovation does not appear by name in the preceding list, search Instructional Functions in Subtask 05.05. For example, a trainer to identify and interpret auditory signals would not be represented in the above list. Trainers in the vehicle inventory with this property would be identified by searching under 05.05, Instructional Functions: type of stimulus: auditory.

3. Assemble the descriptor names that fit the innovation and retain them for use in searching the data base of the instructional vehicle in order to determine those items in the inventory that are appropriate to the innovation.

4. If the innovation deals with a type of vehicle but is restricted to a class of training objective, a two-stage description and search will have to be made. The second stage that restricts the innovation to a given set of training objectives will be treated in Subtask 05.04, Select Class of Training Objective.

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: SELECT CLASS OF TRAINING OBJECTIVE

DESCRIPTION

It is desirable to determine the widest potential applicability of the innovation to instructional vehicles because the economies of scale may transform a minor contribution to one of major importance. But the application of the innovation may have to be qualified within a vehicle type by several factors. It may be restricted to a given class of training objective, although extensive to all examples within that objective. The innovation may also be limited to a class of instructional environment; thus slides require a slide projector and this may imply a space requirement that limits its range of application.

The types of training objectives listed below are general, and intended only to suggest a training context. This level of descriptors, when added to the vehicle type descriptor, may be adequate to search the instructional vehicle inventory list and yield a reasonable range of candidates for manual culling.

PROCEDURE

1. Select the one or more descriptors which, by exclusion of the other descriptors in the set, properly restricts the range of applicability of the innovation.

   - Reference Knowledge (see definition in Subtask 05.20).
   - Knowledge-Task Specific and Enabling (see definition in Subtask 05.21).
   - Task-Skill Formats (for definition see Subtask 05.22).

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: SELECT VEHICLE PROPERTIES

DESCRIPTION

Assume that the choice has been made to identify the applicable instructional vehicles in the vehicle inventory by the specification of instructional function or utilization function. Presumably, the innovation represents a functional capability that is fairly independent of the kind of training content which the vehicle instructs.

The following list of Instructional Functions is not arbitrary. It is a fairly complete and definitive set of functions for control of the teaching and learning processes. Some instructional vehicles may in themselves contain only several of these functions. A graphic aid such as a chart, in itself, is characterized only by a visual stimulus and a given type of content such as a "flow diagram". In this case, the remaining functions in the list of instructional functions must be performed manually by teacher and student.

The second list, Utilization Functions, cannot claim equivalent comprehensiveness, and might potentially have to be supplemented. Almost certainly a Utilization Function would have to be combined with other descriptors, such as Instructional Function or type of vehicle (Subtask 05.03), in developing a usable search argument to apply to a vehicle inventory listing.

PROCEDURE

1. After examining the description of the innovation, select one or more of the instructional functions listed below to which the innovation applies. Set down both the name of the function (such as "Type of stimulus presented to the student") and the item or characteristic listed under that function which applies to the innovation (such as, for example, "auditory"). If no item in this list applies, examine the list of Utilization Functions in Step 2.

   INSTRUCTIONAL FUNCTIONS

   - <u>Type of stimulus presented to student</u>

     Visual -- for example, the display of simulated landing strip; or a flowchart diagram; or printed text.

     Auditory -- examples, simulated sonar data; sounds of defect in moving mechanical assembly; voice transmission through noisy channel.

     Kinesthetic -- examples, control force in aircraft stick and rudder; torque applied to a bolt; the feel of a potentially broken human limb.

Tactile -- examples, smoothness of surface of a mechanical bearing; conducted temperature to junctions adjacent to one being soldered; texture of a type of cloth.

- Type of content displayed

Text - verbal -- examples: continuous text; formatted text as in job instructions; text in tabular format.

Diagrammatic -- examples: flowcharts; PERT diagrams; histograms; logic charts; decision tables; schematics.

Representational

Comment: Representation, as applicable to instruction, covers a wide range of kind and degree. The topic is often in the context of simulation fidelity where transfer of training value and costs have complex interaction and tradeoffs. As defined here, a "representational" display is one which has some degree of isomorphic identity with the physical appearance of real-life task objects and situations. The classification here, as elsewhere in this section, is based on what the student sees, not on how the material displayed to him is generated. The following three items roughly cover the range of representational formats.

Abstracted pictorial representation: example -- a landing runway displayed only as a rectangle in changing perspective and size for training in aircraft landings. Secondary cues such as terrain, buildings or other structures, are not presented, but the shapes of the rectangle correctly simulate the appearance of runways under different landing conditions. In other training contexts, the silhouette of aircraft types or types of ships would be abstracted pictorial representations.

Pictorial representations: images of actual appearances of objects and situations such as projected by motion picture cameras, photographs or realistic drawings.

Physical representations: examples, the actual work object itself, or three-dimensional mockups.

- Type of presentational sequence

Library of "frames" or items -- the creation of a library serving as a source of instructional material, but where the items as stored in the library have no inherent sequentiality.

Presentation sequence not applicable to vehicle -- as for example, the physical model of a device, or a cutaway model.

Fixed sequential frames or items -- for example, the standard Kodak carousel, or slide film, or a continuous motion picture.

Random selection of frame sequences -- sequence may be conditional on choice of user or program, or based on student response such as in branching type of computer assisted instruction.

Dynamic change of content within frame by display attributes or variables -- as is typical of computer controlled simulators where altitude indication may change independent of airspeed indication, or the elements in a display of a simulated display may remain constant but change with respect to simulated point of regard.

- Selection source for sequencing

Internal program -- for example, a computer program, the operation of which selects a next frame or item where the selection is based on student response to a problem presentation; or a fixed mechanism for advancing each next frame in fixed sequence.

Instructor -- selects what will next be presented to the student either as a specific item or a sequence of related items.

Student -- selects next item of presentation by voluntary choice.

Student performance -- the outcome of the student's response to a learning item determines what next item will be presented to him.

Combinations of the above four items.

- Type of external control operated by student (relevant to task operations)

Not applicable directly -- for example, because the instructional function of interest is not linked to a student's response.

Artificial or symbolic response by student -- such as when the student selects from multiple choice options presented verbally.

Representational (semirealistic) response by student:

By symbolic selection -- as by pictorial display of control switches keyed to an answer sheet.

By dummy control activation -- physical switches and other controls manipulated by student, but which are not operational.

Task-manipulative response:

Nondynamic in time and force with respect to changes that take place in the presentational display of the task.

Dynamic and interactive fidelity (to some degree) in time and control forces with display change.

- Feedback presentation logic

Not applicable to the issue being investigated.

Selects next stimulus item or sequence -- what is next presented to the student depends upon an evaluation of the student's response.

Gives evaluation of preceding response to student -- the instructional vehicle presents the student with information that to some degree critiques his response or set of responses. This may range from "right" or "wrong" to an explanation of why the student's response was right or wrong or inadequate.

Selects and presents guidance information as well as problem data -- the guidance data presented is conditional upon the student's previous responses.

- Response evaluation logic

Not internal -- depends on instructor evaluation of student's response, or the student's evaluation of his response.

Evaluation limited to student's immediate response.

Evaluation extended to a set of student response, and/or to classes of student response -- for example, as in a debriefing of a simulated mission where the student's general strategy is evaluated.

Tolerance limits on acceptable student response:

Fixed -- in terms of acceptable or non-acceptable response.

Variable -- such as dependent on amount of practice or stage of learning the task.

More than one of the foregoing instructional functions may apply to an innovation. Furthermore, the innovation may not necessarily apply to a mechanized function, but to human activities in the instruction/learning process.

The reader is reminded that the concern in the Instructional Vehicles section of determining range of effect of the innovation is directed towards displaceable costs by substituting the innovation for an existing or projected alternative. Where the training function is intended to have a benefit in what is learned by the student, the assessment should include the analytic route called "Task Content Training Analysis". It is this distinction which rules out such factors as student motivation, student aptitudes, learning efficiency from consideration in this Instructional Vehicles section.

2. Select one or more applicable Utilization Functions from the following list. Note that whereas innovations may improve the "convenience" of any of these functions in a device, it is generally possible to translate convenience into some kind of dollar value as a justification.

UTILIZATION FUNCTIONS

- Programmability and control of device operation.
- Portability, including storage.
- Multiple usage -- as of job aid as well as training vehicle.
- Set up and operating simplification -- requiring less ability and training time for the instructor to use effectively, or that enables the student to perform the operations.
- Maintenance simplification; dependability.
- Updatability in instructional function.
- Combining instructional capabilities heretofore distributed among several media/devices.
- Modularization of training content for more general applicability.
- Direct translatability from a format for describing job task requirements into training decisions and the selection or programming of training content and sequence. (This item is also treated in Subtask 05.24.)

Note that a Utilization Function in itself cannot be effectively used to search a data base of instructional vehicles. It will have to be combined with additional classificatory terms such as Vehicle Type and, very likely, subsets within Vehicle Type beyond the descriptors in the range-of-effect section. The device context of the innovation itself may provide more or less self-evident characterizations to be added to the search profile, or may point directly to the set of relevant vehicles to an individual with a general knowledge of the Navy's inventory of instructional vehicles. (For an exhaustive listing of media and instructional vehicles, see the report by Training Analysis and Evaluation Group (TAEG), A Technique for Choosing Cost-Effective Instructional Media, Appendix B; published April 1974.

3. Identify training functions that may be supplementary benefits to displaceable costs. These supplementary benefits will be useful in formulating the benefits picture for the innovation beyond the primary benefit of cost advantage. It should be understood, however, that a formal assessment of the innovation's value for an increased training benefit in generating knowledge and skill in students must go through task content training assessment as in Subtask 05.09.

TRAINING FUNCTIONS TREATED AS SUPPLEMENTAL BENEFITS TO DISPLACEABLE COSTS

- Extended Range of Control of Learning Conditions. Taking learning to a higher level of performance or expertise on a task or task-cluster. May be by enabling more practice on the same materials to become practicable, or by modifying presentation content and units and feedback, or modifying rate of action demand, or by fostering the integration of part-tasks already learned.

- Extended Range of Subject Matter for Practice. This can enable a skill to be generalized to the range of conditions encountered in real life, coping with contingencies, and adapting to environmental constraints and opportunities.

- Extended Range of Task Functions on Which Training is Given. For example, a device specialized for signal detection and identification becomes adapted to instruction on interpretation of the meaning of information patterns, or to coping procedures and strategies.

- Instructor Roles Facilitated.

  a. The instructor's capabilities may be extended for the purpose of sharpening instruction to the individual or group.

  b. Clerical requirements are reduced so that greater time and attention can be given to the teaching/learning process.

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: COMPLETE THE CREATING OF SPECIFICATIONS FOR SEARCHING THE INSTRUCTIONAL VEHICLE INVENTORY

DESCRIPTION

After following the procedures and using the descriptor listings thus far in describing the innovation as it might relate to items in the instructional vehicle inventory, it may be useful to look at the results with a view of adding commonsense to the search operation. For example, if the devices to which the innovation applies can be used only in classroom environments (and there are no formal descriptors which distinguish this kind of training environment), add the term to the search specification. The assessor should be careful, however, not to include a term in the search specification that will be improperly restrictive and will risk loss of a large portion of relevant devices along with the elimination of a few irrelevant ones. If the innovation is a promising one for whatever vehicles it applies to, the assessor is advised to follow the safe strategy of throwing out a wide net that may capture a fairly large portion of items that, on his manual inspection of the context descriptions of the device, he recognizes as irrelevant to the innovation and discards as candidates.

PROCEDURE

1. Organize and set down all descriptor terms that are relevant to selecting applicable candidates from the inventory of instructional vehicles, while rejecting those that are not applicable. The descriptors may be drawn from, but not exclusively from, those under Vehicle Type, Vehicle Property-Instructional Function, Vehicle Property-Utilization Function, and Class of Training Objective.

2. Check the descriptor set used in the data base that describes each entry in the listing of Instructional Vehicles for further clues as to relevant descriptors that will link the innovation to appropriate vehicles and exclude inappropriate vehicles.

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: IDENTIFICATION OF RELEVANT INVENTORY OF TRAINING VEHICLES

PROCEDURE

1. Run the search specification summarized in Subtask 05.06 against the data base of the complete inventory of instructional vehicles used by the Navy. The search operation will attempt to match the descriptors in the search specification with the descriptors of each item in the inventory list. Those that match will be presented as a listing to the assessor. Accompanying the name of each of these "hits" will be an abstract or summarized text description of the vehicle, plus a structured but detailed description of the vehicle. The output will (or should) include other data relevant to the benefits assessment to be made in the next step: quantity, range of usage, courses and course objectives used for, anticipated future demand rate, and various categories of cost.

   This output listing and accompanying contextual descriptions of the hits made by the search specification is only the first stage in developing a list of vehicles relevant to the innovation.

2. On the basis of a manual inspection of the context descriptions of the candidate vehicles in the output listing reject those that are inapplicable, and accept those that realistically fit the full characterization of the innovation.

3. Retain the listings of the relevant vehicles and the context data associated with each of them for Benefits Assessment, Subtask 05.08.

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: IDENTIFY BENEFIT PATTERN FOR INSTRUCTIONAL VEHICLES

## DESCRIPTION

The assessment of benefits in this path of analysis must be limited to determining the cost advantages or disadvantages of the instructional vehicle, or its property, to which the innovation is relevant.

There are two considerations in assessing the benefit pattern. One is the replacement of the instructional vehicle by another, which may be the innovated device where cost is the sole variable of interest. The second consideration is the potential benefit that may be obtained by using the innovation as impacting one or more of the Utilization Functions (Subtask 05.05).

## PROCEDURE

1. If the benefit involves the replacement of one vehicle type by another, and there are no benefits or liabilities associated with this replacement, then the benefit is restricted to the cost differential. No further analysis is required if the replacement does not have hidden costs.

2. If the innovation affects certain attributes of the vehicle for which benefits can be identified, the same process should be followed that is used in Subtask 05.18 by using the "Format for describing a supplementary benefit or liability."

3. If the benefit pattern of displaceable costs does not appear to justify acceptance of the innovation (which would permit going directly to Task 6) then additional benefits should be explored via the Task Content Training Route (Subtask 05.09) using the information collected in Subtask 05.04.

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: DEVELOP A BACKGROUND FOR TASK CONTENT TRAINING ANALYSIS

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DESCRIPTION

Assume that the innovation points to a more efficient or effective set of operations for producing a knowledge or skill which may be a training objective or an on-the-job performance capability. If the intended outcome can be related to existing training objectives, the benefit may be assessed in terms of a cost improvement. In this case, the evaluation would depend on the courses and student-hours affected by the innovation in the context of existing objectives on student performance levels.

If, however, the innovation points to performance benefits that go beyond existing training objectives, and no cost improvements can be demonstrated from the innovation, the analysis must be applied to job tasks in the Navy's operational milieu. If the innovation increases training costs, the estimated benefits of the added performance capabilities must be assessed as worth the added costs or not worth the added costs.

The following steps for determining, by means of task descriptors, what training objectives are relevant, also apply in principle to determining what tasks in the operational environment are relevant -- assuming no training objective exists that is relatable to the operational tasks or jobs in question.

Assume that the learning outcomes of the innovation have been verbally described. The assessing officer must probably be familiar with the learning processes and outcomes of the innovation in operational terms, as well as with the innovator's descriptions of conditions and outcomes. This substantive knowledge may enable restrictions, as well as amplifications, to the verbal range-of-effect perceived by the innovator. Thus, an innovation that the innovator perceives as applicable only to the medical student's learning of the names, positions, and actions of muscle and bones in the body, may be generalized to the integration of instruction on nomenclature and identifications of <u>any</u> sets of work objects, and <u>also</u> for instruction in the verbal stages of learning sequential procedures of <u>any</u> kind. The following sets of categorizations should foster the making of this kind of generalizing insight, as well as to place proper restrictions and qualifications on the range of applicability.

PROCEDURE

1. Become familiar with the conditions for selecting the task content analysis route for determining the range-of-effect for the innovation.

2. Study the description of the innovation in Task 1; the statement of task objectives, training objectives, and especially the context of the empirical findings as reported in Task 1.

3. Examine the terms in the various subtasks from 05.12 through 05.21. Some one or combination of these terms (and their reference definitions in the text describing the subtasks) may suggest a more direct way of describing the innovation for searching through the inventory of Navy training courses and the inventory of Navy job tasks, than the formal route structure might require. Notice that each choice of a descriptor along the route both opens a corridor of relevant applicability of the innovation, and at the same time, closes off other potential corridors as irrelevant to the innovation.

4. Do not be limited to the description of the tasks and courses by any terminology appearing in the subtask analyses. If you can confidently go directly to the names of all the courses clearly relevant to the innovation, do so. Or, if there are other terms which will more quickly, and comprehensively, identify the jobs and tasks, or courses, use them.

5. If the innovation is, without doubt, limited to an already identified job and task within the job, or an identifiable course and course objective, it is unnecessary to go through an elaborate search operation. Go directly to Subtask 05.18, Assess the Benefit Pattern. It is possible, however, that the innovation, either as instruction or as a result in a skill level, may be applicable to a class of courses and jobs with which the assessor is not familiar. The data base search on selected descriptors would then be a safe hedge against this unfamiliarity.

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: IDENTIFY THE LEARNING OBJECTIVE

## DESCRIPTION

The primary source of information for specifying the learning objective(s), preliminary to more formal analysis, is the description of the innovation made in Task 1. That description may be supplemented and qualified informally by training experts who have operational knowledge about the innovation and any studies performed with it, or more detailed knowledge about the jobs and tasks targeted by the innovation than was known to the innovator.

## PROCEDURE

Modify or extend the description of the innovation as appropriate about the training product or process to which it applies, and the task and task context to which it applies.

## COMMENT

The procedures in range-of-effect will result in further analysis of the innovation, and some of those results may be redundant to what is done in this subtask. However, since the description of the innovation made here will be a major starting point and reference for further analysis, the completeness of the description made here, including restrictions and qualification, should facilitate later steps.

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: MAKE PRELIMINARY EVALUATION OF BENEFIT IMPORTANCE

## DESCRIPTION

This subtask has two major parts:

a. Is the training objective to which the innovation is limited of minor, moderate, or essential importance? If the innovation is directly tied to a class of task such as the rigging of models of sailing ships, it may be possible to discard the proposal quickly. Note whereas an out-of-hand rejection of an innovation at this point might save further assessment work, it could lead to overlooking a significant instructional principle. In general, instruction in a nonskill directed knowledge should have less importance than skill training.

b. Is the magnitude of the found or potential improvement in training benefit, or achieving the training objective, small, moderate, or very substantial? When humans must convert a principle or reference model into actualities in their own contexts, a substantial degradation of the potential benefit of the principle tends to occur. A benefit of, say 20% shown in a laboratory, may shrink to just a few percent, or zero, when applied by average practitioners. Exceptions may occur.

## PROCEDURE

1. Examine carefully the description of the innovation, and the extended description of the kinds of training objective towards which the innovation appears restricted, as described in Subtask 05.10. Take into account the learning requirements of the student in his pattern of learning and fulfillment of training requirements, but consider even more seriously the importance of the instructional objective (as characterized thus far). Select the answer which best fits your conclusion:

   The training objective to which the innovation is targeted seems, in terms of the training mission and operational mission of the Navy, of:

   a. Identifiable but minor importance

   b. Moderate importance

   c. Very substantial importance

   d. Crucial importance.

2. Examine the empirical data or other basis for estimating the magnitude of the incremental benefit in training value of the innovation as compared with the existing or reference condition. Take into account not only data averages but their distributions (standard deviations). Select the answer which best fits your conclusion:

   The magnitude of the benefit, taking into account all factors that could have practical bearing on the results, is:

   a. Of no practical importance

   b. Of identifiable to moderate importance

   c. Of very substantial importance

   d. Of almost crucial importance.

3. A low or negative score on both of these questions could lead to an immediate termination of the assessment process with a rejection of the innovation. However, even though the assessor had well in mind the major variables in training and in on-the-job performance requirements, and he ran this internalized model against his understanding of the innovation, the risk of losing a good bet might be small, but not nonexistent.

   If the innovation is rejected at this point, the work done thus far should be documented and entered in the data base of rejected innovations.

4. If the innovation passes through this test, proceed into the determination of range-of-effect and formal benefits analysis. Proceed to Subtask 05.12, Determine If the Benefit Applies to Skill or Knowledge Training.

| TASK | SUBTASK | PAGE |
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TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: DETERMINE IF THE BENEFIT APPLIES TO SKILL OR KNOWLEDGE TRAINING

DESCRIPTION

Determining range-of-effect for knowledge training is a different route than range-of-effect for skill training. The descriptors along each route should be the primary basis for the selection of the route. These descriptors are intended to provide the basis for the distinction. Skill training is actual practice on an operational work task, in actual or simulated conditions. Note that different stages of skill learning may call for different learning conditions. A skill is a doing or ability to do; it has specific references in equipment and other work objects, environments, tools, reference information, and criteria of goodness. Skills may be symbolic and cognitive such as decision-making as well as manipulative, procedural as well as tracking. Training that is not skill-oriented is, by definition, "knowledge" oriented.

It should be repeated that making the classifications that follow is not an end in itself, but a means to find a set of descriptors that fit the range of training objectives and training and learning processes appropriate to the innovation's potential utility. The necessary and sufficient training supports for the learning of a tracking skill, for example, differ from those generally necessary and sufficient to teach and learn a procedural skill, which in turn differ from decision-making and constructing skills. Each category implies a training resource that differs in kind or magnitude for a training resource both efficient and effective for another category of skill. This statement applies mainly to the difference between skill and knowledge pathways, and to terms listed under Task Structure Element, Task Formats, and Stage of Learning.

Distinctions are made here between "Reference Knowledges" and "Enabling Knowledges." The latter are skill-oriented but may be acquired through cognitive and symbolic processes, rather than by actual practice on the task itself in some real or simulated task setting.

The distinctions summarized here are clarified in the body of the respective topics.

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: SELECT TASK STRUCTURE ELEMENT OR TASK "FUNCTION"

DESCRIPTION

This is another step in selecting descriptors that will pin down the applicability of the innovation, while at the same time probing for the extent of its range.

A skill, generally, is made up of a number of components. Although there are many ways of classifying or subdividing components, the set of descriptors used here is related to instructional and learning properties. Each task element denotes a class of capability that has somewhat different demands on what is necessary in an instructional capability, than is required for another task element. Thus, clearly, learning to scan a piece of equipment and detect burned insulation, broken wires, or leaking receptacles, demands a lower minimum effective instructional capability than would be essential to learning to identify the damaged wire or leaking receptacle, or interpret the cause of the damage or its effect on the performance of the device.

In this subtask, we are trying to narrow the relevant applicability of the innovation. The result of this step will have sharpened the description of the conceptual applicability of the innovation, in readiness to apply it to a search of the job task inventory for reasonable matches to the specification developed thus far.

The name of the relevant task structure element, in itself, can sometimes serve as the principal search description applied to an inventory of training courses and training objectives, or to an inventory of task descriptions. Thus, a training technique for the "Identification of figural elements in complex perceptual fields" may apply to a skill in "identifications" from reconnaissance photos to visual checkout of an electronic chip layout.

The following is a brief list of what may be called task structure elements or functions. Although the set is small, it covers a wide range of real-life tasks, and especially if the items are taken in combination. Thus, scan-and-detect may be combined with identify, identify with interpret, interpret with decision-making, and so on, in order to match with the training or job objective in the innovation.

The following points should be clearly understood:

- Every work activity will be represented to some degree by all of these task functions. But in most tasks as performed in a given situational context, only some one or several will predominate and be the critical training factor.

- Each of these functions has a learning and training requirement that differs somewhat from each of the other functions.

- It is possible for learning to be achieved in each of these task functions independent of learning on other task functions, and at suitable stages of learning, to be effectively integrated with what has been learned independently on other task functions or elements. This ability to combine part-learning efficiently into whole patterns of ability does not apply to any randomly conceived subsetting of behavior and performance "elements".

In this subtask, the set of task structure elements of major utility will merely be listed, and brief identifying descriptions will be given. The two exceptions are Procedure Following and Tracking. In Appendix A, most of these terms are given a more detailed and analytic treatment, and implications for training will be spelled out. The assessor is advised to become familiar with task structure in the present context because of the power it can confer in the design of highly efficient and cost-sensitive systems of overall skill training.

The list of task structure elements consists of:

Goal Projection
Scan-Detect
Identify
Interpret
Procedure Following
Decide
Construct/Plan
Tracking
Motor Performance
Interpersonal Interaction
Recall Task-Cycle Information
Recall Enabling Information.

These elements are briefly defined on the following pages under Procedure, Step 1. Most of them are treated more extensively in Appendix A.

PROCEDURE

1. After careful study of the description of the target tasks in the innovation in the light of the definitions of the task structure elements given below and in Appendix A, select the one or more task elements which apply to the innovation.

   - Goal Projections: Projecting a mental picture of what the result of a good performance of the job or task under given circumstances should be. This picture, if complete, would include a representation of all relevant criteria of effective completion. It is an image of what the outcome of a given performance should achieve. It should be realistic and practical in terms of a competent performer acting in a context of concrete circumstances. The goal projection serves to initiate task behavior, direct and sustain it

to a work cycle conclusion. A test of the validity of the operator's goal projection, other than in his performing the task itself, is his ability to discriminate an adequate from inadequate representations of proper goal states, given a concrete set of conditions under which the task is to be performed. If the operator has a clear and complete goal image, it is possible for him to compare the results of his actual performance with the results of criterion performance, note the deviations and thus give himself "learning feedback" which he can use to improve his performance when he performs the task again. The goal image thus serves the dual purposes of directing performance and of directing effort in skill improvement.

- Scan-Detect: Scanning a work environment, using appropriate senses, and detecting the presence of cues or conditions requiring some form of action to be taken. The action may consist of further examination of the cue, leading to an identification or to assisting an interpretation; or an immediate overt action (such as avoiding collision with an obstacle) may be the result. Learning to scan-detect in a given task context is learning what to pay attention to and notice; in complex tasks it will consist of suitable divisions of attention among sources of cues. In some tasks, scanning technique may require sophisticated search strategies, or emphasize sustained vigilance. There are tasks in which the detecting component is made difficult because relevant cues are obscured by noise, irrelevance or distractions.

- Identify: To differentiate an object or process or condition from others in a set, and generally put a name or label to it. Or, conversely, given the name, to point to the applicable object or condition. To identify may be not only to differentiate, as one hammer from another, but to generalize within a class or set of entities such as "hammers". Being able to apply verbalized job instructions demands the incumbent's ability to link the appearance of the object (or the making of the operation) to the matching word or expression. In some tasks, such as target identification in radar displays or in sonar presentations, the skill itself is in the perceptual process of detecting and organizing cues that, as a pattern, will yield a recognition of an identity.

- Interpret: Responding to one or a group of cues as a pattern or context that has meaning where the meaning is a cognitive inference. The letter symbols "cat" will tend to have a different significance or meaning, depending on whether they occur in a discussion about domestic animals, earth-moving equipment, or malicious women. Interpretation requires adding information to that which is physically presented as individual cues. It may also require responding to a collection of separate cues as a pattern or gestalt. Interpretations may be incorrect: a power cord out of the power source socket may "mean" that the appliance is not in operation -- but only if the appliance lacks some other power source. The output actions in some tasks may depend heavily on the incumbent's ability to respond to patterns of cues in terms of what they reference or mean rather than to their individual presence or absence. In perceptual tasks, an example is reconnaissance photo interpretation. In conceptual, cognitive

tasks, an example is tactical or strategic planning on the partial basis of signs by the enemy that are interpreted as his "intentions".

- Procedure Following: Carrying out a sequence of discrete actions or steps in a more or less invariant order except at conditional branch points. The sequence of steps in some classes of procedure is more fixed by prescription than in others. The procedure is ordinarily initiated by an explicit demand signal in a work context and terminated by a specified final action step or identification of a goal state. Each procedural step is characterized by: (a) a stimulus state or specified cue appearing on one or more indicators or physical objects; (b) a specified task action; or (c) a result of the task action appearing as a specified cue of response adequacy or inadequacy; this feedback cue may be the stimulus for taking (or selecting) the next step in the procedure.

The set of steps to be taken in a radar checkout or alignment operation constitute a procedure. This is an example of a highly prescriptive procedure; each step is well-marked, the sequence is fixed, the cue for each step is explicit and unambiguous. (The exceptions may require an "interpret" task element.)

On the other hand, the set of steps to be taken by a surface vessel in locating the position of a suspected enemy submarine may be a highly strategic procedure: although a principle specifies what general steps are to be taken and in what order, each step is largely conditional on environmental context and on the results of previous steps. More information processing is required to perform strategic procedures than to perform prescriptive procedures, therefore, the latter require less training time and facility where other factors are held equal. Training for strategic procedures overlaps considerations for decision-making training.

Special recognition needs to be made about activities loosely called "Communicating Verbal Information." In some work settings, the structure of the communications is highly standardized. One example is that of the control tower personnel interacting with pilots. Another is that of the mechanic filling out a maintenance form detailing the work he performed. These are examples of procedural formats, and may be taught and learned as procedures. Remember that learning a procedure should also extend to learning to cope with contingencies associated with the procedure. A second class of "communicating verbal information" requires the more or less free form construction of a narrative or scenario: the technician's explanation of "why the flying of a mission with an airplane having a given defect would be dangerous" would be an example. The task element rubric "Construct" would apply to the latter as an indicator of training and of performance characteristics. But where the rational and objective factors must be supplemented by skills in perceiving and formulating responses to emotional and attitudinal factors in interpersonal communication, a new dimension in task requirement, aptitude, training and performance is introduced. This dimension is acknowledged in the separate task element called "Interpersonal Interaction."

Procedures may combine prescriptive and strategic components. The improvised welding of hull plates at sea would provide many examples. Using heavily damaged engines to bring a ship into port would inevitably combine the prescriptive with the strategic.

Learning to execute a procedure is generally preceded by cognitive phases in which the component stimulus indicators and indications are identified and located and named, as well as the objects (controls) on which the student's response is to be effected. This enables the student to use verbal or diagrammatic information to formulate a conceptual model (or picture in the head) of the sequence of cues and actions making up the procedure. This conceptual picture, if it is sufficiently clear and the student is able to translate it into perceptions and actions, can guide student performance. This cognitive image may be supplemented during practice by job manuals that describe the procedure.

Retention and recall of a procedure is poorest when the procedure has been learned to an intermediate degree. This is the level at which the student may have learned many of the behavior components, but not their relationships and sequences, either cognitively or in perceptual-motor behaviors. This level may be evidenced by an appearance of "bare mastery" of the procedure such as in an early, stumbling carry-through of the procedural scenario. (Unfortunately, much formal training for many students terminates at about this point in learning level, and further practice in the task resumes on the job itself where procedural errors may be difficult to identify and eliminate.) Retention, as measured by recall and savings in relearning, tends to be high when the student, by sufficient repetitive practice, has integrated the procedural components into a smooth sequencing of perceptions and actions. At this stage, he can be interrupted and then resume readily where he left off; he can anticipate what step he will be taking next; he can retain information specific to a given task cycle. In this stage, he has learned not merely a chain of otherwise isolated behavior elements, but a <u>context</u> of associated behaviors that, as a combination, resists forgetting and interference influences.

- <u>Decide</u>: Selecting a course of action by systematic processing of information about outcome requirements and the situation on the one hand, and response alternatives and strategies on the other. Choices are usually made in some degree of uncertainty about the actual situation, the need, and how a given choice will work out. For example, under marginal weather conditions and a given importance of mission and a given aircraft with performance limitations, to choose whether to fly the mission or not, assuming an option for choice exists. In general, a decision differs from a straightforward procedure in that all of the information necessary and sufficient for choosing an action is not available, or is ambiguous, so that probability and risk (in some degree) are involved in selecting an action.

Note that where specific rules cover the selection of the "correct" response from potential alternatives, the operator learns a procedure. The procedure may be complex, but is nonetheless a procedure and may be learned by the

mechanics of procedure learning. There may be occasional gray areas between a task that is performed as a procedure or that may be performed as a decision-making (or "judgmental") operation. Even in the latter cases, however, the separation of the procedural format from the decision-making format for managing uncertainty may be useful for instructional and performance purposes.

The greater the number of variables that should be considered in reaching a choice, the more difficult it is to learn to make the decision proficiently. The multiple variables may characterize the definition of the problem situation, or multiple options may characterize the choice of the response, or both the situation and the resources for response selection may be complex. Because the selection of the response is made on a probabilistic basis, it is generally impossible to be absolutely rigorous in evaluating the student's choice, except where an ineffective choice occurred because of neglecting a key variable in the situation or a key variable in the resource committed to a response.

The decision maker learns to cope with the variables in the problem class; he must also learn to cope with the kinds and levels of uncertainty inherent to the class of decision he makes.

- Construct/Plan: Creating a response pattern that tends to be unique to a unique pattern of conditions and objectives and resources. But the variables in the kind of construction that is made (such as a table of organization) or in a plan (such as planning a landing operation), tend to be constant from one case to another. (The variables in planning a landing operation tend to be about the same from one landing to another.)

- Tracking: Responding to a more or less continuously changing stimulus by more or less continuous changes in response action, having the critical requirements of smoothness, coordination and timing. A given tracking skill is the manifestation of the operator's anticipation of the dynamic relationship between target data (the movement of the "cursor") and given actions on the controls he manipulates. In pursuit tracking, such as flying an aircraft visually towards a moving or stationary target, the operator can differentiate the dynamics of the target from the dynamics of the device he operates with controls (his aircraft). In compensatory tracking, such as in blind flying to the aircraft's attitude indicator, the dynamics of the target (such as air turbulence) are not readily differentiable in the displayed information from the dynamics of the control instrument (the aircraft's responding to control manipulations). This confounding of dynamic characteristics of the external target with the dynamic characteristics of the controlled instrument or vehicle makes learning to anticipate their interaction very difficult; compensatory tracking is notoriously more difficult to learn than pursuit tracking.

Piloting a vehicle differs from aiming a gun at a target. A vehicle must be moved through apertures that the pilot must project ahead, to the side, and even to the rear if he is concerned with safety. The aperture must

be large enough to include tolerances for the pilot's skill, for probabilities of invasion of the projected aperture by obstacles, either from the sides or on the surface of the roadway. Maneuvering a vessel has equivalent variables and requirements. The skill of the operator depends as much on his ability to project the behavior of aperatures in his operating environment, as on his ability to project the behavior of the vehicle in response to the control dynamics he applies to accelerator, brake, and steering wheel.

The technology of instruction and learning of tracking tasks is an extensive literature not to be reviewed here. There is little that can be learned from verbal materials that transfer to tracking tasks. Tracking must be learned by doing. On the other hand, there are many examples of simulators that seek levels of physical "fidelity" in display-control dynamics that are unwarranted logically and psychologically, but achieved at very high cost.

In real-life tasks, the operator must generally attend to multiple streams of information at the same time. To do this effectively requires large amounts of practice. The performance of procedures is often mixed with tracking activities. To the extent that the procedure does not depend on information contexts outside the procedure itself, these procedures may be efficiently learned to high degrees of mastery on procedural trainers before the student practices them in full work context -- that is, on a high-fidelity simulator where the operator must make suitable divisions of his attention.

It should be clear that an understanding of the learning process enables the formulation of a training schedule or scenario which maximizes the learning and transfer of training benefits from a family of instructional devices, each of which may cost an order of magnitude less than the next higher in functional capability. This issue relates both to Stage of Learning and to part-task training considerations.

- <u>Motor Performance</u>: Executing a pattern or sequence of motor activity where the emphasis on the totality and its parts is on dexterity, control, strength and precision of output. The major concern is on differentiation and organization of muscle groups into performance patterns. Examples: typing and other keying operations, hand-to-hand combat, rowing a boat, sports in general. In a widely different context, control of the voice in speaking, singing or in learning to pronounce in a foreign language.

- <u>Interpersonal Interaction</u>: Apprehending and presenting information to other individuals in a manner that facilitates getting a collective job done by the participants. This task function connotes more than procedural factors in the sense of job manual instruction. It includes personality elements, attitudes, interpersonal predispositions and style -- and other concepts that are difficult to reduce to operational definition except indirectly, such as by the observation of performance consequences. It is outside the scope of the present project to develop

analytic structures and rationales that apply to the learning and expression of interpersonal skills. It is relevant, however, to acknowledge them as a special and important class of activities in any work environment, and to recognize that in some jobs they may be as important than technical competences: intimate leader-follower relationships and team coordination situations are examples.

- Recall Task-Cycle Information: Remembering and applying data peculiar to a work cycle and relevant to the activities performed in that work cycle. Examples: remembering what one has already done and not done in carrying out a procedure; a pre-mission briefing; a special operating condition such as a device having an intermittent fault; the temporary exposure of a live, high tension wire. The process of being aware of what has been completed and not completed while performing a procedure depends on this memory function. It is necessary to hold in mind the information acquired over time that enters into the making of a decision. In psychological jargon, this task function may be called "working memory" or "short term memory." In Appendix A, the name used is "short term memory". Its operation is obviously essential to the performance of any tasks above the most primitive conditioned response levels. Clearly there are training and learning techniques that can enhance or, on the other hand, depress the effectiveness of this function. Reliable recall of task cycle information depends on the learning and exercise of task formats as described in Task 05, Subtask 23.

- Recall Enabling Information: Remembering and applying facts, rules and conceptual principles applicable to task performance. The classes of information that fit here have been previously identified as Enabling Knowledges. Enabling knowledge ranges from the stall speed of the airplane one is flying to the Centigrade equivalent of 70 degrees Fahrenheit or the shank diameter of a number six wood screw. Correctly recalling such information in response to a classroom test is a different condition for performance from that of recalling the same information under the stress of operational conditions. In the Appendix A treatment of this topic, the concept of this long-term memory is called "Store" in order to distinguish it from "Short Term Memory". It should be recognized that the performance of Procedures implicitly implies the recall of information that supports procedural performance. But because the learning, remembering and applying of support information can have aptitude and training requirements that differ from the learning of procedural operations as such, the recall of enabling information justifies its own identity and characterization as a task function. Furthermore, if two tasks differ in procedural operations, but demand similar classes of enabling and support information, there should be substantial transfer of training from one to the other that is evident after the early stages of procedural learning in the second task.

2. Retain the names of the relevant task structure elements and any information context about them that can be useful for the next stages of determining range-of-effect. In many cases, this subtask of selecting task structure

element(s) will merge into the Subtask 05.14, identifying relevant jobs and tasks in the Navy inventory of jobs and tasks.

3. Proceed to Subtask 05.23 to determine if the innovation is specifically applicable and restricted training in task formats.

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: IDENTIFY RELEVANT JOBS AND TASKS

DESCRIPTION

The key objective in determining the range of the innovation's effect will be achieved in this subtask, assuming that training courses will be readily identified when the specific job tasks have been identified. In all cases, the assessing officer is advised to think beyond the surface matching of words used to describe tasks and attempt, rather, to match on the processes and things that lie behind the words used to describe them. "Disassembling" a pocket watch and "disassembling" a steam turbine may have some points of overlap in terms of their respective skills, and the instructional operations for acquiring them, but their differences are likely to be greater than their similarities. On the other hand, similarities in the names of objects or of tasks are good hypotheses for looking further into the relevant similarities.

Finally, however, the decision of relevance or non-relevance of the innovation to a concrete job task or family of job tasks, is an act of personal insight and judgment. For example, an innovation in instruction on aiming and firing handguns has perhaps shown a 40% efficiency advantage over other methods of instruction. Does the innovation also apply to the aiming and firing of rifles? Of authomatic handheld weapons? Of mortars? No generalized list can possibly eliminate the need for some operational knowledge about the various tasks involved in this decision.

It is realistic to assume that the empirical testing of the innovation will rarely, if ever, sample from all the potential range of training problems to which it might apply. Therefore, the potential value of the innovation must be supported by informed guesswork. The more "similar" the candidate task is to the researched task, the better the bet that the candidate task will show a similar benefit. But, what may seem similar on external appearances, may frequently not be similar psychologically, and vice versa.

The following guidelines are therefore proposed. The assessor has already broadly classified the relevant job task into one of the five groupings: tracking; procedural; decision-making; constructing; or leadership-interpersonal. Within this grouping, he will have further classified the instructional objective of the innovation into one or more task structure elements: goal-image; scan/detect; identify; and so on. He can generalize and delimit the relevant range of job tasks on one or a combination of the concrete identifying factors that define real tasks in real environments that will be listed below.

The following set of task context variables should be treated as coordinate variables; the data they develop are a complete pattern. In some cases, the description of the innovation will point rather directly to the variable that

is primary for generalizing range-of-effect. For example, "training in use of handheld soldering iron or soldering gun", identifies a procedure for using a tool, and all job tasks that call for soldering iron skills are candidates. One could search a data base of descriptions of Navy jobs directly with just that information. But an innovation claiming efficient instruction in "strategies for operating vehicles through turbulence" could, potentially, apply not only to aircraft (on which the innovation may have been validated), but also to surface and subsurface vehicles, as well as land vehicles operated over rough terrain. In this example, the key factor in stipulating a potential range-of-effect is "operating a vehicle through turbulence", so the search should look for the operations and the vehicles (equipments) operated in an environment of "turbulence". The linking term is turbulence.

These examples should demonstrate why it is not practicable to set up a limited set of taxonomic descriptors with universal range and applicability to job training and performance.

The following variables, taken together, comprise a job task context that must necessarily be regarded as guides, both in probing for the potential full-range of the innovation, as well as for delimiting that range. Nor should the order in which the variables appear determine the order in which descriptive terms are sought; the order should be based on the key characterizations in the description and understanding of the innovation.

The objective variables that characterize task contexts are:

- Equipment and objects used in the task
- Environments in which the task is performed
- Tools used in connection with the task
- Reference information used in performing the task
- Task operations (made up of "task structure elements")
- Criteria applied to task performance such as "time" and kinds of "errors".

PROCEDURE

1. If applicable, classify the training objective in terms of target job tasks into one or more of the following categories:

   Operations
   Maintenance
   Service
   Command.

   This is a broad grouping, but it may help as a rough first pass at subsetting the inventory of Navy jobs into a target group. It should be noted that an efficient search strategy is one which, as early as possible, excludes the largest segment of the total universe to be searched as irrelevant to further inquiry. This is the Twenty Questions Game principle. If the innovation cuts across any kind of categorization such as suggested in this step, abandon it. In any event, go on to step 2.

2. Using the guiding categories that are named and described in the topical sections that follow, identify and set down the objective or external characterization of the skills and task structure elements that limit the applicability of the innovation. For example, the use of an electric arc welder is applicable to all jobs that would be characterized as: Procedure -- Use of Arc Welder. But a turn on procedure specific to an ABA-10X equipment would clearly be restricted to the operator of the ABA-10X equipment and the field maintenance job on the ABA-10X equipment.

   If there is some doubt about whether to use a more restrictive or a less restrictive characterization, use the less restrictive, or more general characterization. What is now being constructed is a search of candidates for judgments of relevance. The assessor will make another examination of the job task descriptions in their individual contexts, so he will have an opportunity to reject those that do not apply. On the other hand, if the search specification is more restrictive than it should be, candidates that are genuinely relevant to the innovation will be overlooked in the retrieval search. Better to cast the net too wide than too narrow.

   Similarities for training purposes may be established on the basis of patterns of similarities among the following characteristics:

   - Equipment and Other Operational Objects Used

     The name of the equipment or class of equipment operated by the operator, or maintained by maintenance personnel, is usually a primary descriptor for identifying jobs and, by implication, of the tasks associated with those jobs. If the description of the innovation can include relevant equipment names, the data base search can be narrowed rather quickly. On the other hand, if the innovation extends to equipment in addition to that initially specified, the greatest penalty in restricting the proper range of the innovation will be imposed.

     In assessment practice, it will be good policy to identify equipment names and types <u>after</u> task structure elements and relevant environments have been identified, unless the innovation has to do with manipulative operations. Manipulative activities tend to be equipment and tool specific. Note that this recommendation is embedded in the present procedure -- see Subtask 05.13 on Task Structure Elements.

   - Environments

     An environment sets conditions under which a task is to be performed. The differences in conditions may imply a different kind or level of skill. Aiming a gun from a stable platform is different from aiming a gun from a moving platform. Driving a vehicle on flat terrain differs from driving on mountainous terrain, and both differ from driving in congested downtown traffic. Performance in forgiving environments,

such as stall recovery at a high altitude, may require a skill that differs both qualitatively and quantitatively from performance of the same task in an unforgiving environment, such as stall recovery at a very low altitude.

- Tools

Tools may be regarded as a special kind of equipment. The ability to use a given tool, such as a recording voltmeter or a torque wrench, implies some general range of tasks and skills, but must usually be qualified by the equipment or materials or other work objects applicable to the task context. It is possible, however, for the name of a tool in itself, to constitute a search specification to a job task data base.

- Reference Information

Reference information data that may be in the incumbent's head, or available externally (such as manuals of instruction or handbooks) in normal, expected conditions of performing the task which may be essential to carrying out the task. Examples are the normal waveshape for a given electronic checkpoint, the number of U.S. gallons to an imperial gallon to an American motorist in Great Britain, the temperature at which a given flux will bond given materials together in the task of welding.

Reference information may also consist of procedure information to supplement or substitute for memorized procedures. Such supplements may be necessary for procedures that are performed relatively rarely by the incumbent.

- Task Operations

Responses made by the incumbent to task situations in carrying out his duties are denoted here. The description of task operations may be made at many levels. Task actions can be described in operational terms with task Structure Elements as a general format for scenarios of procedures, decision-making, constructions, and so on.

Task characterizations are generally weakest in the descriptions of perceptual-cognitive demands on the incumbent. However, these demands are often the most important for skill learning and for the transfer of skill from one work instance or situation to another. Scenarios of task operations frequently tend to emphasize the action demand of the moment, while neglecting the concurrent range of perceptual-cognitive activities that differentiate the mechanical step-by-step prescriptions For action from the full context of action required for competence. Thus, safety and efficiency in driving in heavy traffic require not only steering the vehicle in order to avoid collisions, but continuous

awareness of the dynamic changes in the size of the "slot" in the traffic which constrains the driver's maneuverability.

- Task Criteria

These are the variables in performance which apply to determinations as to whether the task is performed effectively or ineffectively, and at what level of effectiveness. Some ultimate criteria may be imposed by nature, such as in the recovery from a spin in an aircraft or by the enemy in a combat situation. Secondary criteria may be set up by instructors and evaluation experts who observe the extent to which the actual operations conform to prescribed operations.

General criterion variables consist of time to perform tasks or task actions and kind and frequency of errors or deviations from prescribed norms. A third criterion, less explicitly applied, may be the qualitative and quantitative range of situations with which the incumbent may be stressed before performance breakdown or failure. Increases in situational complexity would be an example of such stress.

3. Add the job task characterizations derived from steps 1 and 2 to those obtained from Subtask 05.13, Select Task Structure Element or Task "Function".

4. Organize the descriptors into one or a set of search arguments with appropriate logical connectors. A logical connector is either an AND or an OR, or a NOT.

For example:

Type of skill training: Construction

Task structure element: Procedure/Manipulation

Task characterized by:

Environment: Improvised in field
Objects used: Softwood OR hardwood, NOT metal
Tools: Hand saws AND improvised bench
Operation: Sawing
Criteria: Not applicable.

(The example is artificially simplified.)

5. Search the Navy inventory of job task descriptions for those relevant to the target knowledge and skills in the innovation. Step 4, just preceding this step, will have yielded one or a group of search arguments, including descriptors and logical connectors between descriptors. It is expected

that the descriptors of jobs and job tasks in the Navy inventory will have matching descriptors for automatic search. If this is not the case, human interpretations will be required for comparing the innovation descriptors with the job inventory descriptors and deciding whether the concepts behind the respective words used are, for training purposes, a match or a mismatch.

Bear in mind that the final decision as to whether a given job task in the Navy repertory is or is not relevant to the innovation, will be an inspection of the context and tests of the meaning of the descriptors of the Navy job task. That is, the hits made by the search operation will not be automatically accepted as relevant, but only as candidates for acceptance. This is similar to making a search request for a book in a library; the search by the librarian results in a number of books, each of which is examined before making a final decision to accept or reject the candidate.

Search strategy has trade-offs. A small set of relatively abstract descriptors will tend to result in a large number of hits or matches with items in the listings, but a large proportion of these hits, upon fuller examination of their content, may turn out to be irrelevant. However, the probability of getting a large proportion of relevant items will be high. On the other hand, a large number of specific and qualifying descriptors will tend to result in a smaller number of hits in the listing, and a larger proportion of these hits will turn out to be relevant. However, the risk is increased that many potentially relevant candidates will be missed in the search.

In common practice, important searches are made iteratively. The first net is cast widely and its contents sampled. If the sample reveals a large proportion of rejects on the basis of judged irrelevance, additional qualifying descriptors are added to the search specification and the search is rerun with a consequently smaller number of hits.

Much the same search principles may be applied when inquiry is made into the knowledge of the expert on Navy job tasks: He will formulate an "image" of the job task characterization of relevance and evoke images from his memory that tend to match. The search may be facilitated if the searcher scans a list -- in this case, of the names of jobs and, perhaps, duties within jobs in the Navy inventory of jobs and duties.

An alternative to a search on job and task listings and descriptions is to search on course names and course objectives. This choice assumes that the innovation is relevant only to those skills and skill contexts for which courses are available. This operation is a jump to Subtask 05.16, Identify Relevant Courses.

The result of the search and verification of job tasks relevant to the effect of the innovation on training and/or performance benefits, is a list of Navy jobs and job tasks (or skills) and such qualifying information as can be added to each item on the list.

Following the identification of the Stage of Learning to which the innovation applies, the job and task listing will be used to search and identify relevant training courses.

6. For each job and job task identified in the Navy inventory, obtain the following information if it is available:

    - The number of existing incumbents.
    - Projections of the number of students who are to be trained for the job and job task in each of the next five years.
    - Any expectations projected about changes in the job or job task structure and when they may happen in the five year future -- as these changes might bear on the validity of the innovation for the job incumbent.
    - Projections of changes in the characteristics of the input student population to courses leading to assignment in the jobs relevant to the innovation.
    - Projections of changes in the conditions and environments for the training in the relevant jobs that could bear on the practical value of the innovation.

COMMENT: If these kinds of data already exist in the training course descriptions for Navy job training, they need not be obtained from the Navy job inventory descriptions.

7. Determine if the description of the job in the Navy job inventory includes identification of the training courses prescribed for acquiring the job knowledge and skill. If so, take this information and, if it is sufficiently complete and up-to-date, a major portion of Subtask 05.16, Identify Relevant Courses, has been completed.

8. Organize and retain all data obtained in this subtask. It will be most useful if presented in a tabular format that is keyed to the Navy's name of job and job task.

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: SELECT RELEVANT STAGE OF LEARNING

## DESCRIPTION

Different stages of learning call for different factors in training. An innovation that may be effective for one level of skill acquisition may be irrelevant or even counter-productive to another level of skill. Differences in skill level training may be reflected in course levels, but more specifically in units of training within a course. The characterization of skill level, therefore, enables a more precise determination of the training operations to which the innovation is specifically applicable.

The practical aspects of stages of learning are those of acquiring a skill. The reason for concern with stages of learning is that the minimum fidelity to the job task for effective progress in skill acquisition changes from one stage and level to another. Whereas words, diagrams, and pictures may be adequate and effective at an early stage in acquiring a skill, or the components of skilled performance, later stages demand more physical and functional fidelity for useful growth and transfer of skill from training to operations. And whereas, in early phases of skill learning, adequate student response may be verbal, in later stages the student response must be the literal equivalent of the job task response with the physical work objects and tools of the job. Temporal and other dynamic relationships must become realistic so that the student develops proper cause-effect "anticipations" of the tool, equipment, material, and environment. At high stages of skill learning, the full information-handling load of simulated or real environmental conditions and contingencies must be presented, else the skill will level off at less than a reliable, on-the-job competence. Not only must higher degrees of physical fidelity to the real job task accompany higher stages of task learning, but the form of measurement and analysis of student performance changes, as do the desirable properties of instructional control.

Sophisticated awareness of cost-effective instruction will take into account the minimum requirement for students, consistent with effective learning at a given stage, and for the transfer of that learning to a later stage of what is being practiced and learned. For example, a growing body of studies is revealing the fact that many sequential procedures can be learned to near-operational levels of proficiency on relatively crude mockups, rather than on operational equipment or expensive, high-fidelity simulators. This section of training analysis, therefore, characterizes the major stages of skill learning at which various kinds of instructional options, with substantial implications for cost-effectiveness, can occur.

A summary of stages of learning emphasizes the student's learning processes. With continued practice, the behavior processes within the student tend to change. These changes are more or less systematic and predictable, and depend

on instructional sequencing, kind of presentation of content, and the nature and extent of conceptual content. ("Concept", here, refers to an idea of a property or class, not merely the name of a word.) Transitions are gradual rather than abrupt, and for a given student not all aspects of a task being learned make the same shift at the same time. The major transition is from the stage where the student gives himself verbal instructions about what next to notice or do, to the stage where the same behavior is largely automatic -- that is, executed with little or no verbal mediation. When a class of behavior has become "automated", the effective channel capacity of the student (what he can carry in his head at one time) becomes increased so that he can process more information at the awareness level. The source of the information may be additional kinds of task input data, feedback, or guidance from the instructional vehicle. This automatization of behavior tends to develop in perceptual task activities, cognitive activities, the organization of motor activities, and in perceptual-motor activities.

What tends to get automated are the relative constants among a set of task experiences in what is perceived, or thought about, or the movement patterns executed, or the relationships among all three. These constants, in terms of conditions and processes, among a set of task experiences may be thought of as a "task format". A constant may consist of a variable in a task input, processing link, or task output. An example is "altitude" in flying conceptually, or the altimeter in actually flying the aircraft. The momentary reading on the altimeter is the value which this variable may take. Other variables which are consistently required in heavier-than-air flight are course heading, attitude, and air speed. The information processing format of necessary variables (called constants above) for flying includes, but is not necessarily restricted to, this group. After having internalized this format of variables by extensive task practice, the pilot can more readily use different physical sources of data (such as a different kind of altimeter dial) for given variables, than the more inexperienced pilot who depends on procedural sequences for information. A task format is somewhat analogous to a printed form that has been standardized by a business for a given kind of transaction, such as a bill or invoice to a customer. Task formats also apply to routinized decisions, and to constructions such as routinized planning.

The concept of task format, and the processes whereby task formats are required is essential to account for (hence, to train for) the transfer of training (or what has been learned by the student) from one practice environment to another.

An attempt is made to adapt stage of learning differentiations to more or less fit the terms and descriptions in Navy training documentation. The translation will by no means be a precise fit to the processes described above, but the approximation may be adequate for interpreting the intent in course descriptions, course element objectives, instructor manuals, and student manuals.

PROCEDURE

1. Determine to which one or more of the following stages of learning the innovation is restricted in its applicability.

- Orientation and Familiarization

These may be general reference and context knowledges. They may include information about goal states, environments, appearance and properties of tools and other resources, communications and job interfaces, roles on the job and roles in the training environment, and relationships of tasks to each other. If these kinds of information are not presented and credible to the student, he will tend to develop his own images and hypotheses. The concepts acquired during orientation may, in some cases, serve the student as mnemonic models for learning, retention, and generalization -- that is, he acquires a general picture of what to expect and the more specific content he learns gets tied in with these expectations. The expectations can serve to organize the details of what is learned later.

Theory of operation is included here because it may serve mainly as orientation to the skill, rather than as a component of the skill. It becomes a skill component only if it becomes integrated with practice in one or more of the actual tasks performed by the incumbent, and the "theory" information must be referenced by the student (or job incumbent), rather than direct procedural instructions from a procedurally oriented job manual. But theory of operation may apply to various kinds of content; what the system is supposed to do and how it does it in principle, criteria of system effectiveness, environments in which the system is to operate, and interdependence of subsystems, physically and functionally. Theory of operation may include some, and possibly all, of the <u>nomenclature</u> associated with learning and performing tasks by incumbents.

The instructional vehicle requirements are essentially those for presenting text, diagrams, and pictures (static and dynamic), and for receiving and evaluating symbolic responses from the student.

- Task Nomenclature (Identifications, Locations, and Names) and Facts, Rules

This stage may be merged into, or be an extension of, the orientation and familiarization phase. The student learns to identify and differentiate task-related entities (situations and objects and operations) and to associate names with them. By learning nomenclatures, the student can be briefed and symbolically guided by the instructional vehicle. This enables symbolic rehearsal of task actions. It also facilitates the student's ability to mediate between situation and <u>overt</u> task response, by giving himself instructions with words and images when the nomenclature is organized into descriptions of task procedures.

The instructional vehicle requires the ability to present the appearance or image of the entity paired with its label. This pairing of appear-

ance and name may be presented by a variety of means. In general, identifications of things are learned more quickly when they are shown in meaningful contexts.

Facts, such as the color coding of resistors for their resistance values, or the weight and dimensions of a given piece of apparatus, can be learned with similar vehicle properties.

The learning of direct symbol translation rules, such as for converting inches into meters, depends on minor if any change in properties to the instructional vehicle for facts and nomenclatures. The proviso is that the rule is a simple, one-for-one, translation of elements in one symbol set (such as degrees in Fahrenheit) to elements in another symbol set (degrees in Centigrade).

- Task Formats at the Conceptual Level

At the termination of this phase, the student is able to give a more or less specific description of what initiates the task or duty being studied, and of the major sequences of activity that comprise the task. Where operational task formats are learned, the student should also be able to state or identify the major variables comprising (a) the task situation or problem, and (b) the goodness criteria in the task outcome. In another form of test, the student is presented with motion picture sequences of the task being performed and he describes what is going on and why.

This phase may be more specific with respect to job tasks than familiarization, but less specific than the learning or memorizing of the descriptions of step-by-step procedures. The Navy officer does not usually learn how to perform the actual task itself, but gets a "working knowledge" about the performance of the task.

A task format at the conceptual level is a general map of what is done in disassembling-replacing-assembling an electrical or mechanical assembly, the general pattern of operations in sighting a piece (or class) of fire control equipment, or the general steps in making a chemical analysis of the water in a boiler. This conceptual knowledge may become a cognitive "organizer" for actually learning the task as a verbalizable procedure, and actually performing it. Because the concept of task format is not formalized in Navy training documentation, this is an "implicit category" at present. Its meaning as a training objective can be interpreted in the content of some theory courses.

The training vehicle presents symbolic materials and the student makes symbolic responses. In addition, the presentation may include live demonstrations of task performance, or representations of it, ranging from text descriptions through motion pictures. More sophisticated

and "enriched" presentations may present the task action as a "cause", and some system outcome as a related "effect". This material is useful as a training experience to the extent that it is remembered and transferred to relevant work situations, or to later training situations.

Note that this stage of learning is equivalent to the content of instruction to be specified in Subtask 05.22, Identify Type of Task Format. If analysis was made in Subtask 05.22, its results can be carried over directly into this topic, and possibly the next topic below. See Subtask 05.22 for a more analytic description of task formats.

- Procedures Learned at the Verbal Level Only

The student demonstrates his completion of this phase when he can either describe in detail the steps in the task procedures, including the signs or cues that specify the task response to make, or preferably when he can, in the presence of the task objects and environments, describe verbally, and by pointing, each step in the task procedure.

It is possible to memorize the verbal equivalent of a set of printed job instructions. The evaluation of incumbents on their proficiency in the training path system used in submarine and fire control contexts, puts heavy emphasis on the ability of the incumbent to give verbal descriptions of procedures to be followed in the array of tasks making up a requirements pattern. The verbalized procedure may serve as a more effective precursor to learning the live context procedure if the student can readily imagine the <u>appearance</u> of the presented task situations and the overt task <u>operations</u> as the incumbent performs them. This implies effective learning of "nomenclature -- identification and locations and names" and their presentation in the context of rehearsing or practicing the steps in the verbal procedure.

Devices more sophisticated than printed text can increase the efficiency of learning the verbalized procedure, its reliability, and especially its transferability to the actual or simulated physical work situation and actual procedural performance. But the display and student response acceptance facilities of even this device may be symbolic representations rather than physical representations.

- Performing Task Components with Guidance

This level corresponds to actually carrying out the task in full, but with some degree of external prompting.

In Navy language, a skill consists of a "doing operation" -- that is, actual task behaviors. Performing a task with guidance is equivalent to a "middle stage of learning" -- where the student is giving himself verbal instructions in task performance (mediated performance) with growing degrees of independence from outside sources of task information.

- Doing the Entire Task/Job Procedurally: Barely Acceptable Mastery.

  The student or incumbent is able to make his way through the task unaided, but with errors and fumbling and at a slow, uneven pace; he is unable to attend to other tasks or ongoing activities at the same time. This should be the equivalent of a late stage in "middle learning", where subtasks are getting organized into performance, but where getting through the procedures correctly uses up most of the student's attention capacity. The range of his job experiences has not yet been great enough to give him a wide repertory of response patterns for contingencies, nor has he had enough practice in doing the task to make its behavioral elements more or less automatic, like subroutines. This category can have its equivalent in the Navy evaluation expression of "performs task procedures without supervision", if the expression implies "meets minimum or marginal acceptable standards for job performance".

  This level may be reached after some hours of procedural practice on the raw equipment, with the help of manuals of instruction and/or the divided attention of an instructor as guide. The performance level deteriorates rapidly during a few days of nonpractice and is not rapidly restored with renewed practice.

- Highly Proficient Task/Job Performance in Work Context

  The student or job incumbent performs the entire task without hesitations in a manner that indicates that he is anticipating and making provision for future steps as he proceeds; he is also able to attend to and respond to other concurrent activities.

  This is a learning phase and a skill level not identified in most course objectives, nor in incumbent evaluations. As a stage in learning, it is characterized by a high degree of "automatized" performance of routinized task operations, including components of many decision-making operations which now are performed with comparatively little mental "figuring out the solution". At this level, the student or incumbent can perform a task strategically; he can optimize resources across a number of steps rather than proceeding merely one step at a time. Not only can he plan several steps ahead, he can anticipate conditions and situations, perform efficiently as well as effectively, and keep in mind special information about the environment, the mission, priorities, and other specifics that he could not do if his attention was completely dominated by trying to remember what next to do. This level implies that many procedural operations (whether correct or incorrect) have been learned so well that they are virtually automatic, and that his anticipations are effective in transitioning his activity, smoothly, from one sequence of responses to another. This level of skill is well-retained over long periods of time and is quickly relearned from any degradation in recall.

This stage is reached only after extensive and varied repetitive practice that makes the full demands on attention required in the job. But it can be erroneous to assume that only job experiences in great number and variety can lead to this stage. We should recognize that job experience is also a learning experience, and any learning experience is potentially subject to deliberately induced training actions. Wrong procedural responses can be overlearned as readily as correct procedural responses. It is a good working hypothesis that many job incumbents who could reach the level that combines smooth, reliable automatic response with correctness of response and strategic capabilities, fail to do so for reasons that could have been controlled by training type decisions and actions, and that many others are delayed from reaching this level for the same reason.

Rather high fidelity of performance requirements, both in kind and range, of task situations is required, plus instructional functions of response evaluation and immediate corrective feedback. Plus guidance functions. Plus very extensive blocks of time for practice.

- Unusual Task Conditions

This is learning to cope with the multitude of things that can go wrong, such as from human error, equipment malfunction, extraordinary environmental conditions, incorrect information, and so forth. This is supplemental training rather than a stage in learning, although it may be introduced in a stage of learning regimen. The learner should be competent in handling routine operations before having the additional learning burden of exceptional conditions to cope with. Unless the job incumbent can cope with exceptional conditions peculiar to the job task, his practical usefulness is limited.

Because of the rare opportunities for the incumbent to practice rare events on the job, training for exceptional conditions -- such as emergencies -- requires large redundancies in the content of what is learned, in order to achieve a useful reliability in recall when the situation demands recall. Retention of procedural skills over long periods of disuse will also be supported by periodic refresher type training. This is likely to be most effective if given in the full context of task performance, such as is the case with refresher training in emergencies for aircrew given in simulators. But any operators or maintenance personnel are faced with unusual task conditions which challenge mission accomplishment.

- Performing Job/Tasks at Key Man Level

This is demonstrated by performing the job at a level of skill that is recognized by others as unusually proficient so that the individual is depended on to contribute his expertise in situations when others having the same job are by-passed or have failed.

There can be a combination of training, job experience, aptitude and motivations that make some individuals the key technical men in their organization and specialty. These individuals tend to contribute far more than their share to the mission effectiveness levels of their organization. The key person phenomenon is likely to be more than a mere sum of skilled performances, hence applicable to the person rather than merely his skill attributes. In some cases, the key person may not have done well in academic phases of training such as often demanded by the conceptual demands of theory of operation or verbal memorization of procedures and other rote demands. But the practical importance of such individuals in organizations makes it desirable to identify and characterize both the role and the skill level in any complete range of description of competence.

The development of the key man probably requires substantial catering to individual differences and more or less unique training routes.

- Refresher Learning

At the beginning of refresher training the student cannot perform or recall to criterion performance levels, tasks and task information which he was once able to perform, but at the conclusion of refresher training he is again able to perform at his once established level or better.

This is a "stage" of learning intended to compensate for the forgetting effects of extended periods of time with no practice of the skill, and/or intervening experiences some of which may interfere with the recall of the correct responses to make in the old task.

If the tasks were learned to high levels and performed a large number of times, recall with practice may be rapid. But the rapidity of recall and full reinstatement of the original skill may be slowed or increased depending on conditions of refresher practice. The principle of effective retraining of an old skill is that of inducing any other content of retention: the greater the extent to which the original situation and all of its psychological context is reproduced, the greater the probability of recall of the responses made to the original situation. In refresher training, a highly significant factor in that context is the actual making of the responses (cognitive and motor) under the same conditions of response made in the original learning. This is not altogether a paradox.

Take an example. You once memorized a poem. Years later you are given the title and asked to speak the poem. Not a single word can be recalled. A prompter gives you the opening phrase. You speak the opening phrase aloud. The probability of your being able to continue the words of the poem vastly increases. As you complete the utterance of the first line of the poem, the probability of your recall of the second

line increases still more. If all sections of the poem were learned equally well, each additional phrase you speak continues to increase the probability of remembering the remainder of the poem. If you learned it by speaking it aloud, it will best be recalled by speaking it aloud. The recall is assisted by the "response context" which, especially in serial activities, becomes the most significant set of cues for recall. But the effectiveness of response context is not limited to serial activities.

This principle helps to understand that attempting to relearn the skill by practice which simulates the original early learning conditions will be highly inefficient for redintegrating the old skill at its terminal level when it ceased to be practiced. The kinds of responses made in early practice are not the kinds of responses made at full competence level. Relearning an old skill should attempt to simulate the terminal levels of performance of the skill. When its psychological context has been restored, practice may concentrate on ironing out the deficiencies.

Studies have shown that procedural skills, such as emergency operations in an aircraft, if once learned to a high level of performance reliability, can be "refreshed" as effectively by verbal rehearsal as by practice in the simulator of the actual procedures. No doubt the verbal rehearsal, to be effective, must be accompanied by some internal imagination of the cues and responses connoted by the verbalizations. It is unlikely that procedural skills learned only to intermediate levels can be effectively refreshed by symbolic rehearsal. Skills dependent on complex perceptual-motor or motor patterns will probably have little or no refresher value derived from verbal rehearsal, except perhaps to alert the operator to a changed context of cues. Example, the American driver who has returned from driving in the United Kingdom, when getting into his car at the airport reminding himself that in the U.S.A. one drives on the right rather than the left of the road, and rehearses some mental imagery to that effect.

2. Add this Stage of Learning characterization to the description of job task skills that emerged from the determination of relevant job tasks in the Navy inventory of jobs, Subtask 05.14. The assessor can now formulate a search argument for retrieval of relevent courses from the course description data base.

COMMENT

The foregoing definitions of learning and performance levels are intended to help assign the relevance of an innovation in training by persons with some background in the psychology of learning and training. Existing Navy terminology and distinctions were adapted where possible in this determination of relevance,

but not all concepts of learning level described here are represented in formal Navy documents about course objectives on one hand, or performance criteria on the other. The possibility should exist that Navy practices may be at least moderately changed to adapt to the distinctions described here, and for more reasons than merely to evaluate innovations in training technology. For example, the least overall cost-effective level of learning, followed by a period of disuse after which on-the-job retention and transfer is measured, is likely to be the "level of bare procedural mastery" which terminates much formal training.

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: IDENTIFY RELEVANT COURSES

DESCRIPTION

At this point in the task content skill route, the following have been identified:

The general class of skill

The task structure elements that are applicable

The relevant job tasks from the Navy inventory

The applicable stage(s) of learning, including formats for procedures, decisions, and constructions.

This information should enable a variety of search strategies to be applied to a data base of course and course objectives descriptions.

As in search operations described previously, the two stage activity consists of using the search specification to get a list of candidate courses potentially relevent to the innovation, and then validating or rejecting each candidate on the basis of informed judgment based on at least a general knowledge of the course content. Mere descriptive labels of courses and course objectives will generally be insufficient for the validation by judgment phase.

Because many courses are set up to fill standard time slots in terms of weeks, there is bound to be arbitrariness as to the stage or level of a skill that a given course will carry a body of students. This fact justifies a "stage of Skill Learning" characterization applied to the innovation.

The identification of courses in the curriculum relevant to the innovation may also have to depend on the names and objectives of training units within the courses. Unfortunately, if there is not a match between the nomenclature used in the search specification and nomenclature used to describe the training units and their objectives, a knowledgeable person may have to mediate the translation.

The identification of training units within courses will have to be made in the next step, if it has not been done here.

PROCEDURE

1. Identify by title and other identifying code, each course of instruction, current or projected, that fits the criteria of relevance to the innovation. Each course so identified will presumably contain one or more training units or elements (or portions of the course) specifically relevant to the innovation.

2. Even those innovations intended only for on-the-job benefits should have a determination of the relevant courses so that a training cost reference may be established.

3. The relevant training courses should be unambiguously identified so that the cost analysis performed in later tasks can find the correct reference data.

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: IDENTIFY RELEVANT TRAINING UNITS WITHIN COURSES

DESCRIPTION

Much or all of this subtask may have been accomplished in the process of identification of relevant courses, Subtask 05.16. The determination of training unit applicability may have been somewhat perfunctory. Furthermore, the identification of merely one relevant training unit within the course would justify including the course as relevant, without examination of the possibility of additional training units also being applicable.

The present subtask, therefore, requires an examination of all of the constituent training units and objectives with a course of instruction for meeting the contextual, as well as descriptor, matching of innovation to training requirement and training process. All previous analytic descriptor selection and search operations have focussed forward to the decisions of acceptance or rejection for relevance to be made in this subtask. That is to say, only candidates for acceptance have been selected.

PROCEDURE

1. Review carefully the description of the innovation in Task 1. Note not only its targeted objectives, but the contexts in which the empirical data were developed, and other substantive aspects of the innovation. This context of information should be held in mind while examining the context of the descriptions of each candidate training unit within the course.

2. Examine the context of the potentially applicable training unit with equal care. A guide for comparison is not so much in the training operation as in the clear identification of the specific skill or skill component that is to be learned by the student. This is an operational reference which is generally better than merely a verbal reference. The judgment of relevance may be facilitated by anticipating the next subtask by asking, "Will the innovation really improve, or not improve and impede the skill element that is being learned here?" If a strong doubt exists, it may be better to reject than to accept a candidate, so as to avoid unduly inflating the estimate of potential benefit from the innovation.

3. If the innovation aims at skill components that are clearly not identified in otherwise clearly relevant courses, these components must be so identified so that they can be evaluated as on-the-job benefits. The reference course should be identified, and the training units or objectives most appropriate by the acquisition of the added skill identified. This will enable a cost analysis for adding the necessary training to be balanced against assessment of on-the-job value.

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: ASSESS THE TRAINING BENEFIT PATTERN

## DESCRIPTION

The assessment procedure on the task content route has, to this point, identified the courses and training units within courses that are relevant to the innovation. In this step, the magnitude of the benefit will be assessed, the importance of the kind and magnitude of the benefit weighted, and the probability of achieving the benefit estimated.

The major target types of benefit consist of: training time reduced, aptitude level reduced, attrition level reduced, and performance level increased or extended. The benefit targets that can be most readily translated into cost advantages are reduction in training time and reductions in attrition levels.

Note that when relevant courses have been identified, the cost assessment model will identify the number of students and other multiples of the unit of benefit that have been estimated for the course.

## PROCEDURE

1. Answer questions about reduction in training time.

   Each of the following questions should be applied to each of the training course elements that is potentially relevant to the innovation. If more than one judge makes independent estimates about the same entity, the evaluation program will average the estimates, but also use the distribution of judgments as a measure of reliability of judgment about the effects of the innovation on that training course element.

   Question 1A. For each training element (or unit) relevant to the innovation, what is the estimated percentage reduction in training time for that element?

   The estimate will be a judgmental extrapolation from the description of the innovation made in Task 1, and any empirical data contained in that description, modified by subsequent investigation by the assessor. This estimate assumes that the innovation is technically feasible and is applied in moderately favorable conditions.

   If, however, the assessor believes that if the innovation is introduced, training time will actually increase rather than decrease or remain as it is, he should go to Question 1A Negative.

Question 1A Negative

Assume the assessor believes the innovation will increase training time over comparable conditions. He would specify NEGATIVE and the percentage of the training time increased over the standard or projected training time for the training element. He would then answer Questions 1B, 1C, and 1D as they are put, but with reference to the negative value.

Question 1B. For each of the next five years, what is the number of students that will be affected in that training element or unit?

Question 1C. What is the relative importance of this particular benefit in relation to all of the other benefits (or liabilities) offered by the innovation?

Use the following scale for estimating importance:

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| trivial importance | | identifiable but minor | | moderate | | very substantial | | crucial | |

This judgment enables the various benefits that may be derived from an innovation to be weighted against each other. It also enables a liability, if identified and assessed as part of the evaluation, to be weighted against other liabilities, and against benefits. The assessor may thus express the value he assigns to qualitative influences that should emphasize or de-emphasize quantitative expressions of benefits and liabilities in comparison with each other, with a general reference to the Navy's training and operational mission.

Question 1D. What is the probability of achieving the estimated magnitude of the benefit?

In Question 1A, the assessor identified the magnitude of the benefit estimated to occur under moderately favorable conditions. The assessor now makes the following two estimates.

a. What is the estimated magnitude of the benefit under conditions that would be most favorable? This value should exceed, by some amount, the estimate of the magnitude of the benefit under moderately favorable conditions.

b. What is the estimate of the magnitude of the benefit under conditions that would be highly adverse to it? This value should be less than the estimate of the magnitude of the benefit under moderately favorable conditions. The value could become a negative one, in which case the proposed innovation would be a liability with regard to this variable.

2. Answer questions about reductions in attrition rate during and at the end of training.

The innovation may be aimed only at a reduction in training time, holding attrition rate constant. Or the innovation may be aimed only at a reduction in attrition rate, while holding training time constant. The third alternative may attempt to combine reductions both in training time and attrition. The topic here applies to the second and third alternatives.

Estimation on change in attrition rate should focus on each training element or unit found relevant to the innovation. The standard formula used to express attrition rate in Navy training will define the present meaning of attrition. One should also assume that present standards or criteria of acceptable performance would apply to the innovation.

Question 2A. <u>For each training element (or unit) applicable to the innovation, what is the estimated percentage reduction in existing attrition rate (or normally projected attrition rate) to be expected from application of the innovation?</u>

Because attrition rates are expressed in percentage figures, the estimate will be a percentage of a percentage. Thus, if the normal attrition rate for course X is 20%, a reduction of the attrition rate by 30% would reduce the existing rate by approximately a third, to 14%. But because proportions <u>seem</u> generally easier to estimate than actual values, estimate the percentage (or proportion) of <u>reduction</u> of trainees normally attritioned that would not be attritioned if the innovation were introduced. Thus, estimate the percentage reduction in the existing attrition rates if this innovation were to be applied under moderately favorable conditions.

If, however, the assessor believes that under conditions moderately favorable to the innovation, the attrition rate will <u>increase</u> rather than decrease or remain the same, he should go to question 2A Negative.

Question 2A Negative

Assume that the assessor believes that the innovation will worsen the otherwise expected attrition rate. He would specify NEGATIVE and the percentage of attritioned students that would be increased. Thus, the expression NEGATIVE 25% would mean that a quarter more than the present attritioned students would be attritioned if the innovation were introduced.

He would answer Questions 2B, 2C, and 2D as they are put, but with reference to the negative value.

Question 2B. <u>What will be the number of students in the training element or unit in each of the next five years?</u>

Question 2C. <u>What is the relative importance of this particular benefit in relation to all of the other benefits (or liabilities) offered by the innovation?</u>

Use the following scale for estimating importance:

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| trivial importance | | identifiable but minor | | moderate | | very substantial | | crucial | |

This judgment enables the various benefits that may be derived from an innovation to be weighted against each other. It also enables a liability, if identified and assessed as part of the evaluation, to be weighted against other liabilities, and against benefits. The assessor may thus express the value he assigns to qualitative influences that should emphasize or de-emphasize quantitative expressions of benefits and liabilities in comparison with each other, with a general reference to the Navy's training and operational missions.

Question 2D. <u>What is the probability of achieving the estimated benefit in the reduction in attrition?</u>

In Question 2A, the assessor identified the magnitude of the benefit estimated to occur under moderately favorable conditions. The assessor now makes the following two estimates.

a. What is the estimated magnitude of the benefit under conditions that would be <u>most</u> favorable? This value should <u>exceed</u>, by some amount, the estimate of the magnitude of the benefit under moderately favorable conditions.

b. What is the estimate of the magnitude of the benefit under conditions that would be highly adverse to it? This value should be <u>less</u> than the estimate of the magnitude of the benefit under moderately favorable conditions. The value could even shift to the negative side and become an <u>increase</u> in attrition rate as compared with present attrition rate.

3. Answer questions about reductions in aptitude requirements.

Assume that the intent of the innovation is to reduce the normal or expected aptitude requirements for achieving course objectives, while maintaining existing training time and attrition rate as constants.

In this context, an "aptitude" is defined as a score on standard selection tests that are used for the classification of Navy personnel, which is a minimum score for acceptance to a given training program. By lowering a minimum aptitude level, more persons become potential candidates for the

course or training program. If the cutoff aptitude scores are on the high slope of the distribution of the ability, small reductions in aptitude requirements may result in very large increases in potential candidates.

A reduction in aptitude requirements for a given training objective will be valuable if the Navy sees: (a) shifts in overall demand for higher level aptitudes, thus increasing competition for higher aptitude people; and/or (b) a shift in supply of recruits towards lower aptitude levels. Either of these issues presents problems that are not subject to resolution solely in cost justifications. They will, therefore, not be directly addressed by the present procedures, although the issues may be expressed qualitatively in the following format.

It is possible within a given training context to assess the value of the innovation applied to aptitude level in terms of training time and attrition rate. Assume that the innovation claims to be able to reduce the relevant aptitude scores by "5 points". In existing training procedures (without the innovation), the people within these 5 points on the aptitude measures would require an average of 20% more training time, as compared with the average training time of those students within present aptitude levels. In addition, the new group would have an attrition rate of 30%, whereas the attrition rate of the old group was 10%. These are cost factors which can be used to evaluate the innovation.

Assume that the range-of-effect analysis has identified the training courses relevant to the innovation. It is also assumed that the minimum aptitude scores relevant to the innovation have been estimated. If this estimate has not been made, this estimate should be a part of Question 3A.

For each of the relevant courses, the following questions should be answered in making both quantitative and qualitative assessments.

Question 3A1. <u>What is the proportion of students in the innovated class who would be introduced into the class if the innovation were to be applied?</u>

This would be an estimate of the proportion of the average class size that would fall below the minimum existing aptitude scores and above the new minimum aptitude score. For example, the range of the reduced aptitude levels could account for 20% of all the students in the revised course makeup. In future questions, this group will be called the "affected students". Assume the innovation has been introduced under conditions moderately favorable to it when making this estimate.

Question 3A2. <u>What would be the average additional training time for the affected students to reach the criteria of the course objectives on the assumption that present conditions held, and the innovation were NOT introduced?</u>

It is possible to use existing experience in the course which relates level of aptitude to class performance for extrapolations to the lower aptitude levels.

Question 3A3. <u>Assuming the additional training time estimated for the affected students without the innovation, what would be the estimated attrition rate for the affected students?</u>

It is recognized that it is very difficult to make judgments about two interacting variables. Nevertheless, there will be a proportion of students who would have to recycle, even with an extended training time for the average of the affected group. Furthermore, there would be inevitable washouts who couldn't learn the material even with very extensive training.

Question 3B. <u>For each of the next five years, what is the number of students in the class of course of instruction affected by the innovation?</u>

Question 3C. <u>What is the relative importance of this particular benefit in relation to all of the other benefits (or liabilities) offered by the innovation?</u>

Use the following scale for estimating importance:

```
        1    2    3    4    5    6    7    8    9    10
      trivial   |       moderate     |          crucial
    importance  |                    |
           identifiable          very
            but minor        substantial
```

This judgment enables the various benefits that may be derived from an innovation to be weighted against each other. It also enables a liability, if identified and assessed as part of the evaluation, to be weighted against other liabilities, and against benefits. The assessor may thus express the value he assigns to qualitative influences that should emphasize or de-emphasize quantitative expressions of benefits and liabilities in comparison with each other, with a general reference to the Navy's training and operational mission.

Question 3D. <u>What is the probability of achieving the estimated magnitude of the benefit?</u>

In Question 3A, the assessor identified the magnitude of the benefit estimated to occur under moderately favorable conditions. The assessor now makes the following two estimates.

a. What is the estimated magnitude of the benefit under conditions that would be <u>most</u> favorable? This value should <u>exceed</u>, by some amount,

the estimate of the magnitude of the benefit under moderately favorable conditions.

b. What is the estimate of the magnitude of the benefit under conditions that would be highly adverse to it? This value should be less than the estimate of the magnitude of the benefit under moderately favorable conditions. The value could become a negative one, in which case the proposed innovation would be a liability with regard to this variable.

4. Answer questions about supplementary statements of benefits and liabilities. This would be Question section E to be added to Question 1 or 2 or 3, depending on which was answered by the assessor as the primary target of the innovation. This section is also a proper supplement to benefit evaluations derived from the Instructional Vehicle assessment route (Subtasks 05.02 to 05.08) and to benefit patterns applied to on-the-job benefits assessments.

Study of the innovation in the context of the evaluation process may bring to light a number of liabilities and benefits possibly overlooked in the assessment format. The assessor is invited to identify such additional benefits and liabilities, state them qualitatively and, where possible or applicable, quantitatively. By liability is meant an undesirable outcome of the application of the innovation -- NOT an impediment to the realization of the innovation. The assessor may see long-range effects, or side effects, or backlash effects not directly evident in the innovation.

The assessor should also review the data obtained in Task 3, Make Preliminary Feasibility Profile, and reaffirm or modify the feasibility factors as evaluated at that time. These factors may suggest additional benefits and liabilities inherent in the innovation.

As in his other estimates and predictions, the assessor should express, as best he can for each statement of benefit or liability on a variable, an estimate of its magnitude, its probability of happening, and its relative importance. An outline of format is offered in Figure 5.18.1. Where possible, the variable or factor which names the benefit or liability should be expressed as a qunatifiable entity, and an estimate of the magnitude of unit benefit or unit liability be expressed. The size of the multiplier of this unit benefit should be determined or estimated so that the full scope of the benefit can be expressed in the same way that the preceding variables (course length, attrition rate, and aptitude level) have been expressed. This would enable formal analysis to be made.

But even where quantitative magnitudes and the numerical size of the multiplier factor are not feasible, the identification of the supplemental benefit or liability should be made and accompanied by estimates of probability of occurrence and relative importance. Such statements may not be processed formally through cost models, but presented to the decision maker in the form on which they are set down by the assessor.

Use Figure 5.18.1 as a structure for describing the supplemental benefit or liability. It is probably not desirable to make a printed form for this information as the assessor may be constrained from getting and setting down contextual information essential to understanding the message because he is inhibited by lack of space or lack of suitable category heading.

COMMENT: The data developed in response to the previous procedural questions should be prepared and formatted according to the demands of later tasks to which they are input. These include cost-benefits analysis and economic analysis.

5. Transmit data developed in this subyask to Task 6, Perform Cost-Benefits Analysis.

TASK: DETERMINE RANGE-OF-EFFECT

1. Identify the name of the variable or factor which is a supplemental benefit or a liability.

2. Estimate the magnitude of effect of the benefit/liability.

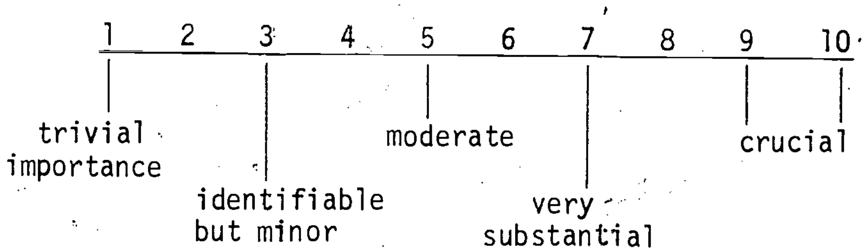
   a. If possible, quantify the unit of magnitude, and the multiplier factor, to apply to the unit of magnitude appropriate to the intended scope of the application of the innovation.

   b. If numerical quantification is impractical, express magnitudes in relative terms.

3. What is the number of entities or instances (jobs, courses, students, etc.) to which this magnitude of benefit (or liability) applies?

4. Estimate the relative importance of the added benefit (or liability) to the overall effectiveness of the innovation.

   Use a scale from 1 to 10.




   Any additional statements that may add or qualify information for the decision maker may be added informally.

5. Estimate the range across which the magnitude of benefit (or liability) may occur.

   a. The estimate of magnitude made in item 2 presumably assumed conditions moderately favorable to the benefit occurring (or moderately unfavorable for the liability to occur) at that magnitude.

   b. Estimate the magnitude of the benefit under conditions highly favorable for the innovation. (The converse for a liability.)

   c. Estimate the magnitude of the benefit under conditions highly adverse to the innovation.

6. State reasons and justifications for these expectations.

FIGURE 5.18.1 FORMAT FOR DESCRIBING A SUPPLEMENTARY BENEFIT OR LIABILITY

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TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: SELECT TYPE OF KNOWLEDGE

DESCRIPTION

A key factor in the economics of training is that, unlike most skills, most knowledge can be learned by demanding only symbolic responses from the student. The presentation may range from text, diagrams, photographs, and motion pictures, to computer generated displays. But the students write or vocalize answers or push answer buttons. Knowledge is symbolic information <u>about</u> things and actions, and rules, whereas a skill is manifest in actions performed as tasks with purposes and goals. Knowledge may support skill, but is not equivalent to skill.

Unlike skill training, which is more or less directly tested by its applicability to job demands, knowledges can be tested for their contribution to learning and on-the-job performance only by elaborate empirical tests which are rarely made, and usually have discouraging results unless one is concerned with where to cut costs. But because knowledge training is relatively inexpensive to administer, as compared with skill training, it widely persists.

Distinctions should be made between reference knowledge and enabling knowledge. A reference knowledge is information context that is not directed to a task or skill, but to various kinds of environments and ideas in which the worker works and the job is performed. Reference knowledge may have motivational value, such as when demonstrating the consequences of accidents that followed violation of safety procedures.

An enabling knowledge is one which directly assists in the learning of a task skill or supports it in practice. Thus, the ability to verbalize a task procedure, while not the task skill itself, assists in learning and performing it as a skill. Other enabling knowledges consist of factual data that are used in task performance.

A major distinction can be made in the way that knowledge content is learned, retained, and recalled. A <u>rote</u> knowledge implies that verbal lists, tables, or sentences are memorized and reinstated in a verbatim sense (multiplication table, stanzas of a poem). Materials learned by rote have a restricted range of meaning, so that the content of rote material generalizes very little. In general, materials of this kind are often learned by repetitive practice. However, they may be better retained over periods of time when supported with mnemonic images; or when embedded in examples and other "meaningful" material.

A second form of knowledge content is conceptual -- it deals with ideas rather than associations between symbols. Concepts are abstractions that apply to

classes of entities and their properties. The meanings of terms like "circuit", "innovation", and "effectiveness" are the nature of a concept. Concepts are subject to generalization by learning and by thinking processes. Concepts can be organized into "principles" and higher order concepts. A learned concept has a label and a meaning or reference, although it is possible to exercise the "meaning" of a concept without knowing or recalling its label.

The value of a knowledge is tested not by its mere existence in memory, but by its recall as a body of content when circumstances would make its recall useful. Thus, it is not only the recall of the knowledge content that is of practical importance, but also the recall of the <u>applicability</u> of the knowledge to a situation other than to a classroom test question. As an illustration, the knowledge of human reaction times <u>should</u> deter the applied psychologist from tailgating drivers ahead of him at high speeds.

It is possible that the following list of identifiers may assist in identifying the courses and course item objectives to which an innovation in reference knowledge training might apply. Perhaps a better terminology would be based on traditional names assigned to these kinds of training objectives by Navy instructors if the names were used consistently. A key name which is fairly general is "theory of operation" which, as identified, consumes many classroom hours in instructional institutions everywhere.

Individual facts and organized clusters of knowledge, meaningfully connected, make up a body of reference information which may be essential to the performance of skills in verbal communication, as described in Subtask 05.13. To this learned knowledge should be added skills that make up the task of "communicating verbal information". As indicated in the following subtask (05.20), reference knowledge, often of more limited scope, can be supportive -- if not always essential -- to many kinds of Navy tasks, including those that are supervisory.

The reader is reminded that an innovation that deals with cost factors associated with a vehicle of instruction -- such as devices that present pictures of things in motion -- may have its range-of-effect more efficiently determined by the Instructional Vehicle route, Subtasks 05.02 through 05.07.

PROCEDURE

1. Determine whether the instructional content or process in the innovation is applicable to a reference knowledge type or to an enabling knowledge type. Make this determination on the basis of the DESCRIPTION under Subtask 05.20, and the categories described in Subtasks 05.20 and 05.21.

2. If the innovation applies exclusively to reference knowledge types, proceed to Subtask 05.20.

3. If the innovation applies exclusively to an enabling knowledge, go to Subtask 05.21.

4. If the innovation appears to apply to both reference and enabling knowledges, follow the route beginning with Subtask 05.20 and Subtask 05.21.

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: SELECT APPLICABLE TYPE OF REFERENCE KNOWLEDGE

DESCRIPTION

A reference knowledge consists of information about the contexts of the personal, technical, and organizational situations in which the incumbent and his work will be active. Thus, the information may be related to the work and work environment, and perhaps the incumbent's living and social environment, but does not constitute a primary work skill, nor does it appear to have any direct bearing on the learning of the skill, except perhaps by motivational routes. An example of the latter might be satisfaction in being identified with important and prestigeful organizations and functions, or the opportunities for promotions and career development.

Each of the following types of reference knowledge may have somewhat different instructional capabilities, but not necessarily. Obviously, all of these types could be transmitted by classroom lecture or by textbook. But imaginative techniques could be devised for each type that could make it more effective -- for whatever purposes training management may have -- as well as more efficient than the traditional alternatives.

PROCEDURE

1. Determine to which one or more of the knowledge types listed below the innovation is applicable.

2. Even if the innovation's description points to a given type of course content, or to a given named course, check its possibilities against the other types and identify them.

   - System Purposes

     What the entire organization and its parts are supposed to do and the various conditions under which its goals are to be accomplished. The concept of mission, and mission objectives, and of the values to be sought and maintained. The "system" may range from the Department of Defense, the Navy, or a branch of the Navy, to the ship or installation and, more specifically, to the purposes and objectives of the arm and watch. The form of instruction may range from platform speeches to motion picture scenarios to dynamic simulations.

   - Organizational Roles

     These could be an extension of system purposes; what organizational entities have what responsibilities and authorities and spheres of influence. Typically, organizational roles are communicated with

organizational charts. Potentially, far more meaningful forms of presentation could demonstrate the cooperative and competitive functions of hierarchic and scalar relationships in organizational dynamics.

- Contexts of Operation

The interfaces between the incumbent's job and job responsibilities that impinge on his own. Also, the range of situations and circumstances in which the incumbent is expected to perform his tasks in real environments. This might include the range within which his initiatives are to be encouraged, but outside of which constraints are imposed on his initiatives.

- Theory of Operation

This may range from theory of electronics to the construction of and operating functions of the classes of equipment the maintenance mechanic is to repair. In another type of job, dietary theory as potentially applied to the planning and preparation of meals. Theory of operation generally applies to how something works. The content may be developed at any of many levels of discourse. It can serve as a basis for learning of nomenclature and identifications that later may be relevant to skill learning.

It is possible that the learning of a suitable kind and level of a theory of operation may enable some job incumbents to <u>deduce</u> task actions in the absence (or forgetting) of the applicable procedure. This assumption may underlie instruction in theory of operation to maintenance mechanics as a substitute for troubleshooting strategies and procedures. The practical justification for this assumption may be debated elsewhere.

It is also possible for the learning of theory of operation to serve as memory aids for procedures, both in their learning and their retention and long-term recall. In order for this assumption to be justified, there would need to be a careful scheduling of instructional sequences such that the two kinds of learned content would effectively support each other in the student's economics of learning.

Since theory of operation generally represents some kind of flow or sequence of process or action, a dynamic display is suggested where process variables may be changed and the consequences observed in overall system behavior, or in the behavior of affected components.

To the extent that learning theory of operation does facilitate the learning of a skill or enhance its performance, it falls into the class of enabling knowledge.

- Organizational Rules and Constraints

  These may range from rules governing security to the procedures for ordering a spare part. They represent realistic factors in both the working environment and the personal environment of the incumbent. Realistic instruction should probably include the kinds of conditions that justify the breaking of a policy and the means of making the justification.

- Nonwork Directed Content of Instruction -

  A miscellaneous category. May range from personal hygiene and recreational facilities to interpersonal psychology.

3. Specify the capability of the innovation to support one or more of these types of reference knowledge, and the key function or capabilities which enable the training or learning enhancement to occur. The description should be structured so as to assist in identifying courses and course content in which the innovation, applied to these or other reference knowledges, may be applicable.

4. Examine the characteristics of enabling knowledges, Subtask 05.22, bearing in mind the possibility of applying the innovation to these kinds of instructional content, as well as to reference knowledges.

5. Since reference knowledges are relatively independent of specific skill training courses, or may generalize as part content across a wide range of skill courses, the assessor may have to proceed directly to the data base descriptions of all training courses in the Navy inventory. "Theory of Operation" is perhaps the only term which is fairly standard for this content in all courses and curricula, at least in equipment oriented training. (But even courses in the culinary arts have a theory of dietary principles, and navigation courses often contain theory of celestial mechanics.) This state of affairs places a burden on the assessor's access to knowledgeability about the knowledge content of courses in general, and terminologies used for course objectives that apply to <u>interpretations</u> of the applicability of the innovations.

RATIONALE AND COMMENT

The issues raised in step 5 make up the general difficulty in the classification of training materials that do not quite point directly to skill criteria, or to a pattern of steps, each one of which has a tangible and identifiable function in progressing towards a skill objective. The characterization of the skill objective, being subject to evaluation in an operational environment where work output can have assignable value, simplifies a naming technique that is fairly unambiguous. By contrast, the naming of knowledge content may be somewhat arbitrary in terms of its inclusiveness on degree of detail.

The assessor may, however, find another dimensioning of knowledge (cognitive) materials useful. They are related to R. M. Gagné's taxonomy of building blocks in learning (see his Conditions of Learning), but do not imply sequential progression. They do imply differences both in the learning process and in effective instructional technique. In brief, the classifications are:

Facts, prescriptive rules, and other content learned by repetitive rote practice or "memorization". Tables of information, such as the arithmetic tables, or one-for-one codes. The rote operations may be embedded in memory aids and meaningful contexts, such as the name of a device with a picture of description of its use.

Concepts, which are ideas that have generality, such as of the properties of things, or of functional relationships among things or processes, or structures. Thus, "hierarchical rank" is a concept, whereas "Always salute a superior officer", is a rule. A concept is a basis for making equivalent the members of a class of things, as red and blue are equivalent under the concept of "color". Concepts have to do with the meanings of abstract terms. They are learned by abstracting the common feature among a collection of otherwise different experiences.

Principles are combinations of concepts in the form of sentences, such as: The vehicle moves (a concept) when its wheels have sufficient friction or traction on the roadway (another concept). Principles are learned and applied by linking verbal statements to a variety of experiences which manifest the principle.

Problem solving may be the application of a structure of facts, rules, and principles to the structure of a problem situation.

These are highly condensed characterizations, each of which justifies a pedagogical chapter to make operational for the purposes of instructional analysis and design. It is possible for innovations to be highly applicable (efficient and effective) for one of these classes of learning, but relatively inapplicable to the others. Thus, much of traditional programmed instruction is directed mainly towards the learning of rote content. By definition, items in rote content have little context (meaningful associations) attached to them.

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: IDENTIFY TYPE OF ENABLING KNOWLEDGE

DESCRIPTION

An enabling knowledge is one which facilitates the learning of a skill. It may or may not be relevant to the exercise of the skill after the skill has been acquired. Although the concept of enabling knowledge has been widely used as a rationale by educators for teaching almost anything whatever as "prerequisite" to skill training, the present pragmatic approach to the acquisition of on-the-job skills emphasizes a direct relationship between the knowledge and skill acquisition. The following categories cover the major range of enabling knowledges that are quite clearly applicable to skill learning.

An enabling knowledge tends to be most effective when it is acquired immediately preceding training on the target skill, or some phase of it, but the economics of instruction may be thought to justify separation in time and instructional context between learning the knowledge and learning the skill it should support.

PROCEDURE

1. Identify the type of enabling knowledge applicable to the innovation.

- Operational Goal Criteria

  The variables in the performance of skills that determine goodness of the performance. Some of these criteria may be immediate and local, others may be remote in time and locale. In effect, this is not only what good versus poor performance outcomes look like, but why they are important to the incumbent, to his organization, and to the Navy mission. Realistic instruction may include the specification of conditions under which some criterion performance levels may be relaxed as a trade-off against no performance at all. If such material is shown in operational contexts, perhaps with specific examples, the student may acquire sets of values that enable him to exercise judgment under the pressure of conflicting objectives in work situations. Verbal abstractions and exhortations may be ineffective in transferring to the work situation. In general, learning about operational goal criteria will be useful to the student in operations, to the extent that he can relate them to choices in his own actions at the time he must select the action.

- Nomenclature, Identification, and Location of Work Objects

  The learning of the names of things associated with tasks, what they look like, and where they are located, has direct transfer value to

the learning of tasks that are not solely manipulative. The better that nomenclature and identifications are mastered, the more readily can the student apprehend and remember instructional content that deals with that nomenclature and associated images of appearance and location.

Instruction in this material may recognize that learning is faster and retention better when the elements are learned as patterns in contexts that are meaningful to the learner.

- Procedure Descriptions

Procedures may be described at many levels of abstraction. How efficient the learning of abstract descriptions of procedures may be to their later learning at the level of detailed steps is not of concern here. Presumably, any image that the student acquires about actual operating procedures which he will have to perform may have some mnemonic value to later learning of the actual procedure as a skill. When the description of the procedure to be learned by the student is highly task specific, the student is learning what is called here a "task format", which is treated more systematically in the section of that name, Subtask 05.22.

Procedures applicable to tasks may extend to action policies, principles, and strategies. Instruction here may consist of what these policies and principles are, rather than in practicing them in simulations of task performance. Knowledge about these policies and strategies may facilitate learning them in practice as a skill.

It should again be underscored that an enabling knowledge -- as contrasted with a task format -- about procedures consists of generalities about procedures or protocols, and <u>not</u> the specific learning of the procedure as a literal action specification. Thus, if the student merely skims a procedure specification in a handbook of instruction, it would be appropriate to call the result of this skimming an enabling knowledge. But so would be a general outline of the procedure which had to be learned, as such, to a high criterion of recall. The result is a general impression of how the procedure is performed.

- Job Relevant Facts

These are facts and data directly applicable to job tasks. These range from the number of degrees in a compass to the temperature at which a soldering flux bonds a given metal, the calories in a pound of potatoes, or the electrical resistance denoted by various color bands on a resistor. Each of these examples can readily be tied in with a class of job task. The relevance of a fact to a task can readily be determined by asking if the task can be effectively performed in the absence

of knowing, or accessing, the fact. Unfortunately, care is not always given in the design of training content to differentiating facts essential to the task from those that are gratuitous. (An innovation might well consist of a technique for making such distinctions.)

2. Procedure cannot be specific in the identification of task-enabling knowledge content in courses of instruction. This content is often mixed with other instructional content. However, many training courses will explicitly identify "nomenclature", or a synonym, as the training objective of some unit of instruction. There may be equivalent designations of "General Procedure" in some courses, expecially those for duties at the officer level. But it may be difficult to parse out course content that is directed specifically towards instruction in "Operational Goal Criteria." The assessor may require extensive knowledge about courses, or interpret the descriptions of their objectives and content in order to identify enabling knowledges.

   For these reasons, no high degree of precision in estimating the potential effects of innovations dealing specifically with enabling knowledge can be expected. The alternatives are either detailed manual examination of course content, or very gross estimates of percentages of given course content, in terms of student hours, spent on enabling knowledges.

3. The output of the analysis performed in this subtask should be passed through Subtask 05.22, Identify Type of Task Format, in order to check as to whether the enabling knowledge supports instruction in task formats.

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TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: IDENTIFY TYPE OF TASK FORMAT

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DESCRIPTION

A task format is a structure of how the task is done. One can learn the task format without being able to perform the task in real life circumstances. But if the task format is genuinely applicable, the learning of the format will generally facilitate learning the task as a skill. This does not assert that learning the format at the same time that one practices the skill will not be more efficient than the two-stage process. And the way in which a format is learned may be significant in its value to learning the skill.

Task formats may be general or they may be specific. Thus, the idealized general format for using a test instrument consists of: (a) determine the variable to be measured, the range of the variable to be measured, and the degree of precision in measurement; (b) locate the test instrument and identify it by name, and check its function and capability according to the purposes of the moment; (c) check its calibration . . ., and so on through its use and return. These are conceptualized set of steps that apply to the use of any test instrument. It is an example of a task format.

At another level, a task format may be a verbalized specification of every detailed step to take in selecting and operating a specific voltmeter. The verbalized instructions are not the equivalent to the ability to execute the self-instructions in practice, but they may serve as a guiding template for carrying out the action.

A printed requisition form embodies the task format of preparing a requisition for one or more objects or services. The <u>names</u> of the blanks to be filled in are the variables in the transaction. The entire task format for making a requisition may include finding a copy of the form, filling it in, and transmitting the order form to the purchase agent.

The learning of a format enables a person to copy with a variety of different situations that fit the variables that make up the format. The concept of task format (whatever the concept may be called) is important to the economics and practices of training and transfer of training. It is not a novel notion in educational and training practice, but its role in training technology should be made explicit. Instruction in task formats is relatively inexpensive in training equipment because it can generally be accomplished with symbolic exercises. The sections in this report that deal with short-term memory and with decision-making (Appendix A on Task Structure Elements) amplify the meaning and application of the task format concept. Appendix A also contains an analytic essay on task formats.

A task format is a skill component, therefore it is set apart from the topic Enabling Knowledge.

PROCEDURE

1. Determine whether the innovation is aimed at instruction in some one or another type of task format. This decision will be based on the general definitions of task format contained in this subtask under DESCRIPTION, Appendix A, and in the topics under step 2. If the innovation is inapplicable to task formats in the specific sense described here, go on directly to Subtask 05.14.

2. Determine the type or types of task format to which the innovation applies. The following are fairly exhaustive of format types with respect to cognitive tasks, or tasks primarily directed by cognitive processes.

   - Procedure Formats

     A task format may serve any one or combination of the following functions: a structure for searching for task information; for apprehending and retaining task information in working or short-term memory; for accessing the relevant content in long-term memory; for processing task information; and for executing the work output required of the task.

     By this definition, task formats may apply to any one or combination of Task Structure Elements (Subtask 05.13). A given work procedure may emphasize some one of these task elements, but many procedures consist of a series of steps in sequence. At one level of format, the student memorizes the verbal statements that comprise the steps in the procedure. Another kind of format -- which may support the first -- is his memorization of a set of pictorial images (such as from a series of diagrams, slides, or a motion picture) of the sequence of steps. Another support may be demonstrations of the procedure by the instructor with actual work objects. To the extent that these various "encodings" of the procedure are consistent with each other, they strengthen each other in the student's memory of the procedure, and his potential ability to translate the format into live action. But, because the student may not have an action repertory to match the symbolic representations of those actions, he cannot perform the actual procedure at acceptable skill levels without live practice.

     Task formats may be learned to some useful degree, independent of practice in the live task itself, with real work objects in real situations. But the learning of task formats is not necessarily independent of learning the task by direct practice on it. Beyond given levels of learning on a given task format, it is likely that

additional practice on the task format will have diminishing returns in transfer and savings effects on the learning of the live task. The smaller the demand by the task on complex information processing by the student, the smaller the relative amount of practice on the task format that will be useful. Sequential procedures where each step is a relatively simple situation-response unit demands, by definition, relatively little information processing except that of the sequence of steps.

In conclusion, many procedure formats will, in practical terms, consist of the verbalization and imagery of procedural steps that comprise the task. The "rules of play" for the game in chess is an example of one level of task format for the game.

- Decision Formats

Because decisions are information processing operations, decision formats and exercises in decision-making can be accomplished apart from live task settings. There are exceptions, such as when the decision is a progressive one and depends on interaction between the incumbent's overt behavior and the response of the environment to his behavior. But even in such cases, limited decision formats may usefully be learned independent of live practice. In fact, this is what many instructors attempt to do when briefing a student in advance of a maneuver in what he should attend to and be prepared to do. The briefing establishes at least a temporary format for the performance.

A decision format is primarily a transactional template of (a) the variables that make up a given type of problem situation, (b) the variables in the relevant response set from which an alternative is to be chosen, and (c) the rules, policies, or strategies for selecting the response to a given problem context. A decision format may include the process of handling absent, ambiguous, or garbled data about one or more problem variables, such as by implicit assignment of probabilities that the variable has some hypothetical value in the given case. The once popular business-gaming exercises attempted to teach students of business the formats of marketing decisions.

Strategy principles for selecting a move, or a series of moves, in chess, are an example of relatively complex decision formats above the level of rules for moving chess pieces.

- Construction Formats

Whereas decision-making tends to be a process of converging on the selection of a response from a limited response set, constructing tends to be both a divergent as well as convergent process. The design of a pattern, such as a plan for building a bridge or for an

attack mission, often requires the <u>construction</u> of alternatives as well as their selection.

3. Specify the type of format, and make a judgment as to the range of types of job tasks for which the innovation might be applicable. Note that all requirements for verbalized learning of procedures in order to fulfill verbal tests of procedural competence, point to what is here called a "procedure format." Any training objective which reads: "Must give a detailed verbal description of the procedure," identifies the learning of a format in the sense applicable here. Training in decision and construction formats is less well understood and practiced.

   Key terms applied to job tasks, and training courses that may be applicable to the innovation applied to decision-making and constructions include; troubleshooting, diagnosis, fault localizing, planning, scheduling, laying out, constructing, problem solving, calculating, and plotting.

4. Pass the descriptions generated in this subtask, as well as information coming from Subtask 05.21, Identify Type of Enabling Knowledge, into Subtask 05.14, Identify Relevant Jobs and Tasks.

5. The alternative can be to use the descriptions of the task formats, applicable to the innovation, for going directly to the data base of course description, bypassing the job task analytic route.

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TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: ASSESS ON-THE-JOB BENEFITS

DESCRIPTION

The making of rigorous cost-benefit assessment of improvements in on-the-job performances of various kinds follows the same principles that were used for developing and applying to functions in the training enterprise. But the gap between principle and practice has not been bridged for formal on-the-job analysis.

However, lack of formalized analytic techniques should not deter useful judgments to be made in practical circumstances where something needs to be done, and an informed guess is better than nothing at all.

The innovation may not be justified by benefits achieved solely within the training organization, such as by reduction in displaceable costs in instructional vehicles, reduction in training time, or reduction in aptitude levels. In consequence, the justification of the innovation will depend on its making a worthwhile contribution to graduates doing their jobs in actual job environments.

A rigorous cost justification of increased job competences derived from analysis in the operational environment is rarely feasible, and when it is, critical variables will be omitted. Examples of such variables may be morale, dependability, readiness, initiative, dedication, and similar abstractions which although having subjective meaning and sometimes even predictive validity when based on subjective evaluations, fail in objectivity necessary for cost and value analysis.

The following is a nonexhaustive list of types of on-the-job benefits which may result from innovations that "improve" the product of training: on-the-job skills and competences. It is assumed that the innovation has been put through the range-of-effect analysis, and that tasks and jobs relevant to the innovation have been identified quite specifically. From this identification, the number of incumbents to which the innovation is now, or potentially, applicable can be quantified. Having identified the one or more types of benefit applicable to the result of the innovation in a job skill, the assessor follows the same format for describing benefits as outlined in 05.18.

In this case, the assessor is not likely to be a training officer, but an operations officer familiar with the relevant job skills and the work environments in which they are performed. Only such individuals are able to make useful judgments of magnitudes and importance of given enhancements to specific skills, and the probability of realizing the benefit under actual work conditions. Thus,

if a person's duties, as they exist, tend to demand his full time and attention, there is little benefit to be gained from giving him skills which demand additional time, or that require him to be elsewhere. Nor is there point to providing him with a skill to be exercised where the tools necessary for exercising the skill are unavailable. A potential benefit must have an opportunity to happen in order for it to become an actual benefit.

Having completed the analysis of a potential benefit derived from an innovation. an attempt may be made to determine its value in various kinds of savings in operational environments, such that these savings can be translated into dollars. Examples of such savings may be in terms of:

Reduction of manpower units in the operating organization.

Reduction in tools, supplies.

Reduction in expendable materials wasted per unit of mission effectiveness; e.g., wasted rounds per kill.

Reduction in units of standby equipments for operational readiness.

Reduction in probability of catastrophic failures; e.g., personnel casualties, planes lost, ship's engines crippled, collision at sea, major oil spill, nuclear diffusion to open environment.

But where savings of this kind cannot be determined or are inadequate to account for the benefit, a subjective evaluation of the benefit must be made by responsible officers. This evaluation of the benefit must then be weighed, subjectively, against the costs of the innovation and the probabilities of its being realized.

If the added cost to training incurred by the innovation must work within fixed training and other personnel resources, then the evaluating officer may have to make a second order decision: what to sacrifice in the existing products of training to compensate for the added cost of the innovation. This kind of decision is typical of management that operates under the constraints of budgets.

The following are types of benefits from enhanced skills.

Greater flexibility in assignment.

Less on-the-job training required for acceptable work performance.

Higher productivity levels, higher quality of performance (fewer errors).

Greater range in work competence -- in situations, environments.

Willingness under stress -- increased motivations to continue working under adverse conditions of discomfort, hazard, fatigue.

Initiative: increased capability for self-initiated and self-directed activities.

The use of one or more of these descriptive titles should be augmented with specifics related to tasks and task contexts in the description of the benefit.

PROCEDURE

1. The assessment of the benefit should be completed by using the "Format for Describing a Supplementary Benefit or Liability" in Subtask 05.15.

TASK: DETERMINE RANGE-OF-EFFECT

SUBTASK: IDENTIFY RELEVANT FUNCTION IN DEVELOPMENT AND ADMINISTRATIVE MANAGEMENT OF TRAINING

DESCRIPTION

The giving of instruction is preceded and surrounded by many kinds of support activities. Although some of these activities may be peripheral to training functions, many of them are mainstream and essential. These activities can be clustered into nodes or functional tasks in the support of training. As processing functions, they receive, process, and output decisions and other classes of work information.

Much of the information developed as output from one node of task activity in the training enterprise, is passed along as input to another node. Thus, task analysis and job requirements and specifications, as an output, become partial input to another node which develops "course specifications" as an output. This, in turn, passes into a node which generates "course content analysis and development." Finally, this sequential network, with contributory branches, results in instruction to students which, hopefully, results in learned skills, which in turn result in on-the-job performance.

With some exceptions, this network of nodes seems rather loosely coupled. That is, kinds and categories of information that function mode A should produce as input to node B in order to precisely meet the requirements of function B, is generally vague. Thus, much of what B ought to have, it does not get from A. And much of what it does get from A, it doesn't need or know how to use. B's difficulties stem partly from not being tightly coupled to function node C. B does not know precisely what input C needs to do its job, and this uncertainty is transferred back to the relationship of B to A.

This loose coupling of information structures and relationships presents great problems in any attempt to evaluate an innovation which claims to "improve" the effectiveness of node function B. If the innovation merely claims to do what B does now, and no better or no worse in terms of input demand or output product, then the innovation can be evaluated only on whether it saves costs in performing or supporting function B. If reducing the cost of the B operation imposes a greater cost on what A must produce, however, then the savings must be the net from the savings effected in B, minus the increased costs in A.

But suppose that the innovation claims to improve the "quality" of B's output to function C, but at an increase in the cost of B. The benefit must be assessed by what happens in C. If C's output to D is not improved as a direct result of B's improvement, the claim of improvement in B cannot reasonably be

substantiated, with this exception: the cost of function C is reduced as a consequence of the new kind of output from B. This chain of referral of "benefit" ultimately ends in the performance of the student after he gets on the job, and in assessing improvements in that performance that can feed back to justify the increase in the cost of function B. The more tightly coupled the functional nodes are to each other, the more readily can such evaluation be made.

This observation should make it clear why many innovations that have high face validity for improving a function in the training subsystem, are virtually doomed unless there are corresponding changes all along the line, or unless the innovation really eliminates duplicated work among various nodes -- but this should really be evaluated as a cost saving, an improvement in the efficiency of what is done now, and not an improvement in the quality of the "service." It should be noted that in actual training operations there is a common reference criterion of "quality": how much did the student learn and perform per unit of cost? This ultimate criterion is measurable, hence subject to assessment against a cost base.

Intuitively at least, there seems to be massive potential for improving the quality and cost picture in the many supporting activities that are here called "Development and Administrative Management of Training" (D&A). But without the ability to trace through the improvement in quality of output in a given D&A function to a knowledge or skill product, the assessment of changes having the intent to reflect in improved quality of operations must be limited to demonstrations of cost improvements, or to quite intuitive hunches that somehow better training will be the result. But, because the system can readily absorb local changes without overt effects, the hunches are likely to be overestimates.

A process model, therefore, needs to be developed which, at some practical level of precision, can enable an innovation in technique or tool made in function B not only to be measured in costs to B and all of the functions that feed or are fed by B, but also to relate the change in B to an ultimate quality benefit in student skills. It is naive to assume that such a process model can be as rigorous as a computer algorithm, but it need not be. Part of the art in developing such a model would be knowing when to stop in seeking precision, and when a practical level of precision had been reached.

These considerations, therefore, lead to focus on reducing costs in given operations within a D&A node, or among a group of nodes. Such analysis cannot differentiate whether the reduction in cost is in something which affects a training product or is irrelevant to a training product. In the case of an exception, where the assessor can relate an innovation in a function directly to a learned product in on-the-job performance, his assessment of the latter will enter Subtask 05.10, Identify the Learning Objective, and proceed through Subtasks 05.11, 05.12, and so on, through 05.18, in the task content training path:

The following is a list of D&A functions and brief characterizations of them. The list is not exhaustive, and the innovation may not fit any particular one of them. This is not particularly important, because in any event the assessor would have to localize the processes or products in the D&A network which the innovation was specifically intended to replace or displace.

- Capture and Description of Skill and Knowledge Requirements

  This is a set of techniques. Their application is of variable quality and utility, although invariably time-consuming. The data feed into virtually all training operations that follow and extend into job incumbent assessment, at which point they can become feedback as "requirements" data to training.

- Matching the Skill Requirement With Descriptions of Available Resources

  This is a decision-making situation. The operation may consist of seeking for and matching a pattern of skills requirement with existing skill and knowledge in trained and/or experienced persons; or it may be an attempt to match the requirements with a pattern of existing resources in the form of aptitudes to learn the required skills.

- Matching the Skill Requirements With Available Training Resources

  This is a decision-making situation. Training resources consist of space, facilities to house and teach, existing courses, and personnel.

- Developing Training Requirements From Skill Requirements Descriptions

  A set of techniques. The training requirements picture will be a breakdown of the overall skill requirements into enabling and terminal instructional objectives, derivations of knowledges to support skills or skill acquisition, functional requirements of instructional vehicles, and allowable training time per student.

- Selecting the Training Environments

  This decision may precede or follow the specification of the training requirements. It will result in a choice of what training objectives are to be acquired in formal training, and which ones in on-the-job training and experience. It may also select the school where the option is available.

- Slow Versus Fast-paced Development of Training Material

  This is a decision which is followed by technique. On occasion, the demand may arise for getting people trained at a very early date, so that the normal processes in the development of training must be by-

passed or accelerated. This bypassing may be costly in hard-to-find talent and other training resources.

- Selection or Devising of Training Modules

  A decision followed by techniques to implement. A training module may be a course used as an element in a pattern of other courses. The module thus serves more than one purpose. The module may be instructional entities within courses or even independent of courses. A good modularity is one which enables the smallest set of modules to be organized to serve a wide variety of purposes with a minimum of waste.

- Selection of Instructional Vehicles and Media

  A decision-making operation. The result is not merely the choice of individual vehicles, but a set of them which, together, are cost-effective in producing a pattern of interlocking skills and knowledge making up a duty, job, or on-the-job competence.

- Designing the Content of Instruction

  Techniques for developing the content of what the instructional vehicles deliver to the student. This results in what the student actually sees, tries to learn, and does. The technique may be general to any training, or restricted to a type of skill or knowledge objective. If the latter, further analysis of range-of-effect should be made by following the procedures in Subtasks 05.19, 05.20, and 05.21.

- Devising Selection Procedures for Students

  Techniques for relating the level and range of training objectives for a job or duty, and time allowed for the training to these objectives with entrant capabilities in the form of existing levels of skill and knowledge acquired by training or on the job, or in the form of measured aptitudes predictive of learning rates and potential terminal skill levels. Note that this item relates to the previous topic on "Matching the skill requirement with descriptions of available skill resources."

- Assessment of the Student

  Techniques for efficiently sampling from student skills and knowledge at the end of training, with respect to training objectives and job requirements. Also, decisions as to cutoff levels for washouts.

- Assignment of Graduates to Job Positions

  Techniques and policies for matching the competences (or the description of competences) of graduating students with the identification or

description of job and work environment assignments.

- Evaluation on the Job

Techniques for efficiently and effectively assessing the on-the-job competences of the graduate, the extent to which his range and level of performance is unacceptable, acceptable, or superior, and the transcription of these data on the student's record for use in his later training or assignment, and for use in the revision of training.

- Career Development

Techniques for the organization of a progression of training and job experiences that are psychologically cumulative and operationally practicable, and decision structures for the matching of a career pattern with individuals at various stages of training and experience.

- Administrative Planning and Control

Decisions and techniques for the planning and control of the overall operations of the training enterprise, or substantial segments of it. The adapting and regulation of input requirements and objectives with existing and planned resources, according to organizational policies and values. The information base may consist not only of current status and projections of immediate future status, but archival data that enable experience to project the implications of trends, and the range of variability in system behavior within which the perturbations will damp themselves out, but outside of which the perturbation will amplify itself. The information base may also contain long-term future predictions of needs that enable the application of structural models for developing game-playing solutions.

- Evaluation of Learning or Entropy of the Training System

Techniques for assessing and evaluating whether the rate of adaptive change by the training enterprise as an operational structure is progressively losing control of its overhead costs, the relation of process to product, and to the required quality of the product, or whether the rate of adaptation is outpacing the entropy characteristic of very large organizations over a period of time. This function is somewhat outside that of operational administration.

PROCEDURE

1. Using the foregoing categories as a guide, but without being limited to the subject matter identified by them for D&A functions, identify the tasks and task activities to which the innovation is relevant, both as a benefit and as a liability. The relevant tasks should be identified as precisely as is

practical for analytic assessment of benefits and costs to be derived from the innovation.

COMMENT

A useful concept for characterizing and bounding a task consists in making a "transactional structure" of the task. This can be done at any of many levels of detail or generality. The structure consists of the following:

a. Source of input information to the task-function.

b. Variables in the essential input "message format" that feed into the function. One or more input message contexts become a "demand" for service from the task-function.

c. Variables in the essential output information or message format from the task-function -- the output represents the "service" performed by the task.

d. Variables in the reference information that serve as supplemental input to the task-function.

e. The operations, principles, procedures, rules, and problem-solving techniques that combine input message contexts and reference information, and transform them into output messages which represent the service performed by the function.

Notice that the basic characterizations of input, output, and reference information are in the variables or categories of information that comprise a message context, whether of an input demand for service, or reference data for generating into output, or in the output information that is used as a service. The categorical structure of the inputs to and outputs from a task enable the tracing of functional continuities and relevances from one task to another in a sequential network. This coupling enables the effects of changes in one part of the network to be predicted (hence, assessed) in other parts of the network.

2. Pass the information developed in step 1 on D&A tasks relevant to the innovation to Subtask 05.18, Assess the Training Benefit Pattern.

COMMENT

The foregoing descriptions of nodes and task-functions of D&A activities are essentially the descriptions of human tasks, since they are performed by job incumbents, and supervised and monitored by humans with task responsibilities. Procedural step 1 will have identified the job tasks in D&A operations to which the innovation applies.

The structure for assessing the benefits of on-the-job tasks is presented in Subtask 05.23, in the section dealing with benefits that an innovation, which leads to improvement in a skill or competence can have for the job environment. Techniques for the quantitative analysis and evaluation of "improvements" in on-the-job functions are as applicable to D&A jobs as they are to the jobs dealing with the operation and maintenance of equipment, or in providing clerical or professional services.

TASK: PERFORM COST-BENEFITS ANALYSIS

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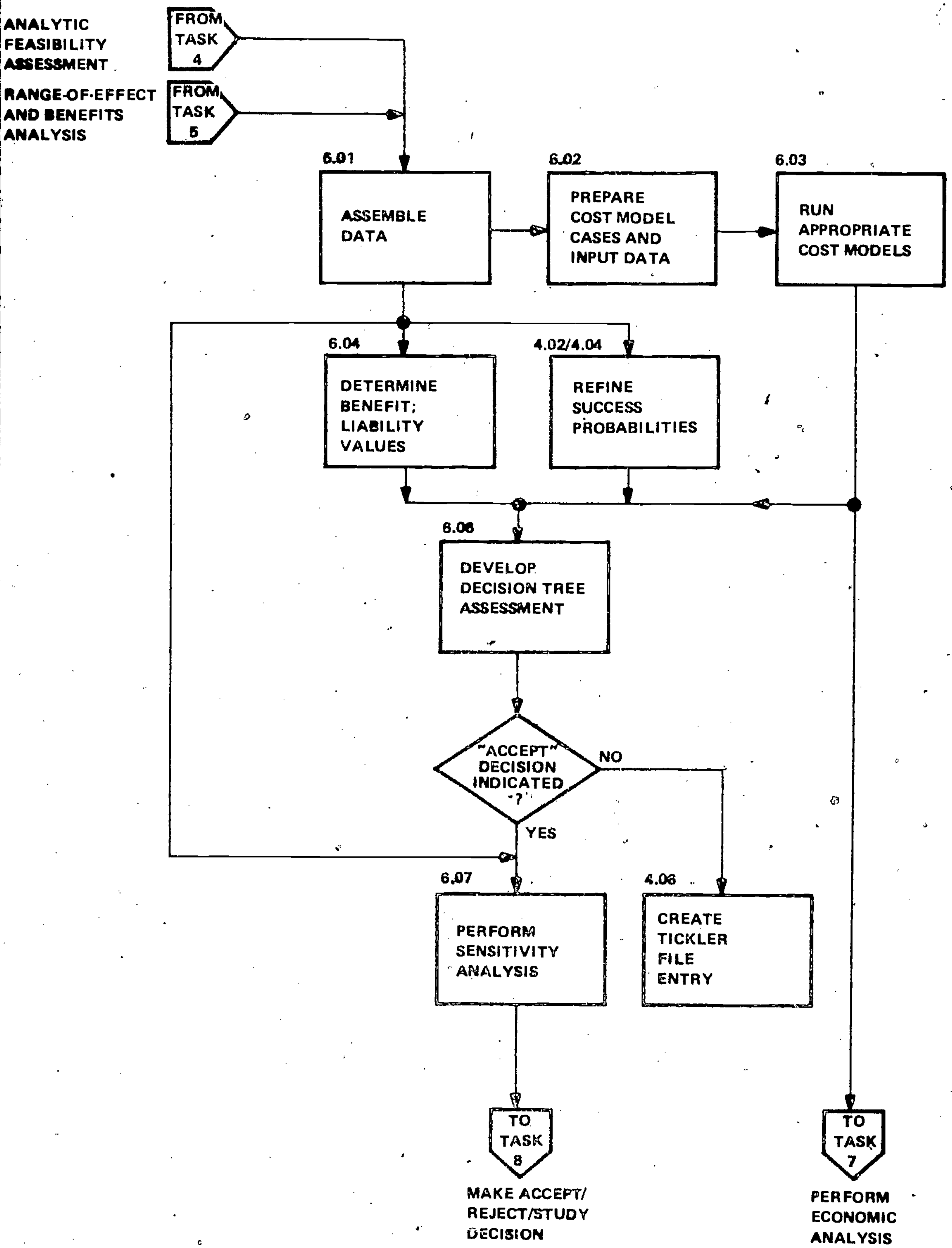

TASK: PERFORM COST-BENEFITS ANALYSIS

Task 3 (Make Preliminary Feasibility Profile) and Task 4 (Perform Analytic Feasibility Assessment) were concerned with preliminary assessment exercises on limited range-of-application data. Based upon a tentative decision to accept the proposed innovation, Task 5 (Determine Range-of-Effect) will have identified the full range of applications and will have, also, provided the full pattern of benefits (and liabilities) intrinsic to the innovation. The purpose of this task is to incorporate these two additional sets of information within the decision process. The decision tree used in Task 4 will be revised to include:

- More precise cost/savings data for each outcome
- Benefits/liabilities data stated in equivalent dollars
- Refined success probability estimates
- A sensitivity analysis identifying critical variables.

Cost data derived within this task will be used in Task 7 (Perform Financial Analysis). It should be pointed out that two separate decision patterns are being developed to assist in the ultimate decision-making step. The first uses the decision tree where an attempt is made to quantify benefits (including dollar savings) and liabilities (including dollar costs) and then to develop a value for each of the possible decision paths. This approach will aid the overall decision process, especially when normally nonquantified benefits and liabilities will have a substantial influence on the decision maker's view of the overall acceptability of the proposed innovation. The second decision pattern (outlined in Task 7) is concerned with a straightforward financial analysis of the proposal using identifiable costs and savings over an extended time horizon. There the decision criteria will be such factors as net cost/savings and return on investment. The nondollar benefits and liabilities addressed in this task (Task 6) will not be included in the financial analysis. However, the results of the two distinct decision processes will be presented to the decision maker as outlined in Task 8 (Make Accept/Reject/Study Decision). The major subtasks within Task 6 are outlined below.

| SUBTASK | REFERENCE |
|---|---|
| 1. Assemble the data from the preceding tasks including the newly acquired range-of-effect and benefits data from Task 5. | 06.01.01 |
| 2. Prepare appropriate cases and cost model input data for each decision tree outcome. | 06.02.01 |

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| 3. | Run cost model for each case to determine dollar value of each decision tree outcome. | | 06.03.01 | |
| 4. | Determine equivalent dollar value for each of the benefit/liability patterns. | | 06.04.01 | |
| 5. | Refine the success probability estimates considering any additional risks from any extended application indicated from Task 5. | | 04.02.01<br>04.04.01 | |
| 6. | Develop new decision tree assessment diagram using the parameters developed in the preceding subtasks; then determine new decision values. | | 06.06.01 | |
| 7. | Perform sensitivity analysis of decision path to selected variables. | | 06.07.01 | |
| 8. | Create tickler file entry identifying criteria for re-assessment of innovation if, at this point, the proposal does not appear feasible. | | 04.06.01 | |

TASK: PERFORM COST-BENEFITS ANALYSIS

SUBTASK: ASSEMBLE DATA

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DESCRIPTION

The cost-benefits analysis further develops the decision tree assessment format from Task 4. These data, along with the full range of entities (courses, jobs, equipment, etc.) and benefit characteristics identified in Task 5, will form the basis for the refined cost-benefits analysis of Task 6.

PROCEDURE

1. Obtain the final decision tree prepared in 04.05 along with rationale supporting the separation of costs/savings by outcome and the probabilities assigned to implementation and user acceptance success.

2. Obtain the final full range of potential applications for the innovation from Task 5. These will include, where appropriate:

   - Course numbers (CDP)
   - Job designators (Rate, NEC, NOBC, etc.)
   - Equipment types
   - Student types
   - Cost elements
   - Taxonomic search parameters
   - Other directly costable elements.

3. Obtain the allocation rules which identify how the pattern of benefits/liabilities is to be apportioned across each of the entities selected as being potentially impacted by the proposed innovation.

COMMENT: Typical allocation rules might be: 1) 10% of the laboratory time in course 12AB will be saved; 2) one hour of maintenance per month will be saved on the XXXX task trainer; 3) three weeks of OJT time for ET2's and ET3's with the following NEC's assigned to shipboard duty will be saved.

4. Obtain the full benefit/liabilities pattern developed in Task 5 which will include:

   - ~~Specific relevant~~ variables impacted by the application of the innovation; e.g., time to train, attrition, etc.

- A figure indicating the relative importance of each variable as compared to all relevant ones; e.g., crucial importance = 10, trivial importance = 1, etc.

- Magnitude and direction of change in each relevant variable; e.g., attrition reduced from 20% to 18% or attrition reduced 10%.

- A confidence range for the estimate of each relevant variable; e.g., under the most adverse conditions, the most likely estimate of attrition (18%) will be no greater than 20% and under the most favorable conditions, it could go as low as 15%, or the most likely attrition reduction estimate of 10% may vary from 0% (worst case) to 25% (best case).

5. Derive the expected value of the relevant variables. Since the variables will generally be bounded at both ends by practical limits and these limits are expressed by the confidence range identified as a part of the benefits/liabilities pattern developed in Task 5, a useful estimate of the expected value ($v_E$) is the PERT statistic:*

$$v_E = \frac{p + 4m + o}{6}$$

Where: $V_E$ = expected value of the relevant variable

$p$ = most pessimistic value of the variable

$m$ = most likely estimate of the variable

$o$ = most optimistic estimate of the variable.

The value derived will be used as the cost model and the decision tree inputs.

COMMENT: The assessor may want to review 06.07 (Perform Sensitivity Analysis) to become familiar with the further use of the expected value and confidence range. Also, some degree of caution should be used in this expected value estimate, especially when the distribution using p, m, and o is highly skewed. If it appears that the decision will be sensitive to certain variables, more systematic methods are available and may be appropriate for obtaining the expected value and distribution for the variables (see Handbook for Decision Analysis - Chapter 9).

* Hahn, Gerald J. and Samuel S. Shapiro, STATISTICAL MODELS IN ENGINEERING, John Wiley & Sons, Inc., New York, 1967, p. 133.

Battersby, A., NETWORK ANALYSIS FOR PLANNING AND SCHEDULING, St. Martin Press, Inc., New York, 1964, p. 174.

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TASK: PERFORM COST-BENEFITS ANALYSIS

SUBTASK: PREPARE COST MODEL CASES AND INPUT DATA

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DESCRIPTION

Four basic outcomes (A through D) have been defined on the decision tree assessment diagram. These range from acceptance, successful implementation, and user acceptance to rejection of the proposal. (This is not necessarily the range considering the net of costs and savings.) An alternative case must be established for each of the possible outcomes which, in the case of failure, means the formulation of a recovery strategy to which certain costs will be attached. Each defined case must have the appropriate cost model and input variables specified.

PROCEDURE

1. Develop basic scenarios for each of the possible decision tree outcomes. In the case where the proposed innovation is accepted, implemented, and used over an extended planning horizon, basic development, installation, and operational factors will be considered. If contingency plans will involve identifiable cost elements, these should be included in the scenarios.

   The scenario for outcome B, where the innovation is successfully implemented but fails to gain user acceptance over a reasonable period of time, might contain the following assumptions.

   - Initial planning is the same as outcome A.
   - A two-year period will be considered as a norm to determine acceptance.
   - The measures of user acceptance planned for outcome A will be incorporated, except that measurement cost will increase by 10% due to increased sampling as measurements move toward the control limits.
   - If rejection is indicated at the end of two years, the baseline plan will be used for recovery purposes.
   - Equipments purchased under the proposed initial plan will have no remaining value due to their specialized character.

A similar scenario should be developed for outcome C. Outcome D, to reject the innovation, will generally be considered neutral.

2. Prepare cost model input data sheets specifying the values of each variable under each outcome outlined by the preceding scenarios. Input data sheets should be prepared for each model appropriate to the costing exercise; i.e., the training cost model will accept, for example, the following factors.

- Technical factors
  - Annual requirements for course graduates
  - Attrition rate
  - Course length
  - Student recycle rate (percent of students set back)
  - Average recycle time (time added by being set back)
  - Average equipment downtime
  - Instructor/student ratio
  - Administrative/student ratio
  - Equipment/student ratio
  - Facilities square feet/student
  - Facilities square feet/instructors
  - Facilities square feet/administrative
  - Instructional materials development ratio
  - Amount of course material requiring new development
  - Percent annual course maintenance requirements
  - Supplies/student
  - Miscellaneous requirements/student.
- Cost Factors
  - Student salary
  - Student travel
  - Instructor salary
  - Administrative salary

- Equipment unit costs
- Life of equipment
- Purchase policy
- Depreciation policy
- Operation and maintenance costs for equipment
- Cost/square foot of space
- Instructional materials development cost
- Value of instructional materials at end of planning period
- Supply costs/student and student position
- Miscellaneous costs/student and student position.

The job model may be developed to accept, for example, the following factors.

- Annual incumbents affected
- Job classification (Rate, NEC, etc.)
- Years service
- Time in grade
- Support personnel ratio
- Job support space (facilities square feet)
- Tools unit cost
- Equipment unit cost
- Salary rate (incumbent and support)
- Recruiting/induction costs
- School training costs
- Transportation costs

- Operational time utilized
- Unutilized time cost
- Error rate
- Error cost.

The equipment model may be developed to accept, for example, essentially the equipment related items within the training cost model.

- Numbers of equipment
- Unit cost of equipment
- Operations and maintenance cost
- Life of equipment
- Purchase policy
- Depreciation policy
- Utilization.

COMMENT: Each cost model when developed will have specific formats for the input data. The approach planned for the training cost model is to define absolute rather than incremental cost factors. This will require that the input data for the baseline plan be defined also, and the incremental value of output variables must be obtained by taking the difference between the two runs. Also, costs should be classified along an additional dimension to avoid any major restructuring in Task 7. The cost categories for grouping data elements are 1) R&D, 2) investment, and 3) recurring.

3. Ensure that the input variables reflect the true "opportunity cost" resulting from the proposal application. For example, if three weeks of OJT time were defined as being saved by the proposed innovation, the full salary costs or the full three weeks should only be taken as a savings if there is an alternate opportunity to use the time saved at the value assigned. This should be considered over the entire planning period under consideration, since while there may be no value for the time initially, additional workload in subsequent years may have value. The value for the entire planning period should be factored into the input variables.

TASK: PERFORM COST-BENEFITS ANALYSIS

SUBTASK: RUN APPROPRIATE COST MODELS

DESCRIPTION

The following outlines the basic steps in making the cost/savings calculation. While these may be carried out manually, generally the input data from the preceding subtasks will be processed using some form of Automated Data Processing (ADP).

PROCEDURE

1. Review input data sheets to ensure relevant variables have been incorporated, that they are adjusted to reflect the true economic value (opportunity cost) achieved by applying the innovation, that is, the value sacrificed by the resource not being available for some alternative use. If, for example, a certain amount of building space is unused, then it has essentially no value. If, however, there were a requirement for the space from some other source, and that source valued the space at its existing cost, then the full cost would be used.

2. Training Cost Model. The development of training costs will generally be performed on a course by course, or program, basis. The major cost categories and the general procedural steps for calculating these categories are outlined on the following pages.

   - Determine Student Requirements. Given the annual requirements for graduates, calculate annual student input and student load considering the attrition rate, recycle rate, average recycle time, and course length.

   - Determine Student Position Requirements. Given the student average-on-board (AOB), calculate the number of student positions required considering the time a student position may be unavailable (e.g., for maintenance) and the percent of extra student positions required (e.g., for queueing).

   - Determine Personnel Requirements. Given the number of student positions, calculate instructor personnel required considering the instructor to student position ratio, and calculate administrative personnel required considering the administrator to student position ratio.

- Determine Equipment Required. Given the number of student positions, calculate equipments required considering the equipment to student position ratio. The actual equipment acquired will be a function of its life in relation to the planning horizon, and also of the particular purchase policy selected; e.g., purchase only to 80% of the maximum requirement over the planning period.

- Determine Facilities Required. Given the number of student positions, calculate total facilities required considering the square feet per student position for students, instructors, and administrators.

- Determine Instructional Materials Development/Maintenance Required. Calculate the amount of time for developing initial course materials considering the course length, the percent of the course requiring development, and the development ratio. Given the amount of time for developing initial course materials, calculate the annual maintenance requirements considering the percent of initial development time to be expended annually for maintenance or course update.

- Determine Supplies Required. Given the number of students or number of student positions, calculate supplies required considering the supplies per student ratio or the supplies per student position ratio, whichever is appropriate.

- Determine Miscellaneous Required. Given the number of students or number of student positions, calculate miscellaneous required considering the miscellaneous per student ratio or the miscellaneous per student position ratio, whichever is appropriate.

- Determine Training Costs. Training costs are calculated by taking each of the preceding technical requirements times its unit cost.

  - Student costs consider salary costs per student year (AOB), student travel to and from school, as well as any travel while in training.

  - Personnel costs consider instructor salaries and administrative salaries.

  - New equipment costs consider the individual equipment purchase cost and annual maintenance cost. Based upon the defined depreciation rate, the life of the equipment, and the length of the planning period, equipment may have a remaining value which will be subtracted from costs. (The assumption here is that the equipment can be sold or put to an alternative use which is equal to its remaining value.) Used equipment valuation should be based upon its opportunity cost, that is, its value in alternative uses.

- Facilities costs consider the total square footage requirements times a cost per square foot factor.

- Instructional materials costs consider the total development and maintenance time requirements and the cost per unit of time. Instructional materials, like equipment, may have some remaining value based upon some alternate use at the end of the planning period. Considering a percentage factor for end of life value, the offset against total cost can be calculated to arrive at a net cost of instructional materials.

- Supplies and miscellaneous costs can be calculated from the unit cost factors.

- Aggregate Costs. Sum the costs on an annual basis over the planning period. A total (nondiscounted) cost is obtained by summing the annual requirements. A more realistic economic value which considers the time value of money is an overall value which has been discounted at a rate representing the annual cost of capital. The annual discounting should be performed and the discounted annual costs summed to obtain a present value cost figure for the program.

- Develop Unit Factors. It is often valuable for comparative purposes to calculate the program cost per graduate, cost per student input, cost per student position, or cost per student day of training. This can be done with both the nondiscounted or discounted factors and displayed on an annual and total program basis.

3. Job Cost Model. In general, the determination of seemingly quantifiable job effects will start with experts, knowledgeable of a specific job (or task) situation, predicting training variations or modifications upon the appropriate job variable; e.g., performance time, error rates, support requirements, etc. For life cycle planning purposes, generally done well in advance of implementation, savings of personnel will reflect in a reduction of a number of costs including base pay, hazardous duty pay, transportation costs, retirement benefits, etc. Navy Military Manpower Billet Cost Data for Life Cycle Planning Purposes (NAVPERS 15163) provides costing information which can be applied once an estimate of the number of personnel affected has been made. Again, the difficulty is in evaluating the opportunity cost for time saved at a task or duty level. The question as to whether time saved can be put to some alternative use with value approximating the factors in the Billet Cost Data is more easily answered when preparing manning level estimates well in advance of implementation than it is when performance times on existing jobs are being affected by an innovation.

Some work has been accomplished in estimating the cost of on-the-job training which could be one of the more frequently impacted variables in the assessment of training innovations. While a general methodology has been developed for making OJT cost assessments, models would have to be developed for each job type (rating, etc.) potentially impacted. The elements of cost identified in an Air Force Study* are:

- Trainee time
- Instructor time
- Delayed entry time
- Records management time
- Remedial training time
- Equipment and material.

Various models for estimating costs in each category were examined and an appropriate one selected for predicting each cost element. If specific models and data such as those discussed above are available and appropriate, they should be used, however, a general procedural approach for combining the data input factors specified in 06.02 is as follows.

- Determine Personnel Costs. Given the number of annual incumbents affected, salary rates can be identified based upon job classification, years service, and time-in-grade factors. The operational time utilized and unutilized time cost become the basis for valuing the time saved or additional time used as a result of the proposed innovation. Overhead or support personnel can be determined from the support personnel ratio and total cost determined using the salary rate. Depending upon the nature of the innovation's impact over the planning period, total personnel costs could include the additional costs of recruiting/induction, school training, and transportation.

- Determine Facilities Costs. Job support space required will be identified and cost determined using the cost/square foot factor.

- Determine Job Performance Support Costs. Certain jobs require specialized tools or equipment which can be costed using unit cost factors for each.

*Samers, B.N., Dunham, A.D. and Nordhauser, F., 1974. The Development of a Methodology for Estimating the Cost of Air Force On-The-Job Training. Report No. AFHRL-TR-74-34, Contract F41609-72-C-0048, AFHRL, Brooks AFB, Texas.

- Determine Performance Change Costs. Some innovations may be modifying the rate of operational errors made by the job incumbent. The error rate and cost per error factors are intended to permit a cost estimate of this job attribute.

- Aggregate Costs. Sum the costs on an annual basis over the planning period. A total (nondiscounted) cost is obtained by summing the annual requirements. A more realistic economic value which considers the time value of money is an overall value which has been discounted at a rate representing the annual cost of capital. The annual discounting should be performed and the discounted annual costs summed to obtain a present value cost figure for the program.

- Develop Unit Factors. Comparisons of alternatives and before/after situations can be made if certain types of unit factors are developed such as, cost per job hour, cost per job hour utilized, error cost per incumbent, support costs per incumbent, etc.

4. Equipment Cost Model. Equipment costs are derived by combining the factors in the following general manner.

- Determine Numbers of Equipment Affected. When an innovation causes equipment to be either displaced or procured, the numbers, by type, will be specified from Task 5.

- Identify Related Resource Impacts. The displacement or procurement of equipment may affect other costable items such as:

  - Refurbishing of facilities costs
  - Transportation
  - Inventories (e.g., spare parts)
  - Maintenance
  - Working funds
  - Supplies
  - Utilities.

- Identify Unit Costs. For equipments and other costable items, determine the unit costs from data bases or other sources.

- Equipment Purchase Costs. Equipment life (actual, not accounting) must be considered to determine the number of procurements to be made over the planning cycle as well as the potential cash flows resulting from an end-of-life equipment value. Purchase and depreciation policies will affect investment and other cash flows.

- Equipment Utilization. Utilization would be an important consideration in arriving at an alternative use cost when displacing or using existing equipment. When equipment is already owned, its economic costs are approximated by estimating its value in alternative uses.

5. Develop the incremental cost/savings value for each of the model cases run. This will be the difference between the baseline or existing system and the proposed systems for each decision tree outcome, A through D. If the innovation requires use of more than one model, the incremental values of each should be summed and assigned to the respective outcome. Be sure that paths (2), etc., contain the implementation costs identified in 04.03 (Define Implementation Projects and Costs). These data will be used in Subtask 06.06 (Develop Decision Tree Assessment) and in Task 7 (Perform Financial Analysis).

TASK: PERFORM COST-BENEFITS ANALYSIS

SUBTASK: DETERMINE BENEFIT/LIABILITY VALUES*

DESCRIPTION

The preceding subtasks have dealt with the tangible values of costs and savings. Sometimes intangible factors may have a significant effect upon the path a decision ultimately takes. The purpose of this subtask is to systematically develop value or utility for the otherwise nonquantifiable benefits and liabilities which result from application of the innovation. The value obtained from this procedure will be expressed in equivalent dollars and will be developed for each of the decision tree outcomes so that the values can be added to the previously developed costs and/or savings.

PROCEDURE

1. Obtain the data assembled in 06.01 for the nonquantified benefits and liabilities. Relevant variables may include process or procedural effectiveness, attitudes, morale, communications, safety, security, environmental quality, manageability, controllability. Magnitude estimates and direction of change, relative importance, and confidence range will have been identified for each variable.

2. Assess the relative effect of a single benefit/liability dimension for each decision tree outcome. Rank the outcomes according to their relative value on a format as shown in Figure 6.4.1. Remember, only a single factor is being considered at this time; for example, student morale. It is possible that this variable could be ranked in several ways depending upon the type of innovation. If the intended result of the innovation significantly improves student morale, then to accept, implement, and have user acceptance might be ranked first, while to accept, implement, and have user rejection (outcome B) might be ranked last. On the other hand, if student morale is negatively impacted (a liability of the proposed innovation), then to reject outright (outcome D) might be ranked first while to accept, implement, and have user acceptance (outcome A) might be ranked last.

3. Develop the weights for each of the ranked outcomes on a scale of 0 to 100. The first ranked outcome is assigned a value of 100 while the last ranked outcome is assigned a value of 0. Determine which outcome is neutral. By determining how much better or how much worse one outcome is in relation to another, each outcome can be assigned an intermediate value between 0 and 100. Figure 6.4.2 shows a completed sheet where each outcome has been

*The approach outlined here was adapted from the "Handbook for Decision Analysis", Decision and Designs, Inc., ONR Contract N00014-73C-0149, and should be reviewed prior to this phase of the assessment.

assigned a value. The rationale for the weights has also been included. The consistency of estimates can be checked by standard gambles. For example, if A = 100, B = 50, and D = 0, does B approximately equal a gamble between A and D each having a 50% probability of occurring? If this is a reasonable approximation, then the values are consistent.

4. Select another variable and repeat the analysis of steps 2 and 3.

## OUTCOME ANALYSIS – BENEFIT RANKING AND VALUATION

| RANK | OUTCOME LETTER | OUTCOME NAME |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |

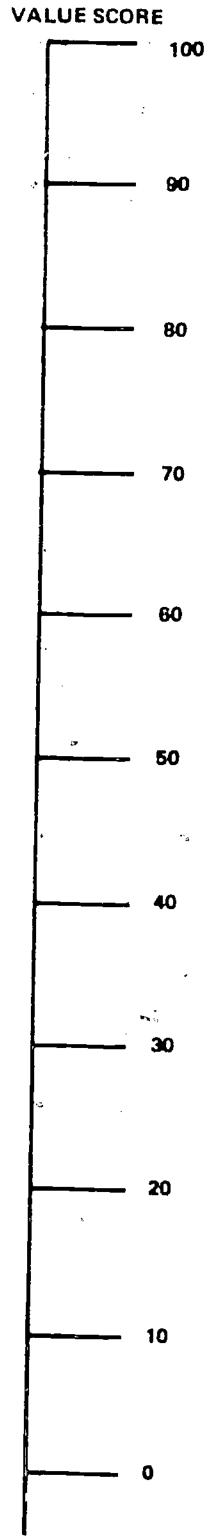



FIGURE 6.4.1. BENEFIT OUTCOME ANALYSIS FORMAT

## OUTCOME ANALYSIS – BENEFIT RANKING AND VALUATION

BENEFIT: STUDENT MORALE

| RANK | OUTCOME LETTER | OUTCOME NAME |
|---|---|---|
| 1 | A | ACCEPT, IMPLEMENT, USER ACCEPT |
| 2 | D | REJECT |
| 3 | C | ACCEPT, FAIL TO IMPLEMENT |
| 4 | B | ACCEPT, IMPLEMENT, USER REJECT |

RATIONALE:

- A CAUSES MOST FAVORABLE EFFECT ON STUDENT MORALE
- B CAUSES MOST ADVERSE EFFECT
- C IS ABOUT 25% AS UNFAVORABLE AS B, AND IS PLACED AT 60
- D IS A NEUTRAL OUTCOME AND IS PLACED AT 80 BECAUSE B IS FOUR TIMES AS UNFAVORABLE AS D IS FAVORABLE

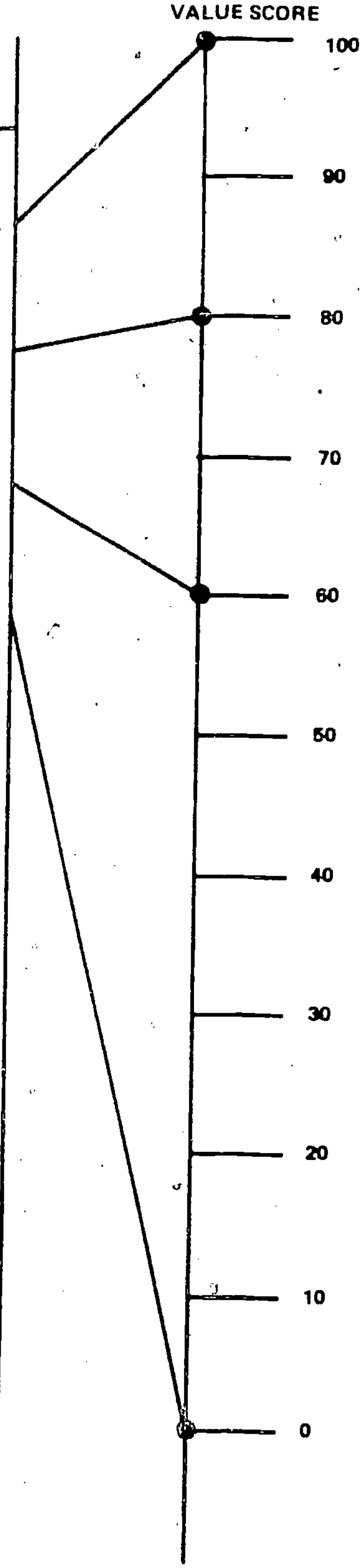



FIGURE 6.4.2. BENEFIT OUTCOME ANALYSIS FORMAT (COMPLETED EXAMPLE)

TASK: PERFORM COST-BENEFITS ANALYSIS

SUBTASK: DEVELOP DECISION TREE ASSESSMENT

DESCRIPTION

The purpose of this subtask is to combine the results of the cost model runs and the noncost benefits analysis by their relative importance weights to obtain a total value for each decision tree outcome in equivalent dollars. The refined success probabilities and the equivalent dollar values are entered into the decision tree assessment format and folded back to find the decision path with the highest expected value.

PROCEDURE

1. Gather the results of the cost model runs from 06.03, the benefit/liabilities value scales from 06.04, the refined success probabilities from 06.05 (repeat of 04.02 and 04.04), and the importance values for each variable assembled in 06.01. The data will be documented on a Benefit Outcome Summary Format as shown in Figure 6.6.1.

2. Develop equivalent dollars for each relevant variable by weighting each variable's scale by the relative importance factor. This procedure involves:

    a. Indicating the cost/savings value for each outcome. (See the example of the Training ACTUAL DOLLARS in Figure 6.6.2.)

    b. Determining the range of the scale for all outcomes. (In Figure 6.6.2, ACTUAL DOLLARS go from +6.0 to -3.0, therefore, the range is 9.0.)

    c. Establishing the relative range of a new variable by the ratio of the new variable importance to the original dollar importance. (In Figure 6.6.2, the ratio of STUDENT MORALE to ACTUAL DOLLARS is 8:5 or 1.33.)

    d. Apportioning the 0-100 scale, for the new variable obtained from the Benefit Outcome Analysis, across the new range. (In Figure 6.6.2, the new range is 1.33 X 9.0 or 12.0, therefore, the STUDENT MORALE variable in the 0-100 scale from Figure 6.4.2 is spread across this new range. Note that the range goes from +2.4 to -9.6 (12.0) because of the relationship of the zero outcome (D) to the entire scale.)

3. Display the range of values for all outcomes and for each variable on the Benefit Outcome Summary and summarize the total for each outcome as shown on Figure 6.6.3.

COMMENT: A major assumption in this summarization is that the utility attributes (e.g., ACTUAL DOLLARS and STUDENT MORALE) can be added together. Requirements (not discussed here) which include utility independence, pairwise preferential independence and pairwise marginality, determine if the additive form holds.* In general, it appears that most attributes which will be combined in the training domain will satisfy the requirements for additivity. Certain tests can be made as outlined in the referenced literature if the assessor is concerned about meeting these requirements.

4. Complete the decision tree assessment diagram by entering the refined success probabilities at the event nodes and the values for each outcome at the end of each decision path.

5. Fold back the decision tree as outlined in the procedure of 04.05. Figure 6.6.4 provides an example of a completed decision tree.

6. Review the decision variable results for reasonability.

COMMENT: The decision tree in the form presented does not include a consideration of sequencing projects in a way that the decision to proceed is a function of, for example, successful completion of project A followed by successful completion of project B. If it is thought that this decision structure will exist and may have an effect upon the decision outcome, then the assessor may want to make a decision tree modification to reflect the decision situation more accurately.

The process described above is only one facet of the decision process, the other is the financial analysis. However, if the decision indicated as a result of this process does not appear reasonable from a global viewpoint, the individual decision components should be rechecked for reasonability.

*William C. Giauque. 1975 Decision Making in the Naval Education and Training System. TAEG.

## OUTCOME ANALYSIS – BENEFIT UTILITY ASSIGNMENT

ASSESSMENT DIMENSIONS

VALUE OF OUTCOMES – EQUIVALENT DOLLARS (MILLIONS)

| | IMPORTANCE | IMPORTANCE | IMPORTANCE | IMPORTANCE |
|---|---|---|---|---|
| + 10 | | | | |
| + 9 | | | | |
| + 8 | | | | |
| + 7 | | | | |
| + 6 | | | | |
| + 5 | | | | |
| + 4 | | | | |
| + 3 | | | | |
| + 2 | | | | |
| + 1 | | | | |
| 0 | | | | |
| - 1 | | | | |
| - 2 | | | | |
| - 3 | | | | |
| - 4 | | | | |
| - 5 | | | | |
| - 6 | | | | |
| - 7 | | | | |
| - 8 | | | | |
| - 9 | | | | |
| - 10 | | | | |

OUTCOME SUMMARY

| | | | | | TOTAL |
|---|---|---|---|---|---|
| A | | | | | |
| B | | | | | |
| C | | | | | |
| D | | | | | |
| E | | | | | |
| F | | | | | |
| G | | | | | |

FIGURE 6.6.1. BENEFIT OUTCOME SUMMARY FORMAT

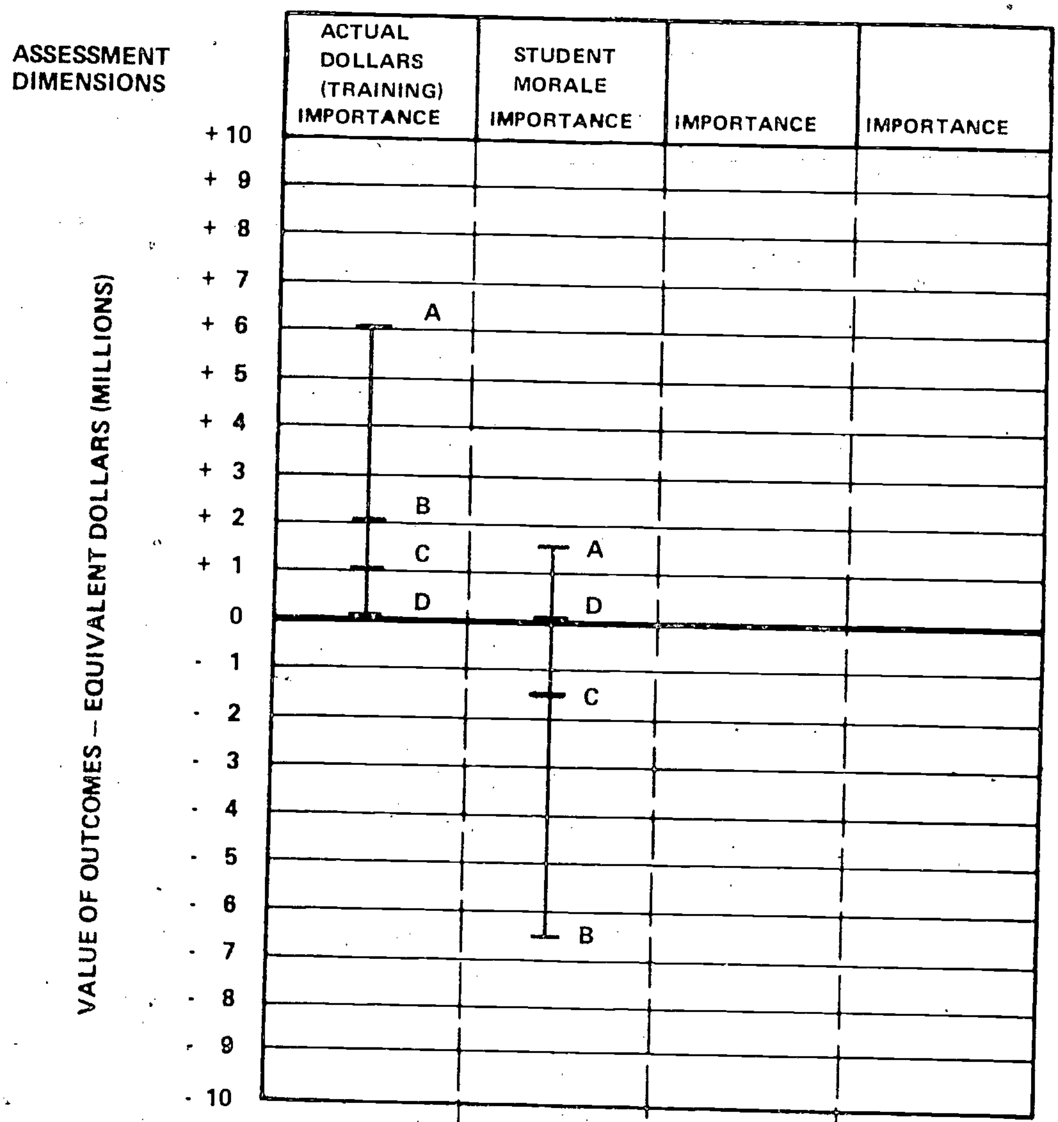
| RELEVANT VARIABLE | RELATIVE IMPORTANCE | A | B | C | D | COMMENT |
|---|---|---|---|---|---|---|
| ACTUAL DOLLARS (Training) | 6 | 6.0 | 2.0 | 1.0 | 0 | Cost/savings data from running Training Cost Model |
| STUDENT MORALE | 8 | 100 | 0 | 60 | 80 | Benefit outcome analysis format Figure 6.4.1 Example |
| (ADJUSTED)* | | 1.6 | -6.4 | -1.6 | 0 | |

NOTE: The STUDENT MORALE variable is 8:6 or 1.33 times as important as the ACTUAL DOLLARS, and outcome D is neutral or zero. Since the ACTUAL DOLLAR range is +6.0 to -0.0 or 6.0, and STUDENT MORALE is 1.33 times as important, the total STUDENT MORALE range is 1.33 X 6.0 = 8.0. Outcome A is 20% of the total range in the positive direction, therefore, outcome A is 1.6. Outcome B is 80% of the range in a negative direction, therefore, outcome B is -6.4.

FIGURE 6.6.2. BENEFIT OUTCOME SUMMARY

(SAMPLE DATA)

## OUTCOME ANALYSIS – BENEFIT UTILITY ASSIGNMENT




OUTCOME SUMMARY

| | | | | | TOTAL |
|---|---|---|---|---|---|
| A | 6.0 | 1.6 | | | 7.6 |
| B | 2.0 | -6.4 | | | -4.4 |
| C | 1.0 | -1.6 | | | - .6 |
| D | 0.0 | 0.0 | | | 0.0 |
| | | | | | |
| | | | | | |
| | | | | | |

FIGURE 6.6.3 BENEFIT OUTCOME SUMMARY (EXAMPLE)

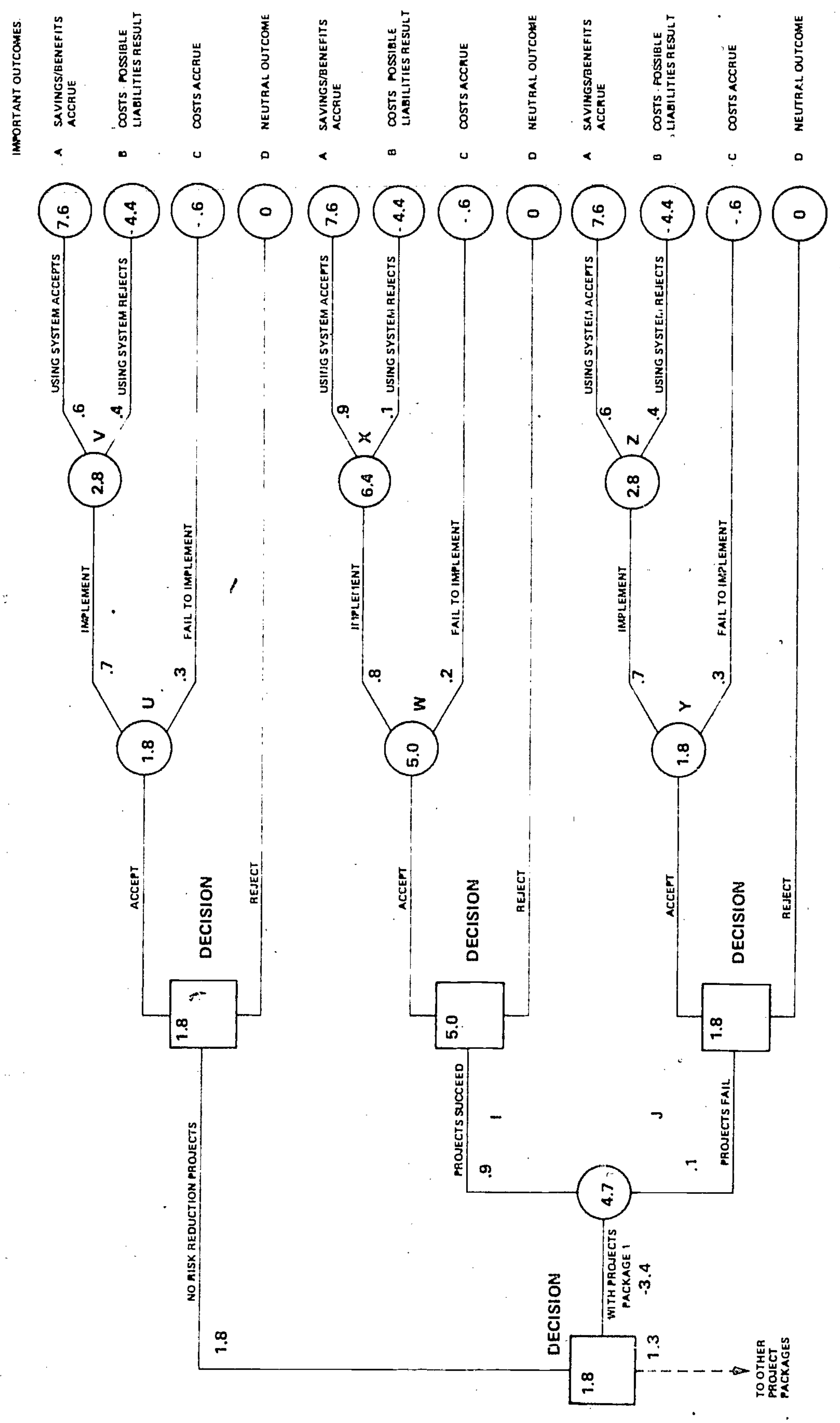



FIGURE 6.6.4. DECISION TREE FOR ASSESSMENT OF TRAINING INNOVATION (EXAMPLE USING SAMPLE DATA)

TASK: PERFORM COST-BENEFITS ANALYSIS

SUBTASK: PERFORM SENSITIVITY ANALYSIS

DESCRIPTION

The assessor may be faced with a decision in which there is very little difference in the decision variable values for the alternative choice; e.g., to accept without continued study versus to accept with continued study. The purpose of this subtask is to present the assessor with an insight into the variables which might change the decision which is presently indicated. This is accomplished by determining which variables; e.g., estimates of success probabilities, relevant costable and noncostable variables, or measures of relative importance, may cause a change in the decision considering the confidence range that the estimator originally had in those particular variables. The results of this analysis may lead to the gathering of additional information or specific variables to which the decision is sensitive so that the confidence in the estimate of their value can be improved.

PROCEDURE

1. Review the sensitivity analysis diagrams for the models used to develop the cost factors to determine if any of the variables affected by the proposed innovation are particularly sensitive. Figures 6.7.2 through 6.7.7, are sample sensitivity graphs for the Training Cost Model.

2. Identify the variables to be inputted to the sensitivity analysis program which will perform the following analytic steps.

   a. Determine if the inputted variables cause a change in the indicated decision across the expressed confidence range.

   b. If no confidence range has been expressed; e.g., where the relative importance variable is concerned, the variable values for which the decision changes will be calculated.

   c. A sensitivity and probability that the indicated decision will change, will be calculated for each variable that causes a change within the confidence range.

   d. The break-even point value for each variable from b. and c., above, will be calculated.

   e. An output report as shown in Figure 6.7.1 will be generated for the assessor to review.

| TASK | SUBTASK | PAGE |
|---|---|---|
| 06 | 07 | 02 |

COMMENT: The probability generated should be applied with caution since some major assumptions are involved in its calculation. First, as with the calculation of the mean or expected value, an approximation of the beta distribution is assumed, therefore, the standard deviation is calculated by:

$$S = \frac{o-p}{6}$$

Where: S = standard deviation

o = optimistic estimate

p = pessimistic estimate.

A Z-value is calculated, assuming the beta approximates the normal distribution by the formula:

$$Z = \frac{b-v_E}{S}$$

Where: Z = Z-value

b = break-even value

$v_E$ = expected value (mean - see 06.01)

S = standard deviation

The cumulative probability is obtained from a table containing values of the standard normal distribution for various Z-values.

3. Review those variables to which the indicated decision appears sensitive and determine if additional information should be obtained to improve the confidence of the assessor that the decision indicated is valid.

4. If a "reject" decision is indicated and affirmed by the decision maker, create a tickler file entry as outlined in 04.06, otherwise proceed in the analysis to Task 7.

SENSITIVITY ANALYSIS

| VARIABLE | MEAN VALUE | CONFIDENCE RANGE | BREAK-EVEN VALUE | FROM/TO[1] | SENSITIVITY[2] | PROBABILITY[3] |
|---|---|---|---|---|---|---|
| Success Probability - U | .7 | .5 - .8 | .54 | ACC-ACS | 32.7 | .05 |
| Success Probability - W | .8 | .65 - .95 | .94 | ACC-ACS | 12.0 | .01 |
| Importance - Student Morale | 8 | ***** | 6.7 | ACC-ACS | 5.6 | ****4 |
| Attrition Rate (as it affects actual dollars) | .02 | .00 - .07 | .06 | ACC-REJ | 1.3 | .03 |

1. The original indicated decision is shown as well as the suggested decision beyond the break-even value.
2. Percent change in the decision variable (output) for each percentage change in the input variable.
3. The probability, based upon the distribution using the mean and confidence limits, that the decision will change as a result of probable variance in the variable.
4. A distribution could not be established because of the absence of confidence limits, therefore, no probability was generated.

FIGURE 6.7.1. SAMPLE SENSITIVITY ANALYSIS CHART

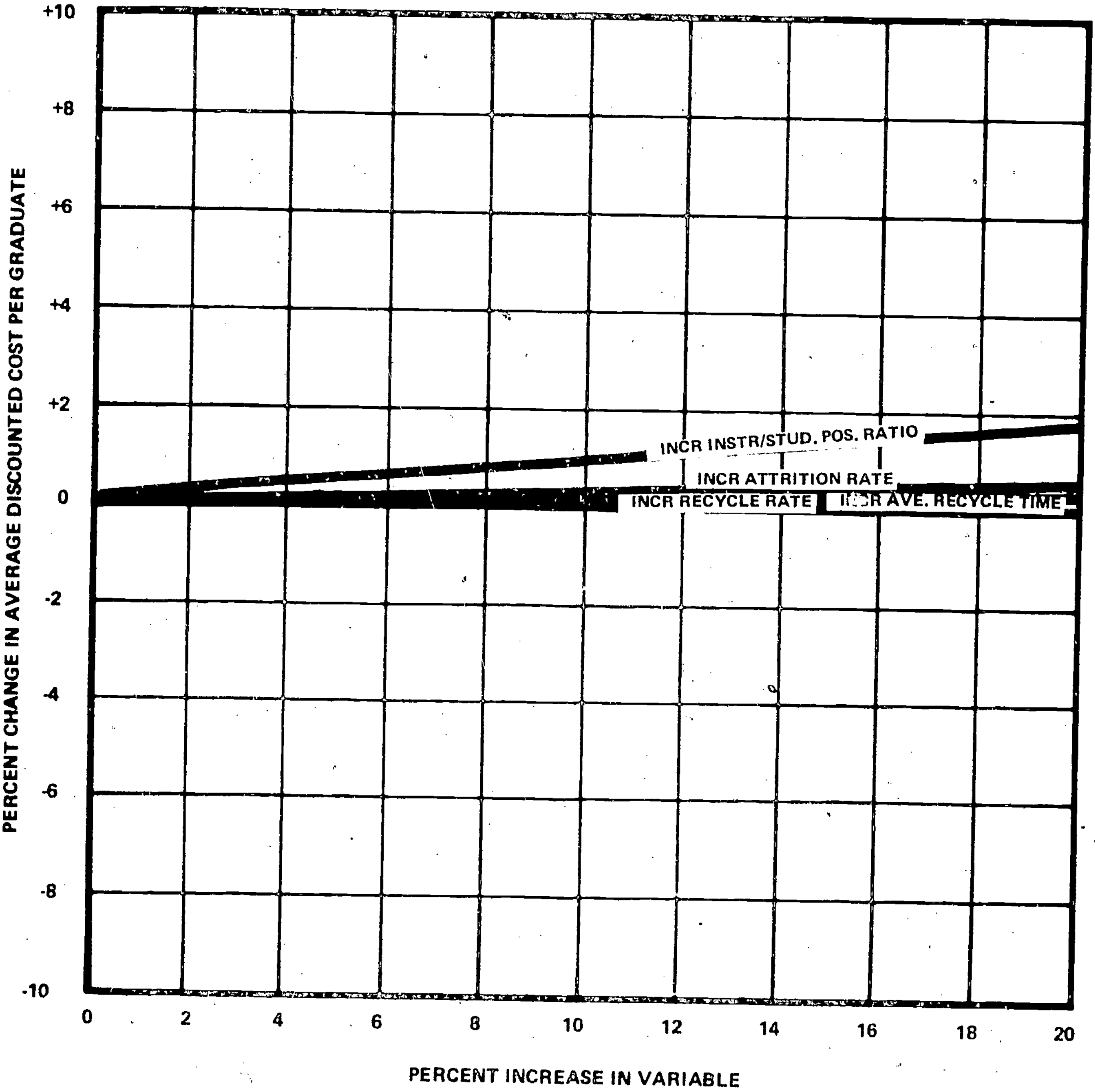



FIGURE 6.7.2. TRAINING COST MODEL SENSITIVITY ANALYSIS
AVERAGE DISCOUNTED COST PER GRADUATE

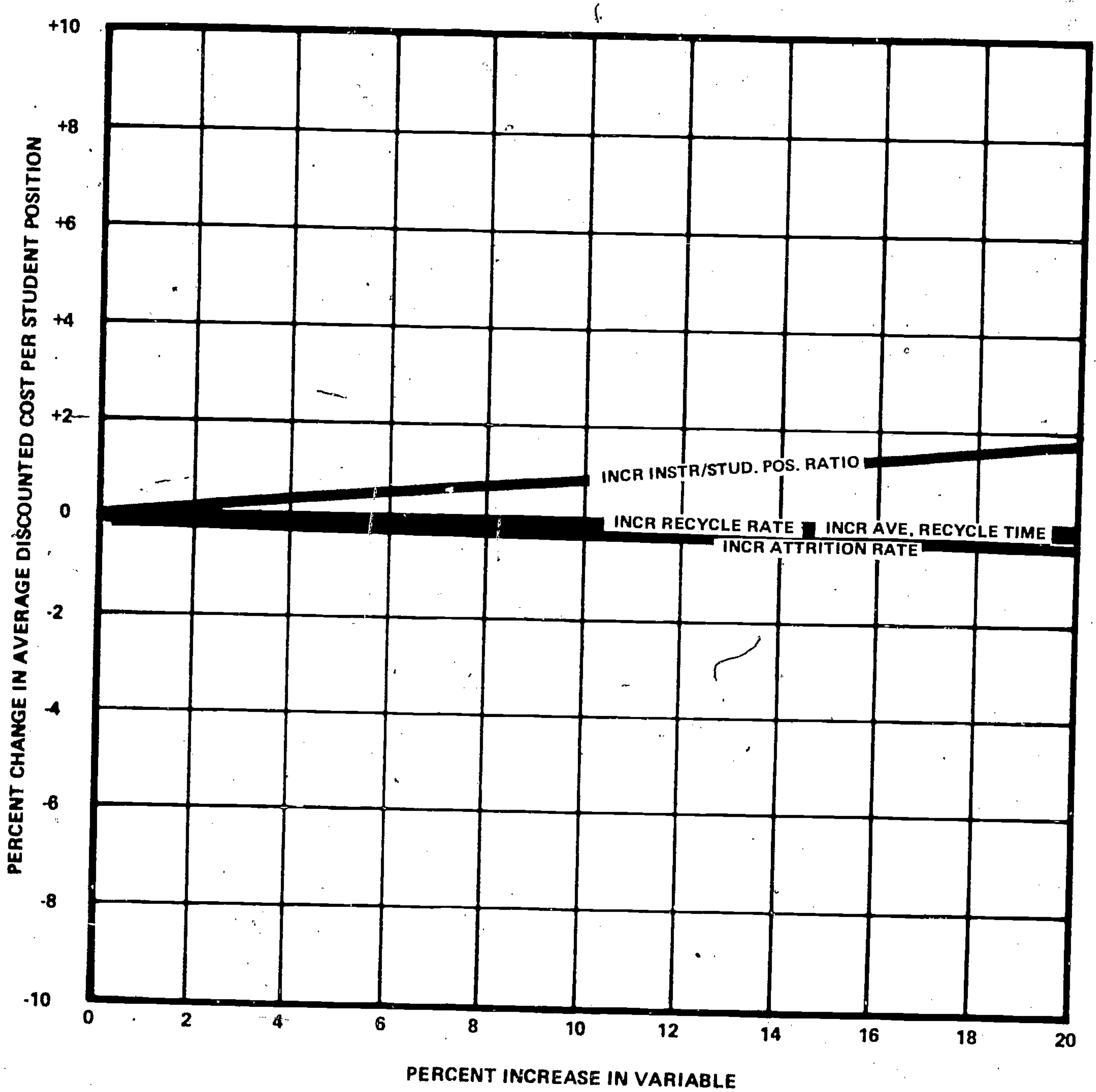



FIGURE 6.7.3. TRAINING COST MODEL SENSITIVITY ANALYSIS
AVERAGE DISCOUNTED COST PER STUDENT POSITION

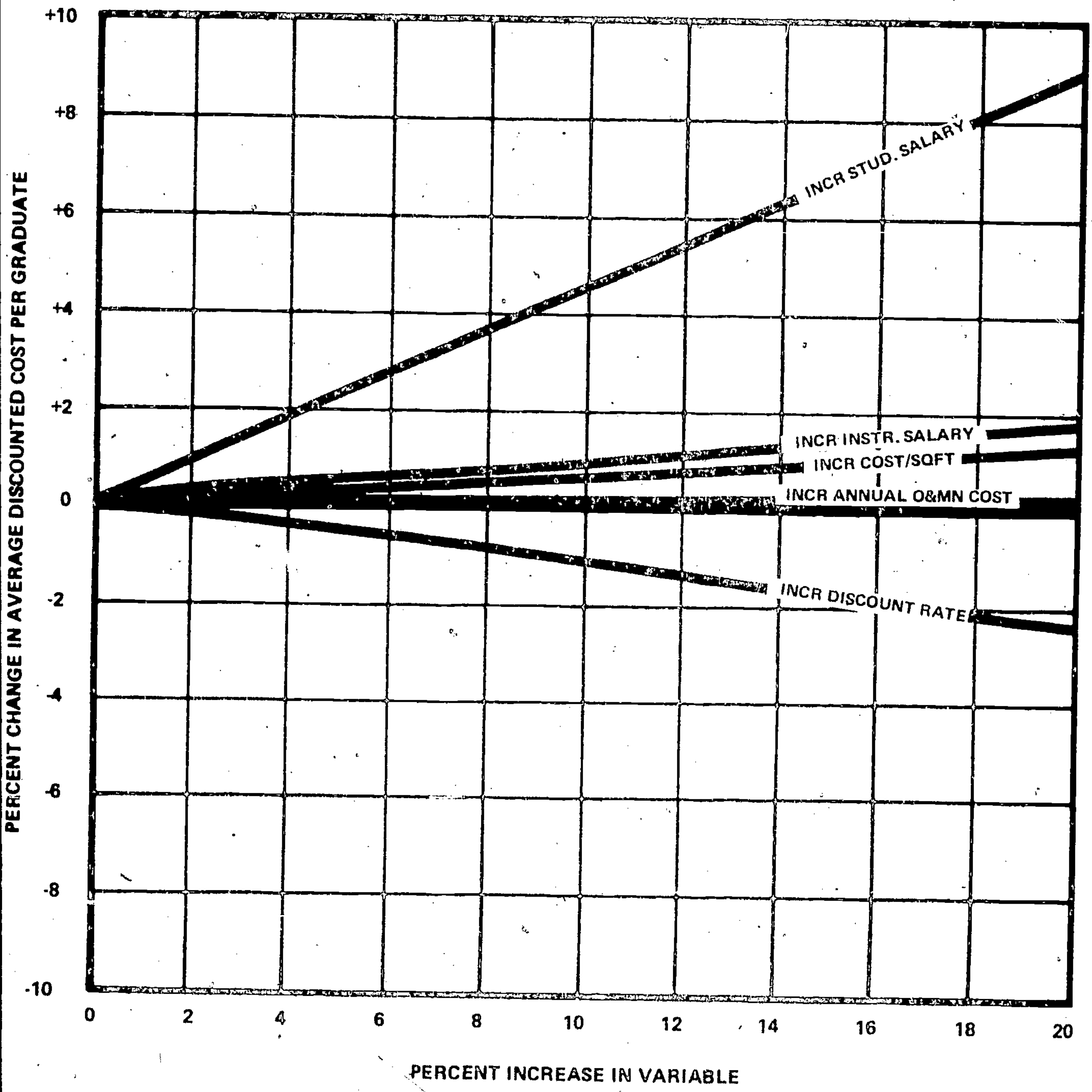



FIGURE 6.7.4. TRAINING COST MODEL SENSITIVITY ANALYSIS
AVERAGE DISCOUNTED COST PER GRADUATE

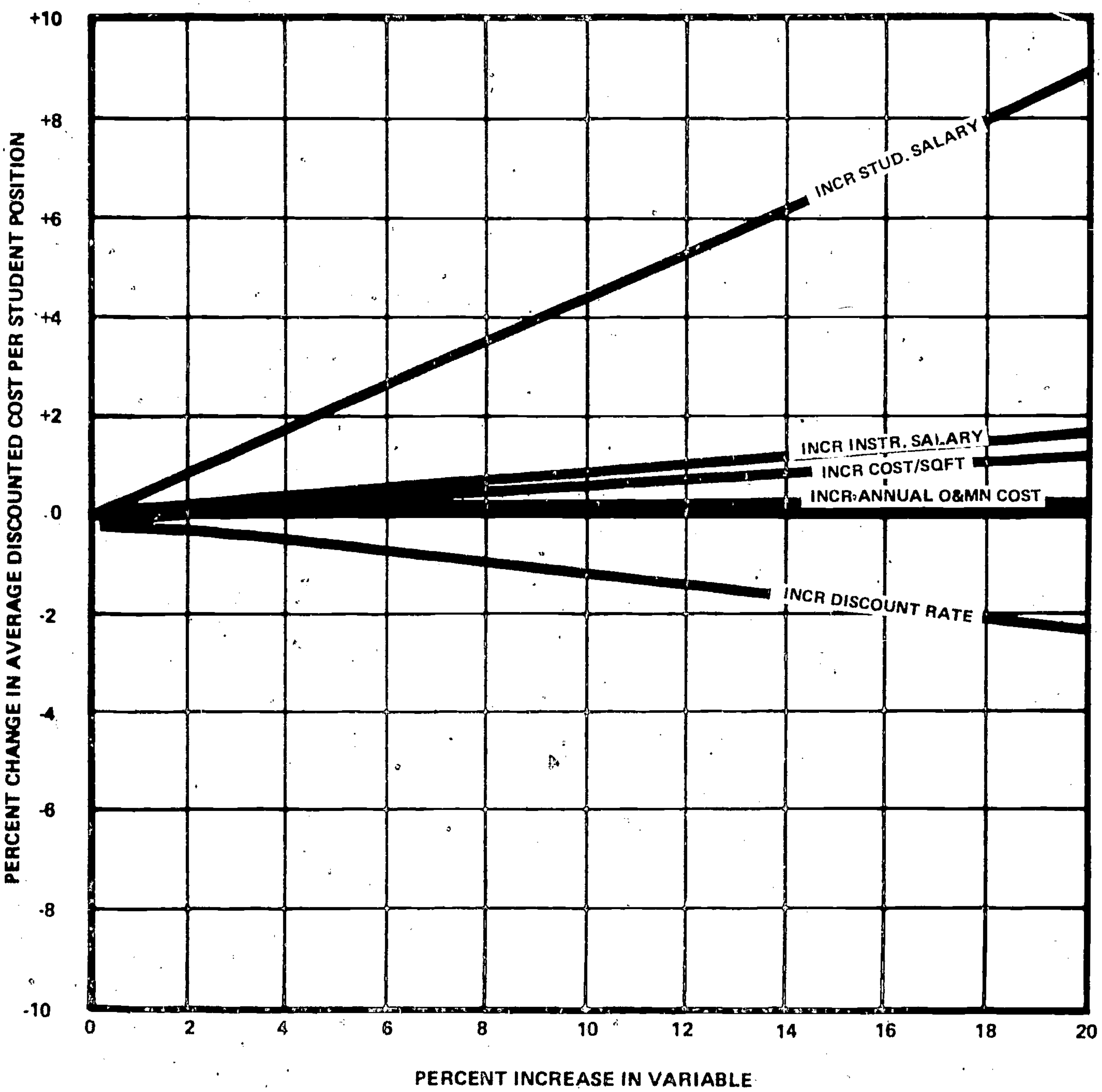



FIGURE 6.7.5. TRAINING COST MODEL SENSITIVITY ANALYSIS
AVERAGE DISCOUNTED COST PER STUDENT POSITION

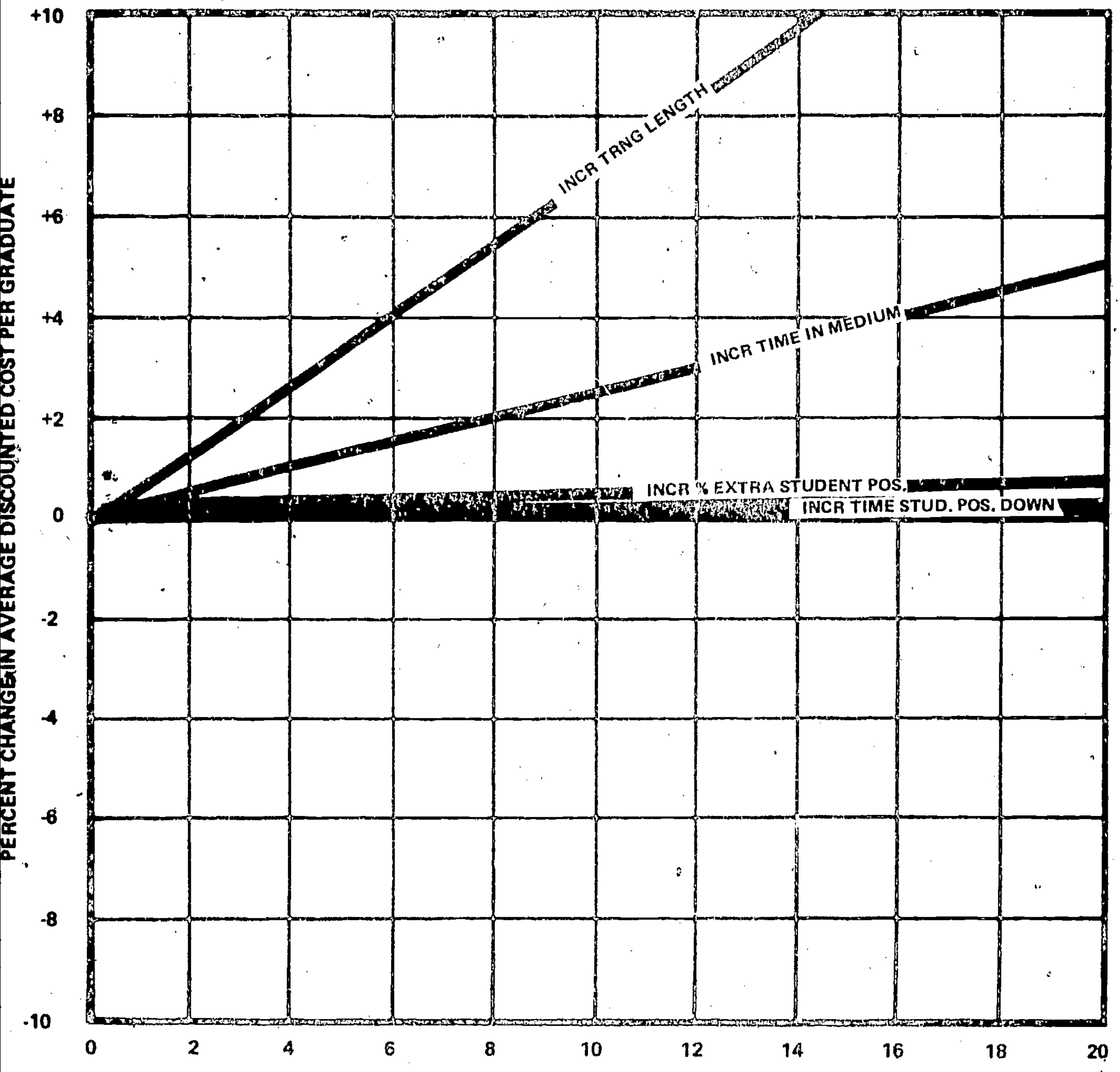



FIGURE 6.7.6. TRAINING COST MODEL SENSITIVITY ANALYSIS
AVERAGE DISCOUNTED COST PER GRADUATE

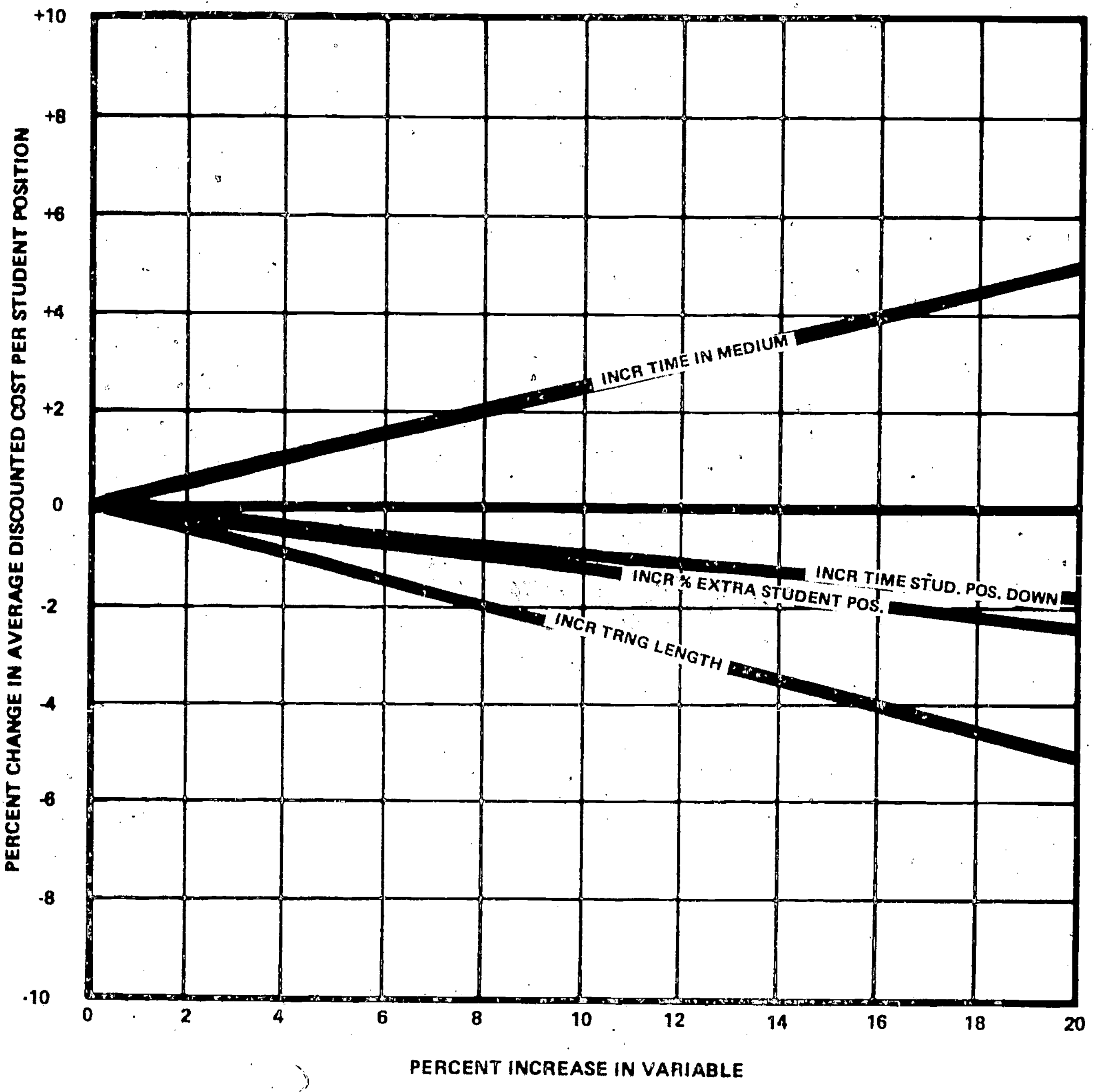
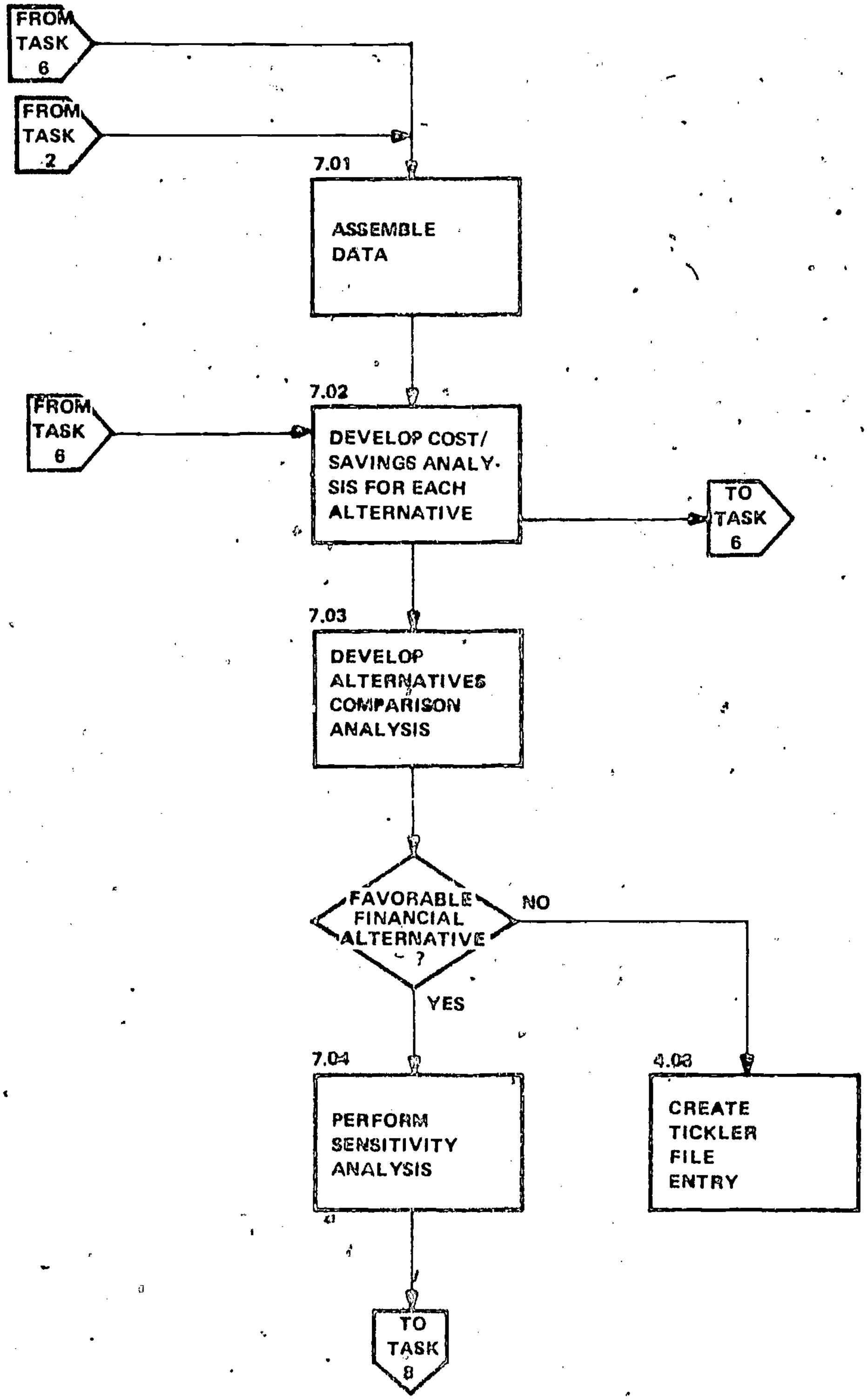



FIGURE 6.7.7. TRAINING COST MODEL SENSITIVITY ANALYSIS
AVERAGE DISCOUNTED COST PER STUDENT POSITION

| TASK: PERFORM FINANCIAL ANALYSIS | TASK | SUBTASK | PAGE |
|---|---|---|---|
| | 07 | 00 | 01 |



TASK: PERFORM FINANCIAL ANALYSIS

Financial analysis adds an additional dimension to the data available for the decision maker to use in reaching a conclusion on the acceptance or rejection. The cost-benefits analysis from Task 6, combined with the following financial analysis, in general, meets the requirements for an economic analysis. The definition of Economic Analysis as stated in SECNAVINST 7000.14A, dated 14 Mar 1973 (Enclosure (1), page 2), is as follows:

Economic Analysis: A systematic approach to the problem of choosing how to employ scarce resources and an investigation of the full implications of achieving a given objective in the most efficient and effective manner. The determination of efficiency and effectiveness is implicit in the assessment of the cost-effectiveness of alternative approaches and is accomplished by:

a. Systematically identifying the benefits and other outputs and costs associated with alternative programs, missions, and functions and/or of alternate ways for accomplishing a given program (usually referred to as projects and activities).

b. Highlighting the sensitivity of a decision to the values of the key variables and assumptions on which decisions are based including technical, operational, schedule, and other performance considerations.

c. Evaluating alternative methods of financing investments, such as lease or buy; and

d. Using benefits and costs to compare the relative merits of alternatives as an aid in:

   1) Making trade-offs between alternatives,

   2) Recommending the cost-effective alternative, and

   3) In establishing or changing priorities.

In terms of this definition, the entire ETAM can be considered an economic analysis. This task focuses on the quantifiable benefits (savings) and liabilities (investment and recurring costs) to measure the justifiability of the proposed innovation in terms of its return on investment; and at the same time it provides a comparative analysis of several alternatives (identified in Task 2). The "General Guidelines for Doing Economic Analysis/Program Evaluation Studies" contained in SECNAVINST 7000.14A should be reviewed in conjunction with this task.

| SUBTASK | | REFERENCE |
|---|---|---|
| 1. | Assemble the necessary input data to develop the required analyses. | 07.01.01 |
| 2. | Develop incremental cost/savings analysis for each alternative procedure to produce a Cost/Savings Source Report. | 07.02.01 |
| 3. | Make analysis of each alternative in comparison with each other alternative to produce an Alternatives Analysis Report. | 07.03.01 |
| 4. | Perform sensitivity analysis of return on investment to selected variables. | 07.04.01 |
| 5. | Create tickler file entry identifying criteria for reassessment of innovation if, at this point, the proposal does not appear feasible. | 04.06.01 |

| TASK | SUBTASK | PAGE |
|---|---|---|
| 07 | 01 | 01 |

TASK: PERFORM FINANCIAL ANALYSIS

SUBTASK: ASSEMBLE DATA

DESCRIPTION

The assessor may or may not have carried each alternative generated in Task 2 through the entire assessment process. If each alternative has been subjected to a rigorous assessment, then the cost data will be available and can be introduced directly into the financial analysis. Otherwise a detailed cost analysis will have to be performed. The data from the proposed innovation which have been carried through the assessment process to this point will, however, be available.

PROCEDURE

1. Obtain the cost data for the proposed innovation generated by the cost model run in 06.03. The cost data should reflect the results of Task 6 which should have led to selection of a particular decision tree path. For example, if the particular path chosen included investment in additional studies or R&D projects, these costs should be included as inputs to the cost model.

2. Obtain the cost data for the baseline system. These data will have been used in Task 6 to calculate the incremental costs/savings resulting from the proposed innovation.

3. Obtain data available for any alternatives to the proposed innovation which may have been generated in Task 2.

TASK: PERFORM FINANCIAL ANALYSIS

SUBTASK: DEVELOP COST/SAVINGS ANALYSIS

DESCRIPTION

In this subtask, each of the alternatives will be subjected to an incremental analysis across the entire range of application. It is assumed that the alternative approaches were designed to meet the same objective as outlined in Task 1 for the proposed innovation; therefore, the range-of-effect analysis should lead to the same results. If, however, this is not the case then a new range-of-effect analysis must be performed prior to costing a particular alternative.

PROCEDURE

1. Determine requirements for additional cost model runs. These may involve costing of alternatives as well as the costing of the specific approach selected for the proposed innovation as a result of the assessment process in Task 6.

2. Ensure that alternatives have been subjected to the appropriate range-of-effect analysis so that the entities to be costed (courses, jobs, equipments, etc.) are valid targets for application of each alternative proposal.

3. Establish the input parameters and prepare input data sheets as called out in 06.03. Each alternative will be incrementally assessed against every other alternative, the proposed innovation, and the baseline (or existing) system. A model run input is prepared, therefore, for each of these cases. Two input factors of concern at this point are the inflation rate and the discount rate. The inflation rate permits an expression of annual figures in current dollars; i.e., the dollar values that would most likely be reflected in the budgets for those outyears where prices have increased. The discount rate permits the time value of money to be considered within the overall decision process. The Department of Defense and Secretary of the Navy have issued guidance on the appropriate discount rate to be used. The present rate stated in DOD INSTRUCTION 7041.3 and in SECNAV INSTRUCTION 7000.14A is 10%. This rate can be modified if the analyst feels another rate is more appropriate. In the private sector, this rate is sometimes adjusted to reflect risk. For example, low risk investments such as in replacement of machinery may use a discount rate as low as the current going-rate of interest. High risk

investments such as for R&D or new market-entry products may use a discount rate that is much higher; i.e., 25% or more. If an alternate rate is selected, model runs should be made at both the alternate rate and the current DOD approved rate; i.e., 10%.

4. Complete model runs for each of the cases prepared in step 3, and generate a Cost/Savings Source Report. A sample of this report is shown in Figure 7.2.1.

COMMENT: The Cost/Savings Source Report shown in Figure 7.2.1 is one of three formats which will be discussed in Section IV of this report under Computer Applications.

The values of costs and savings represent the incremental change or difference in the comparison of the effects of one alternative against the effects of another alternative.

5. Review the total and present value (NONDISCOUNTED TOTAL $ and PRESENT VALUE-CONST $) for each comparative incremental analysis. If these figures are not positive, then the incremental rate of return for the alternative in question will not be to the level expected; therefore, it may be desirable to exclude this alternative from further analysis. The information regarding any alternatives rejected at this point should, however, be carried forward for the review of the decision maker in Task 8.

COST/SAVINGS SOURCE REPORT

INPUT:

DISPLAY FORMAT - COURSE/EQUIPMENT/JOB
PLANNING PERIOD - Ø5 YEARS

DISCOUNT RATE - 15 PERCENT
INFLATION RATE - Ø8 PERCENT

---

OUTPUT:

| CST(-)/SAV(+) SOURCE - | TOTAL | YEAR 1 | YEAR 2 | YEAR 3 | YEAR 4 | YEAR 5 |
|---|---|---|---|---|---|---|
| COURSES | | | | | | |
| 536B | 67.8 | 7.6 | 21.4 | 18.6 | 13.2 | 7.0 |
| 536C | 61.2 | 7.1 | 22.3 | 13.9 | 12.8 | 5.1 |
| 536D | 1Ø2.5 | 8.8 | 3Ø.2 | 24.Ø | 22.2 | 17.3 |
| JOBS | | | | | | |
| EN | 52.4- | 11.5- | 16.6- | 14.1- | 6.1- | 4.1- |
| EM | 51.8- | 12.6- | 18.2- | 1Ø.6- | 7.4- | 3.Ø- |
| MM | 89.3- | 24.Ø- | 17.1- | 18.Ø | 17.6- | 12.6- |
| NONDISCOUNTED TOTAL $ | 38.Ø | 24.6- | 22.Ø | 13.8 | 17.1 | 9.7 |
| PRESENT VALUE-CONST $ | 18.9 | 21.4 | 16.6 | 9.1 | 9.8 | 4.8 |
| INFLATED TOTAL $ | 54.1 | 26.6- | 25.7 | 17.4 | 23.3 | 14.3 |
| PRESENT VALUE-CURNT $ | 28.1 | 23.1- | 19.4 | 11.4 | 13.3 | 7.1 |

FIGURE 7.2.1 COST/SAVINGS SOURCE REPORT

| TASK | SUBTASK | PAGE |
|---|---|---|
| 07 | 03 | 01 |

TASK: PERFORM FINANCIAL ANALYSIS

SUBTASK: DEVELOP ALTERNATIVES COMPARISON ANALYSIS

DESCRIPTION

The purpose of this subtask is to organize the data from Subtask 07.02 in such a way that alternatives (including the proposed innovation) which have been deemed reasonable can be compared with one another. The decision maker will have available certain financial measurements which are indications of the relative value of the alternatives under consideration.

PROCEDURE

1. Select the analytic results from Subtask 07.02 for those alternatives accepted for further consideration.

2. Organize the data so that the incremental annual costs and savings are separated into the following categories:

   - R&D costs - while these costs are not specifically displayed as an output of this subtask, they should be separately identified for subsequent funding requests should the proposal be accepted.

   - Investment costs - these will be primarily equipment purchase costs; however, other costs may be considered investment, such as start-up costs or rehabilitation and modification costs. The assessor should refer to SECNAV INSTRUCTION 7000.14A for a more complete identification of the types of costs which might fall into this category.

   - Recurring costs - these are costs expected to recur on an annual basis, such as costs for personnel, maintenance of equipment, maintenance of instructional materials, supplies, etc.

COMMENT: Data should have been classified according to the preceding categories when originally introduced into the costing cycle in Subtasks 06.02 and 06.03. No major reorganization should be required at this time.

3. Generate an Alternatives Analysis Report as presented in Figure 7.3.1. This report summarizes the incremental investment and recurring costs, and the savings for up to three alternatives, one of which may be the baseline or existing system. The financial measurements calculated and displayed as a part of the Alternatives Analysis Report are:

   - Costs and savings are presented both in nondiscounted constant dollars and their present value, as obtained by discounting at the discount rate (percent) indicated.

- A savings investment ratio is calculated as the ratio of the PV net recurring cst(-)/sav(+) to the total PV of new investment(-).

- The rate of return on investment is the rate which, if substituted for the discount rate used, would have made the total PV of cst(-)/sav(+) equal to zero; i.e., the present value of the savings would have equaled the present value of the investment.

- The uniform annual cst(-)/sav(+) is the average cost of savings spread over the economic life of the alternative used for the analysis. It becomes a useful number for comparing alternatives which have varying economic lives.

COMMENT: The computational aspects of this report and its relationship to the Cost/Savings Source Report will be discussed in further detail in Section IV of this report under Computer Applications.

4. Review the alternatives being compared for those having favorable return on investment. If the proposed innovation shows the highest rate of return, then there should be sufficient basis for its acceptance. However, the following should be considered where the proposed innovation does not show the highest rate of return when compared with either the baseline (or existing) system or with one of the alternatives.

   - The amount of total investment required to accomplish each of the alternatives may be a critical factor in the ultimate decision to accept one or the other. In Tasks 3 and 4, the funding as a possible constraint was assessed in terms of the potential risk it imposed on the implementation and use of the proposed innovation. An alternative, even with a lower rate of return, may be a more favorable approach if the overall risk is significantly lower due to a lesser funding requirement.

   - One concern in financial analysis is with the rate of return obtained on the investment of incremental dollars. If the rate of return on the incremental investment, in going from one alternative to another, is less than could be obtained through some alternate form of investment, then perhaps the additional expenditure should be rejected. If, however, the investment dollars could not be put to better use, perhaps the proposal with the higher investment requirements should be accepted, even though its rate of return is less than an alternative with a lesser investment requirement.

   - If an alternative proposal looks more favorable on a financial basis, it should be subjected to the analytic steps outlined in Task 6 to determine if it might be rejected because of greater nonquantified liabilities or because there is a change in the probabilities that the alternative can be successfully implemented, or successfully applied, by the user.

5. Determine the alternative or alternatives to be considered in the ultimate decision process and perform the required sensitivity analysis outlined in Subtask 07.04.

6. If no candidates have an acceptable level of financial return and there is no hard requirement for selection of one of them for "mission accomplishment" reasons, then a tickler file entry should be created as outlined in Subtask 04.06.

TASK: PERFORM FINANCIAL ANALYSIS

SUBTASK: PERFORM SENSITIVITY ANALYSIS

## DESCRIPTION

The results of comparing alternatives may have shown several to be fairly close to each other in terms of their rate of return, or the selected candidate may have had a rate of return close to the required return as stated in the discount rate. In either of these cases, the assessor may want to know which variables are particularly sensitive, such that their variation may possibly change the ultimate decision. The purpose of this subtask (as with the preceding sensitivity analysis in Subtask 06.07) is to provide the assessor with insight into the variables which could cause a change in the decision if they were to vary over a reasonably expected range. A need for improving the confidence in the estimate of a particular variable may be indicated by this analysis which in turn may suggest the gathering of additional information.

## PROCEDURE

1. Review the sensitivity analysis diagrams for the models used to develop the cost factors to determine if any of the variables affected by the proposed innovation are particularly sensitive. Sample sensitivity graphs of the Training Cost Model were presented in Subtask 06.07.

2. Identify the variables to be inputted to the sensitivity analysis program which will perform the following steps.

   a. Determine if the inputted variables cause a change in the decision variable beyond some expressed limit, first considering the limits of the confidence range expressed for the variables. A confidence range should have been expressed for each of the variables considered relevant to the application of the proposed innovation. However, in the absence of a confidence range, the variable value at which the limit of the decision variable is reached will be calculated.

   b. The break-even value, or point at which the decision variable limit is reached, will be calculated for each variable in which this occurs in between the two confidence limits.

   c. A sensitivity and probability that the indicated decision will change, will be calculated for each variable that causes a change within the confidence range.

   d. A report similar to that shown in Subtask 06.07, Figure 6.7.1, will be generated for the assessor to review.

COMMENT: The cautions in interpretation of the statistical data mentioned in Subtask 06.07 apply here, also, and they should be reviewed.

5. Review those variables to which the indicated decision appears sensitive and determine if additional information should be obtained to improve the confidence of the assessor that the decision indicated is valid.

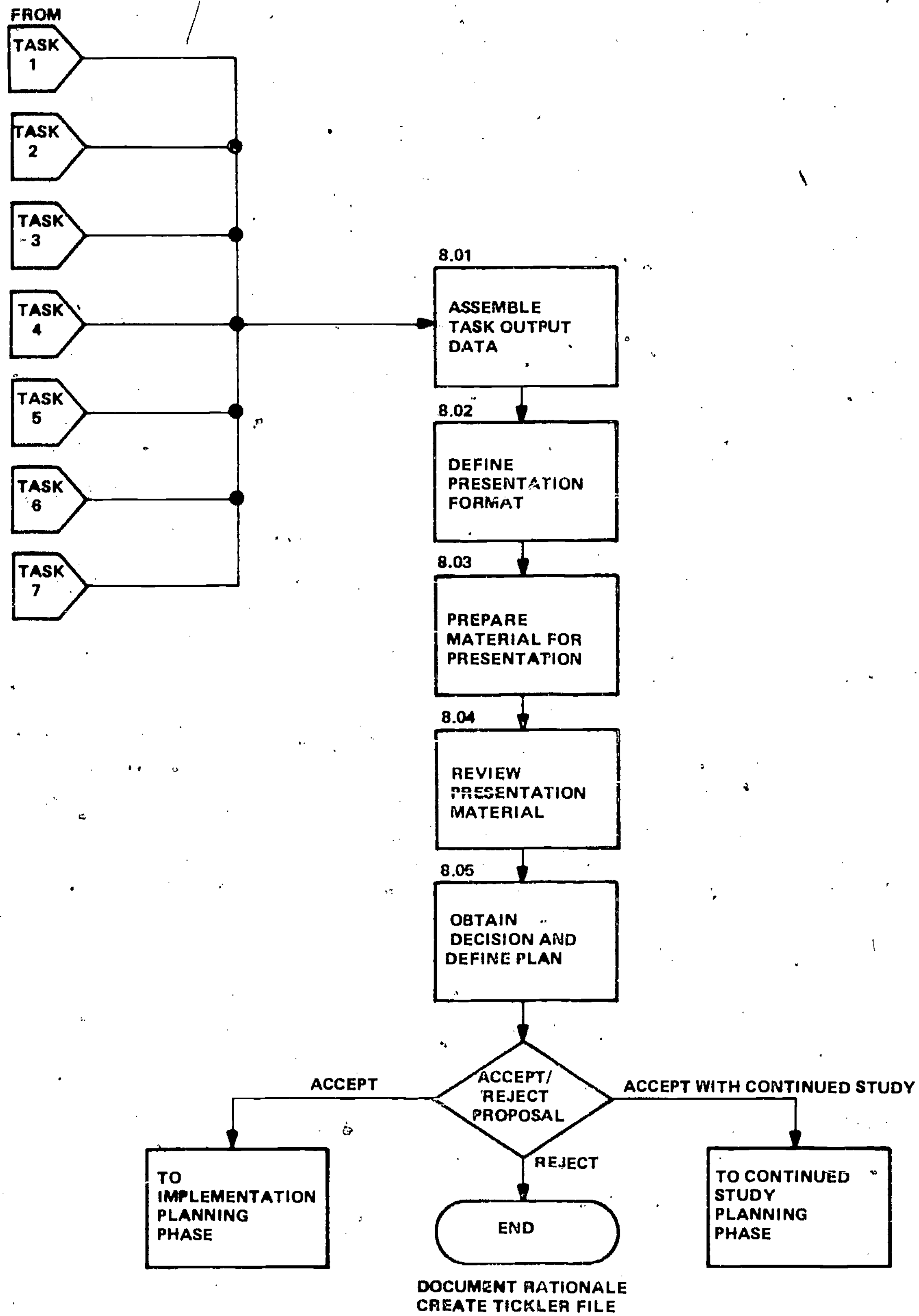
6. The information reports generated in this task will be used in Task 8 as a part of the overall decision-making format. If, at this time, however, there appears to be an obvious basis for rejecting the proposed innovation or any of the alternatives, a tickler file entry as outlined in Subtask 04.06 should be created.

| SUMMARY OF RELEVANT FACTORS CONSIDERED IN THE ECONOMIC ANALYSES: | EXISTING VS. PROPOSED | EXISTING VS. ALTERNATIVE | PROPOSED VS. ALTERNATIVE |
|---|---|---|---|
| Comparative Economic Life of Alternatives (Years) | 5 V S 5 | 5 V S 5 | 5 V S 5 |
| Total Nondisc Net Investment | 100.0- | 40.0- | 60.0- |
| Total Nondisc Recurring Cst/Sav | 220.0 | 100.0 | 120.0 |
| | | | |
| Present Value of New Investment | 100.0- | 40.0- | 60.0- |
| Plus: PV Existing Assets Used | 0.0- | 4.3- | 0.0 |
| Less: PV Existing Assets Repl | 4.3 | 0.0 | 0.0 |
| Less: PV Investment End Value | 14.9 | 2.5 | 12.4 |
| Total PV of New Investment(-) | 80.8- | 41.8- | 47.6- |
| PV Net Recurring Cst(-)/Sav(+) | 143.4 | 68.0 | 75.3 |
| Plus: PV Refurb/Modif Saved | 0.0 | 0.0 | 0.0 |
| Total PV of Cst(-)/Sav(+) | 62.6 | 26.2 | 27.7 |
| | | | |
| Discount Rate (Percent) | 15 | 15 | 15 |
| Savings Investment Ratio | 1.77 | 1.63 | 1.58 |
| Rate of Return on Investment | 35.9 | 38.4 | 29.2 |
| Uniform Annual Cst(-)/Sav(+) | 18.7 | 7.8 | 8.3 |

FIGURE 7.3.1. ALTERNATIVE ANALYSIS REPORT

| TASK | SUBTASK | PAGE |
|---|---|---|
| 08 | 00 | 01 |

TASK: MAKE ACCEPT/REJECT/STUDY DECISION

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| TASK | SUBTASK | PAGE |
|---|---|---|
| 08 | 00 | 02 |

TASK: MAKE ACCEPT/REJECT/STUDY DECISION

This task is to provide guidance to the assessor in order that a coherent decision-making format can be structured for presentation to the ultimate decision makers. It provides examples of both format and content which are recommended for presentation. In addition, it addresses some of the questions the decision maker might have, in order to suggest back up detail that should also be made available as a supplement to the presentation. The objective of ETAM has been to ensure that information has not been lost in the process of quantifying and summarizing the data. Therefore, the information available to the decision maker will be in consonance with this objective.

| SUBTASKS | REFERENCE |
|---|---|
| 1. Assemble the outputs from each step of the assessment procedure, Tasks 1 through 7. | 08.01.01 |
| 2. Define the presentation format so that it is consistent with the requirements of the decision maker. | 08.02.01 |
| 3. Prepare the material to be presented to the decision maker. | 08.03.01 |
| 4. Review the material planned for presentation in the context of potential questions which the decision maker might have. | 08.04.01 |
| 5. Obtain the decision and define a plan for proceeding based upon the decision. | 08.05.01 |

TASK: MAKE ACCEPT/REJECT/STUDY DECISION

SUBTASK: ASSEMBLE TASK OUTPUT DATA

DESCRIPTION

Assemble the descriptive and analytic data resulting from each of the ETAM tasks. These data should have been maintained in a project file and should, therefore, be readily available.

PROCEDURE

1. Obtain the following data which will be used in preparing the presentation to the decision maker.

   a. Task 1 - all information describing the proposed innovation and any of the alternatives subjected to the procedures in Task 1. Of primary interest are the objectives of the innovation and any assumptions made with regard to the application of the innovation.

   b. Task 2 - any alternatives which were considered, whether they were subjected to the entire assessment procedure or not.

   c. Task 3 - the results of the preliminary risk assessment identifying major stumbling blocks to the successful application of the innovation.

   d. Task 4 - the specific projects defined in order to reduce identified risks, and the assessment of costs and impact upon risk reduction.

   e. Task 5 - the search parameters derived from evaluating the innovation in relation to a number of taxonomic structures, the particular entities found as a result of the searches, and the benefits pattern attached to the successful application of the proposed innovation.

   f. Task 6 - the results of each analytic step which led to the formulation of the final decision tree structure, and the sensitivity analysis data related to the decision tree.

   g. Task 7 - the Cost/Savings Source Report for each of the alternatives under consideration, and the Alternatives Analysis Report comparing alternatives on a financial basis. Sensitivity analysis data relative to the selected alternatives should also be obtained.

   h. Any additional references, supporting rationale, or expert judgments obtained in the assessment process should be obtained.

TASK: MAKE ACCEPT/REJECT/STUDY DECISION

SUBTASK: DEFINE PRESENTATION FORMAT

## DESCRIPTION

The decision maker will undoubtedly have a limited amount of time to review the proposal and the analytic results. Also, the decision maker will have format preferences which aid in the comparison of numerous requests for resources. A third consideration is the level of technical understanding of the problem and of concepts inherent in the solution that the decision maker might have. The purpose of this subtask is to provide guidance to the assessor in arriving at a presentation format which meets the above needs.

## PROCEDURE

1. Obtain information on the preferences of the decision maker for particular types of formats. These preferences should be in terms of medium and style.

2. Determine the amount of time which will be available for the review and decision process and the conditions under which the review will be conducted.

3. Determine the degree of background which the decision maker has in both the problem addressed by the innovation, and in the various technical aspects of the solution.

4. Define a format which considers the needs of the decision maker, but at the same time ensures that the relative merits of the proposal can be adequately displayed. Some presentation techniques are outlined in a Department of Defense publication titled, "Economic Analysis Handbook, 2nd Edition."

## RATIONALE

This final step of presenting the results of substantial analytic work may have a significant effect upon the decision outcome. Even a sound and justified proposal may fail to gain acceptance because of shortcomings in the presentation format.

TASK: MAKE ACCEPT/REJECT/STUDY DECISION

SUBTASK: PREPARE MATERIAL FOR PRESENTATION

DESCRIPTION

Once a format has been defined for the presentation, the content of the analysis may have to be restructured to fit. It is important, though, that the final content be organized so that the decision maker is presented with a coherent view of the innovation, its objective in terms of application, the systematic analysis to which it was subjected, the role of experts in making critical aspects of the analysis, and of the final conclusions and recommendations resulting from the analysis. The purpose of this subtask is to provide the assessor with guidance in structuring the content for presentation within the identified format.

PROCEDURE

1. Organize the presentation sequence so that it represents a logical progression from a statement of the problem, in terms that the decision maker will understand, to any background data necessary for understanding why the objective of the innovation is reasonable, to a statement of the objective, to the proposed approach which meets the stated objective, and finally to the various supporting data necessary for the decision.

2. Prepare conclusions which are consistent with the supporting analytic data and recommendations which support the conclusions.

3. Consider alternative levels of presentation which will still retain the coherence intended.

4. Prepare a concise summary which reiterates the general conclusions and recommendations and includes a basic supporting rationale for each.

TASK: MAKE ACCEPT/REJECT/STUDY DECISION

SUBTASK: REVIEW PRESENTATION MATERIAL

## DESCRIPTION

The purpose of this subtask is to suggest possible questions that the decision maker might have with regard to the application of the innovation, the analytic process followed and the data inputs to it, and conclusions and recommendations. It is assumed that the assessment process has considered all of these potential concerns of the decision maker at one stage of the procedure or another. Therefore, the intent here is not so much to ensure that they have been adequately addressed, but rather to serve as a guide to the presenter in preparing for the presentation.

## PROCEDURE

1. Consider the following questions in reviewing the material to be presented to the decision maker.*

   a. Objective, assumptions, and alternatives.

      Is the problem stated the real problem?
      Are all reasonable assumptions identified and explained?
      Are assumptions too restrictive? Too broad?
      Are intuitive judgments identified as such? Are uncertainties treated as facts? Can the facts be verified?
      Are any feasible alternatives omitted?
      Are the alternatives well-defined and discrete? Do they overlap?

   b. Benefit/liability determination.

      Were all relevant benefits and liabilities identified?
      Was the appropriate level of relative importance assigned to each benefit/liability?
      Were the criteria used to measure benefit/liability justified by the context of the study?
      Was the benefit/liability, in fact, unmeasurable? Has there been a rational assessment of nonquantifiable factors?
      Was expert opinion used? Were these experts properly qualified?

*Adapted from the "Economic Analysis Handbook, 2nd Edition," prepared by the Department of Defense.

c. Risk assessment.

Were all potential risk factors considered?
Was the appropriate level of risk attached to each?
Are R&D or study projects to address risk factors reasonable?
Was the reassessment of risk given these projects reasonable?

d. Cost estimates.

What costing method was used? It is appropriate?
Are all relevant costs included? Are overhead costs appropriately included or excluded?
Is the rationale for including or excluding certain costs included?
Are the opportunity costs properly identified? Are sunk costs excluded?
Are the sources of cost data included? Are they accurate?
Are the cost estimating relationships valid, if the parametric method was used? Are extrapolations used without proof?
Was an appropriate discount rate used for obtaining present value?

2. Prepare any supplementary material suggested by the potential questions which the decision maker might have.

TASK: MAKE ACCEPT/REJECT/STUDY DECISION

SUBTASK: OBTAIN DECISION AND DEFINE PLAN

---

DESCRIPTION

The preceding steps should lead to either a firm or a tentative decision upon which some degree of follow-on activity can be based. This subtask suggests some of the follow-on activities to be pursued based upon different decision outcomes.

PROCEDURE

1. Obtain a decision (firm or tentative) to accept, continue to study, or reject the proposed innovation or an alternative.

2. Perform the following activities based upon the decision outcome.

    a. Decision to accept.

    Prepare a detailed implementation with supporting rationale for each phase of development, implementation, and testing.
    Identify resource needs.
    Identify checkpoints and major milestones.
    Develop auditing procedures.

    b. Decision to accept with continued study.

    This decision requires essentially the same items mentioned above, except that R&D and study plans may have to be developed, and go no-go criteria established if appropriate to the intent of the R&D or study projects.

    c. Decision to reject.

    Document rationale for rejection.
    Estimate potential for and timing of future application.
    Create tickler file entry per Subtask 04.06.

# SECTION IV

## COMPUTER APPLICATIONS

The Educational Technology Assessment Model is an organized grouping of procedural sequences that provide a structure for efficiently and effectively assessing the true value of a proposed innovation in training. Efficiency is, however, highly dependent upon the assessor's ability to access data when required, rapidly make calculations using selectable routines (e.g., Training Cost Model), modify input data and make recalculations, and obtain output reports with suitable content and format for effective analysis and decision making. These requirements for an efficient assessment processing structure suggest the need for:

1. Highly organized data bases with rapid search and retrieval capability.

2. A collection of automated routines which can be selected at specific stages of the assessment process for making calculations or manipulating data.

3. A project maintenance facility which will serve as a repository for:

    a. Descriptive data on the innovation.

    b. Input data factors.

    c. Results of data base searches.

    d. Intermediate calculated results.

    e. Implementation subproject descriptive and cost data.

    f. Final analytic results.

4. An "Executive Control System" capable of sequencing data retrieval, data manipulation, calculations, interactive requirements, and output generation based upon the analytic needs at a particular phase of the assessment.

The purpose of this section is to describe the general framework of an automated data system capable of fulfilling these needs, and to provide development guidance in the form of design specifications for those who might undertake the modeling and programming of such a system.

### ETAM AUTOMATED DATA SYSTEM STRUCTURE

The automated data system is composed of five major programs which control the flow of data and sequence of calculations, as well as provide input data paths to the data bases. The interrelationships between these five programs and the data bases are shown in Figure IV-1. Following are brief descriptions of each of the programs.

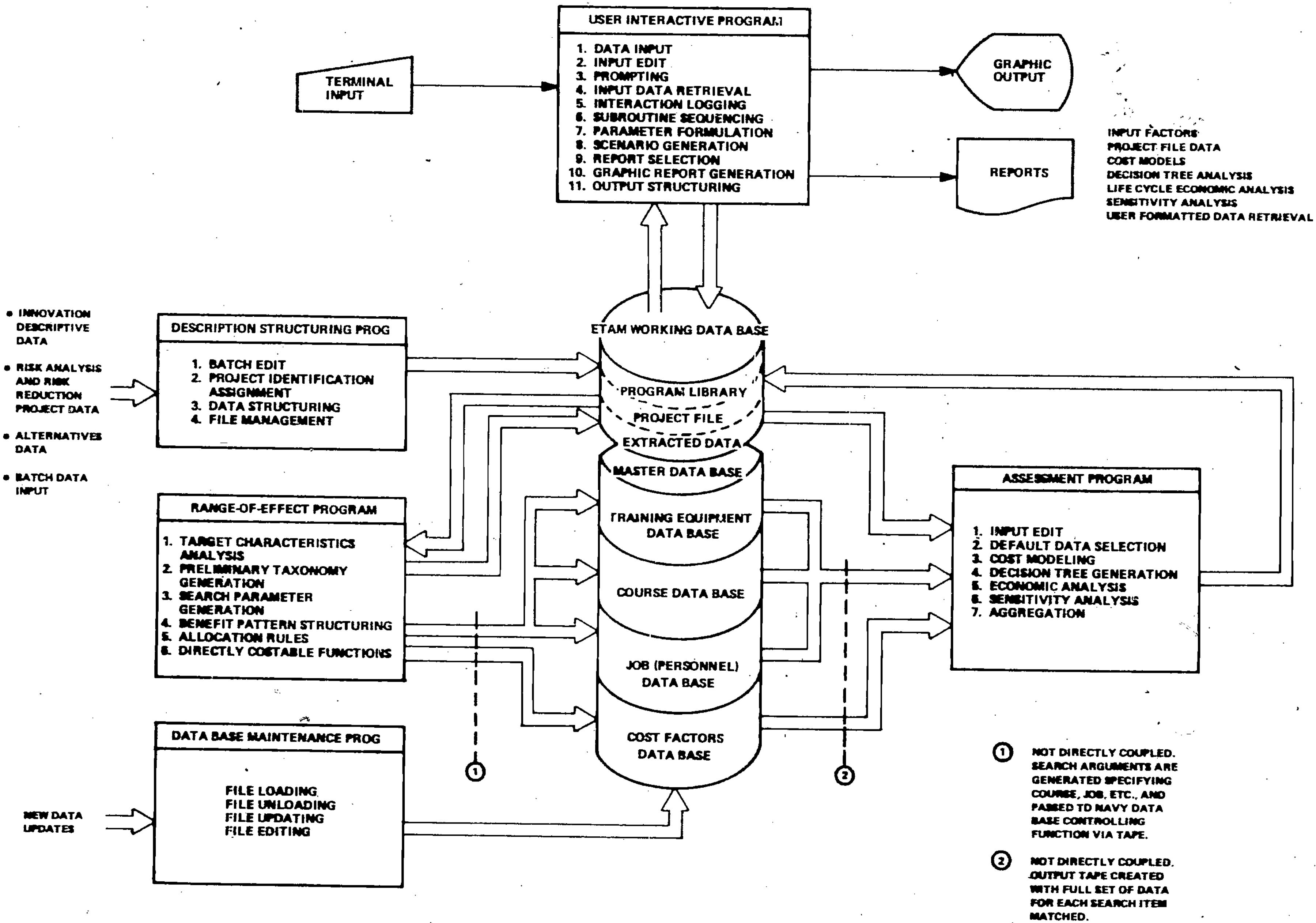


FIGURE IV-1. ETAM STRUCTURE

DESCRIPTION STRUCTURING PROGRAM. Source descriptive and project data are entered via the Description Structuring Program which performs a missing data edit and identifies either the need for additional data or the default data pattern. Project identifications are established to ensure traceability throughout the entire analytic and data transfer process. Overall data structuring, as it relates to the organization of the project file data base, is performed here. Any batch data input (e.g., cost model input parameters) is entered through the Description Structuring Program.

RANGE-OF-EFFECT PROGRAM. The purpose of this program is to formulate the processing pattern which is inputted to the Assessment Program. It will provide the user with preliminary guidance in preparing the taxonomic descriptors which will be used to search out the innovation's full range of application. Once the search characteristics have been defined, either interactively or off-line, the specific search parameter for the equipment, course, or job data bases are generated. The Range-of-Effect Program also structures and edits the benefits pattern to be assigned specific attributes of entities selected from the data bases; e.g., magnitude, importance, and confidence in the attrition factor for course 12AB. Specific allocation rules, which provide further selectivity to the final Assessment Program input, are formulated; e.g., applies only to attritions identified with a prior setback. Some innovation benefits will be direcly costable, which may preclude the need for allocation rules or benefits patterns, other than the direct amount of dollars displaced. The project file data base, containing abbreviated records for all Navy courses, jobs, etc., and user interactive inputs are the primary sources of data upon which the Range-of-Effect Program operates. Any of the entities extracted through a data search operation will be passed to the extracted data base for further manipulation.

ASSESSMENT PROGRAM. The Assessment Program performs major computational steps in the analytic process. It contains four basic types of computational capabilities, namely, cost models, decision tree evaluators, financial analysis routines, and sensitivity analysis routines. In conjunction with these computational routines, basic input editing and default data selection functions are carried out within the Assessment Program. These routines will communicate with the user to identify additional data requirements, or to point out the characteristics of particular default data being used. Interim, as well as. final results, will be retained in the ETAM Working Data Base for additional processing or modification, if desired. An aggregation routine will provide the means of summarizing the data from multiple selected entities (e.g., jobs), so that the computational routines can be run on aggregated data.

USER INTERACTIVE PROGRAM. This program is effectively the "Executive Control System" for the entire system. It includes a skeleton monitor program which controls the sequence of operation for the various routines identified in the other major programs. The User Interactive Program also contains input-output routines for communicating with the user through a terminal and graphic display, or through a set of standard, selectable reports, produced as output from the various routines in the major programs. In certain routines, such as the decision tree evaluation, within the assessment program, interaction with the user may be highly desirable in formulating parameters or in generating the scenarios required for each decision tree outcome. The routines to accomplish this interaction are a part of the User Interactive Program.

DATA BASE MAINTENANCE PROGRAM. This is a program containing a number of standard routines required to maintain the Master Data Bases. They provide the facilities for initial file loading, file updating, file editing, and for unloading or dumping the file to some output device. A similar set of maintenance routines will also be required for the ETAM Working Data Base.

DATA BASE CONSIDERATIONS

The general detail relating to the structure of the ETAM data bases is covered in the portion of this section titled "ETAM PROGRAM DESIGN SPECIFICATION." The discussion here is limited to data base considerations that apply only to the external use of information in the training enterprise for retrieval and analytic purposes. That is, the major concern here is with the disciplines for the naming of classes of data as users will interact with those names and the data. The internal logic and coding of data structures will not be discussed.

PURPOSE. The specific purposes for examining data base factors here are directed towards the issues of matching the characterization of a proposed innovation or change in training practice or technology, and the characterizations of what are or may be affected by that potential change. Thus, a nomenclature is required for the classification of the various kinds and patterns of benefits and liabilities that are associated with any aspect of the instructional process. If the nomenclature is to serve additional practical purposes for evaluation, the variables and entities that are identified should be associated with cost factors. Thus, a given benefit factor can be directly associated with cost because it is also a cost factor, and a term in the classification scheme can be used both to access data about benefits accruing from that term, and also data about the costs associated with that term. The value of this capability in assessing the desirability of a proposed change in method or resource used should be clear.

But the classification scheme should not only identify individual benefits and patterns of benefits, and costs associated with those benefits for the purpose of a technique for evaluating proposed changes in instructional technology, it should also represent the conceptual structure, or model, of instructional technology in its broadest sense. In this sense, the data base classification scheme becomes a taxonomy.

The treatment here is not a rationale for a taxonomic structure in educational technology, nor will it contain justification for the nomenclature proposed here. It will not represent all of the cost variables of the training enterprise by any means -- rather it will identify the major functional variables in education and training around which, for some purposes, cost data should be clustered. These purposes are clustered in the potential manifestations of changes in educational technology.

Specifically, the purpose of the nomenclatures to be proposed in the following paragraphs is to provide key terms to apply to the description of instructional vehicles and media, to students and job incumbents, to jobs and job tasks, and to courses and constituent course units and objectives. It is not proposed that only those descriptors or index terms proposed will be sufficient for all purposes in the use of the training system's data bases.

The Data Sets. A data set may be thought of as a tabular arrangement of data in which a primary list of entities, such as student name, is associated with a set of attribute names, such as "date of enlistment," "training courses taken," "job skills," and so forth. An entry in the table under an attribute may be quantitative, qualitative, or text description. The key factor in the practical use of a data set is in the name of the primary entities and the names of the attributes that make up the headings in the table. The name of a data set is generally based on the name of the primary entity.

The benefits and liabilities analysis in ETAM calls for four major data sets. These are:

Instructional vehicles and their functional attributes

Courses and their instructional attributes

Jobs and job tasks and their functional attributes

Students and their learning and performance attributes.

The search arguments developed by the analytic aspects of the assessment process will be directed towards the identification and retrieval of sets of entities (and entity descriptions and contexts) potentially relevant to the applicability of the innovation or proposed change. Task 5 in the ETAM procedures identifies and defines all of the following terms and implicitly develops their practical justification.

Instructional Vehicles: Types and Functional Attributes. The characterizations are based on vehicle type, vehicle properties, and on instructional context.

Vehicle Type

Instructor

Static graphics

Animated graphics

Static physical models

Procedural trainers

- Symbolic
- Physical mockup

Task simulators.

This typology is not intended to be exhaustive, but to represent a minimum set of useful distinctions. Each type will have subset categories, and any given device or vehicle may overlap more than one type. Secondary characterizations may, of course, be added to the description of any entity.

A second form of characterization of vehicles is by the way in which they manifest or implement each of a set of properties. Properties of instructional vehicles may be differentiated into those primarily directed towards instructional functions and those primarily directed towards utilization functions.

The following instructional functions are exhaustive of the variables that comprise any capability for learning.

Instructional Functions

Type of stimulus presented (e.g., visual, auditory, kinesthetic)

Type of content presented (e.g., static, dynamic, diagrammatic)

Type of presentational sequence

Selection source for sequencing

Type of external control operated by student

Feedback presentation logic

Response evaluation logic.

A second class of properties associated with instructional devices is that of utilization functions. No list of utilization functions can be complete and exhaustive. A selection can be made, however, of these functions which, taken together as a set, make up those generally most important from a practical sense.

Utilization Functions

Programmability

Portability

Multiple usage

Operating simplification or usage

Maintenance

Updatability in instructional function

Combining of instructional capabilities

Modularization of training content

Translatability of a training requirement into a training content.

Another characterization of instructional vehicles is not an inherent property, but is based on the class of use for which it is applied or may be intended. In the specific sense, every item of a given instructional vehicle should be

linked to every training course and specific instructional objective in which it is used, so that a cross-reference can be made between the instructional vehicle entity and the course content entity. But, in addition, a general characterization of training objective for which it is generally used or useful may be useful for inquiry and search.

Class of Training Objective

Reference knowledge

Knowledge: task-specific and enabling

Task skill format

Skill training

Procedural

Tracking.

A final category of classification for the instructional entity is "Where Used" information. This specifies the courses and course objectives and other data that enable the searcher to link the device to its specific applications, which in turn may identify quantifications of how much the device is used, what is learned from or by it, what the learning rate may be, and so on. These categories of data are more likely to be associated with course data sets if the latter keeps data about training operations.

Jobs and Job Tasks. The primary objective of the training enterprise is to take training requirements, based on skill requirements, and convert them into instruction which converts input student aptitudes and skill levels into on-the-job competences. Competence in jobs and tasks is the ultimate criterion of training benefits. It is, therefore, the dependent variable to which all other variables contribute and, therefore, should reference.

The characterization of job tasks should enable the categories to be linked to course content specific to the categories, and to instructional vehicles and operations. Each job task categorization should not only assist in formulating a search argument, but also differentiate a type of learning objective and/or an instructional process or resource. The category structure must optimize between two conflicting criteria: ease and simplicity of learning, and use vs. precision within practical limits imposed by the procedure and the objective.

For present purposes in ETAM, the following structure is offered. Type of skill is a characterization at about the level of duty, and is contextual rather than specific. It would assist in identifying a duty within a job.

Type of Skill

Tracking

Procedural

Decision-Making

Constructing

Leadership/Interpersonal.

The two most important sets of descriptors for jobs and tasks are those that characterize task supports, and those that characterize task structure elements of task functions. Practically every task has each of the following kinds of supports manifest in some way. The similarity or identity of the supports in one task and another tend to indicate the degree of transferability of skill from one task to the other.

Task Support Characteristics

Equipment, objects used

Environments

Tools

Reference information

Operations (task elements)

Criteria of performance: Time, errors.

A supplemental characterization of tasks is in the relative weightings and contexts of performance components, or of elements or functions that comprise the structure of any task. Each of these functions, as identified below, has somewhat different instructional requirements, but the instructional requirements for the given task function are about the same wherever that task function may appear. Thus, one can effectively teach "Identification and Nomenclature" with the same instructional setup, whatever the job or duty may be.

Task Structure Elements

Goal projection

Scan/detect

Identify

Interpret

Procedure operations

Track

Decide

Construct/plan

Motor performance

Interpersonal interaction

Recall task-cycle information

Recall enabling information.

Every task has some representation or weighting of all of these components. But from the standpoint of skill learning, each task has a somewhat different mix of these components, and most tasks tend to have high weightings on one or two. In fact, the preceding structure suggests how tasks may be identified and differentiated from each other for training and for evaluation of performance purposes.

If job tasks are identified by preponderant Task Structure Elements, and also by descriptions under each of the specified Task Support Characteristics, the nature of the skill is readily identified, transferability of skill from one job to another with respect to this task can be at least grossly estimated and the nature of the training appropriate to the task is implied.

Furthermore, if training objectives for skill learning are similarly coded, it becomes easy to cross-reference a skill requirement, or an on-the-job competence, with the training objective. Not only would this facilitate the prediction of the effects of making changes in some aspect of instructional technology, it would also facilitate the development of an archival data base of experiences with alternatives in instructional technique applied to various skill learning contexts. If these archives could be accessed by this taxonomy, ex post facto research could be conducted with historical data. The value of such data for at least preliminary assessment of proposed innovations in technology could be substantial.

Student Characteristics. The Navy has developed extensive classificatory structures for characterizing entrant personnel by tests, interviews, and observations. For purposes of this project, these characterizations may remain as they are. Of particular relevance are the patterns of tests and scores that establish requirements for entrance to various curricula and courses in Navy training. The more demanding the requirements for entering and passing a course, the higher the relative manpower cost to the Navy. It is important that the data base on students enable retrieval of the variables which are pertinent to entrance to instructional programs and courses, and to success, or the lack of it, in those programs and courses.

Training Courses. Characterizations of skills and tasks provide one basis for applying descriptors for courses aimed at skill learning. But there are also many courses directed towards knowledges intended to provide contextual background to students. These instructional objectives tend to share greater similarities in instructional vehicles and techniques than are common to skill learning, hence, the importance of making distinctions among subsets of such material is not so great. The following varieties of reference knowledge are by no means exhaustive of reference knowledges, but are typically represented in courses and in objectives within courses. They may not have the same names as are given.

Type of Reference Knowledge

System purposes

Organizational roles

Contexts of operations

Theory of operation

Organization rules, constraints

Nonwork related content.

Idealized instructional technique could develop methods of teaching theory of operations in ways very clearly different from instruction on these other topics. A tenuous basis for the categories does exist.

Another class of knowledge deserves differentiations. These are knowledges that enable the individual to learn the skill more efficiently, or to perform it.

Types of Enabling Knowledge

Operational goal criteria

Nomenclature, identifications, and locations of work objects

Procedure descriptions

Facts applicable to job performance.

Since enabling knowledges can be directly associated with skill learning objectives, they can be evaluated against a practical criterion: their contribution to learning the skill. It is therefore useful to identify enabling knowledges in course and course element descriptions.

Skills of any kind are learned in a series of stages. A given course, or element or unit within a course, may apply to a given stage of learning. The content and instructional technique and vehicle appropriate to one stage may be inappropriate to another, and in highly cost-effective training systems, these distinctions are recognized as practical. It is, therefore, important in the sense of being useful, to identify a course, and especially units within courses, not only by the kind of skill being taught but also by the skill level being learned. The following structure is used in ETAM. (As in all of the other classifications offered in this section, the reader can find definitions, examples, and rationales for every item in each list in the ETAM procedures, Section III of this report.)

Stages of Learning

Orientation

Nomenclature and identifications

Mediated procedures

Mediated performance

Automated performance

Highly skilled performance in work context

Unusual task conditions

Refresher learning

Transfer of training to new tasks, environments.

The last item is not a stage but a condition applicable to any stage, and is a realistic condition to identify for the programming of training and other personnel design and decision situations.

The empirical data that should be retained and accessible for any course unit or element that have been characterized by the various sets of descriptors specified here, are the following.

Empirical Data to be Retained for Courses and Course Elements

Aptitude level for acceptance to course: should include not only cutoff scores but actual distributions of aptitude scores of students entering a given class.

Training time per course and per course element or unit of instruction.

Attrition rate per course and per course element or unit.

Performance level achieved by student in a given class and in course elements within the course; mean scores and distribution of scores.

Individual student performance scores should be relatable to aptitude scores, entering skill characteristics, scores on other courses.

These empirical data provide targets against which innovations may be directed and evaluated. If feedback data on students can be obtained from on-the-job performance, the targeting can be more precise and more reliably relevant to training mission objectives.

CONCLUSIONS. It should be emphasized that a categorical structure, intended to serve practical search and retrieval activities with human interaction as part of the operation, does not require either mutual exclusivity of data categories nor exhaustiveness. These may be the desiderata of science. Although desirable in practical matters, they are not essential. This lesser requirement for practicality is indeed fortunate because, as R. B. Miller has shown on logical grounds elsewhere, it is not possible to define the meanings of "functions," "purposes," and "properties" in ways that are mutually exclusive and exhaustive. These criteria can be applied only to objects or to the logical definitions of sets of symbols treated only as symbols (i.e., as "objects").

The relative ease or difficulty with which indexers can learn and apply this taxonomic structure to instructional vehicles, jobs and tasks, and courses needs to be determined. At least some of the terminology, and many of the concepts, are already in practice, although not systematically. It also remains to be determined how easily researchers and others who wish to use the data base can learn and use this structured terminology. Indexing and searching are reciprocal activities; effort spent in indexing can be retrieved by ease of search.

ETAM PROGRAM DESIGN SPECIFICATIONS

This section sets down the functional specifications for each of the programs proposed for development within the overall ETAM automated data systems structure. System components exist at various levels of specification and design; some have been taken to a preliminary development stage. Some of the detail has been included here to provide examples of these various levels; however, not every program is carried to the depth of the examples. The intent is to provide sufficient guidance to a modeler and programmer for development of the individual programs within an integrated system's framework It must be pointed out that a major portion of the design specifications is contained within the ETAM procedures in Section III of this report. Program developers must be thoroughly familiar with the overall ETAM structure prior to undertaking modeling and programming tasks.

OVERALL SYSTEM OBJECTIVES. The user is a major concern in the development of any complex interactive automated data system. The following objectives are intended as overall guidance to the development process to ensure a high level of user orientation is achieved.

1. Operational Ease.

   There will be no requirement that the ultimate user be familiar with either the software or hardware design in order to solve his problems using the system. This implies an interface with the computer in a language which is presently within the user's repertory, and sufficient prompting and assistance to promote simplicity in problem entry, as well as in output interpretation.

2. Interactive Capability.

   Much of the data entry initially will be in batch form; however, once the basic analytic process has begun, a high degree of user interaction will be a part of the overall design structure. The user will be able to specify solution formats, to modify and override existing data, to call upon specific calculation or data manipulation routines, or to specify output report formats. The assistance provided the user through on-line prompting will be sufficient to permit rapid convergency toward problem solution and decision.

3. Modular Design.

   As the user undertakes the assessment process, additional calculation and data manipulation requirements may be identified. The software system will

be designed in such a way that existing routines can be easily modified or deleted without impacting other components of the system, and so that additional routines can be developed and easily incorporated as a new module within the existing system framework. This facility is necessary to maintain a "general purpose" character to the assessment process, so that analytic processes unique to assessing certain types of innovations can be added as they are identified.

4. Data Base Maintenance.

Several data bases have been identified to interface with the ETAM programs. The intent is to access existing Navy data bases, insofar as is possible, so that existing data base maintenance approaches can be used. The objective is to minimize the amount of additional data to be collected and stored. However, to facilitate the ETAM procedures an ETAM Working Data Base has been defined to store ETAM programs, project data, and data extracted from other Navy data bases to be used in specific evaluations.

ETAM WORKING DATA BASE. There are three major sections of this data base.

Program Library. The first section of the ETAM Working Data Base is a program library containing the major programs and routines to be called during the processing operations. The programs contained within this section of the data base will be the:

1. Description Structuring Program
2. Range-of-Effect Program
3. Assessment Program
4. User Interactive Program
5. Data Base Maintenance Program.

Programs will be stored as load modules in a partitional data set. A direct access storage device is recommended for storing all programs, routines, and subroutines which are a part of the program library; as well as for storing project data, conversion tables, abbreviated records of entities for search retrieval, and extracted data from Navy data bases.

Project File. The second major section of the ETAM Working Data Base will contain all project data loaded initially using the Description Structuring Program, as well as any additional data developed as a result of performing the ETAM operations. These data will include:

1. Project Descriptive Data (from Task 1)
2. Alternatives to the Innovation (from Task 2)
3. Risk Factors and Risk Reduction Projects (from Task 3)
4. Decision Tree Factors (from Tasks 4 and 6)

5. Range-of-Effect Search Descriptors (from Task 5)

6. Benefits Patterns (from Task 5)

7. Cost-Benfits Results (from Task 6)

8. Financial Analysis Data (from Task 7)

In addition, abbreviated records of all courses, jobs, and equipments will be maintained as a part of this data base. These records will be appropriately subsetted (e.g., courses by phase, etc.) and indexed to permit search once the search descriptors have been formulated from Task 5.

Project data will utilize an hierarchical structure with variable length records. A data base management system which provides interactive capability (e.g., RAMIS®*) is recommended to facilitate modifications to the analysis structure. Relationships between primary project data, alternatives to the primary project, risk reduction project data, and entities being costed and aggregated will be maintained through external tables. The components of the project file; e.g., name, description, objectives, target applications, empirical data, etc., are defined within the ETAM procedures in Section III of this report. The ETAM procedures should serve as a guide in development of project descriptive data and risk reduction project data.

Extracted Data. The third section of the ETAM Working Data Base will serve as a repository for the full set of data extracted from searches of master Navy data bases. These data will be maintained throughout the assessment operation and finally summarized and stored as a part of the project data. Individual hierarchical data sets will be established for entities extracted from existing Navy data bases. Because many of the attributes of courses, jobs, and equipments are subject to frequent change, once extracted they will be used for processing in relation to a single proposed innovation being evaluated. The entity will be repeated in a separate data set if it is related to more than one project. New extraction may be required if the analysis spans a substantial time period or if the entities are related to a major new program which is being subjected to frequent change.

Course Abbreviated Data Base Structure. The primary use of the abbreviated data bases is for searching out entities which match the descriptors formulated through the assessor's analysis of the target application and interactive prompting using the taxonomies related to the entity class (e.g., courses). Figure IV-2 shows a recommended structure for courses to be maintained within the project file area of the ETAM Working Data Base. Additional predevelopment study has been recommended in Section I of this report to develop interim procedures for translating the ETAM nomenclature into descriptions of course, tasks, and instructional vehicle attributes. This is intended to establish the course indix design that will result in a reasonable economic tradeoff between storage requirements and retrieval validity.

*RAMIS® is a data base language developed by Mathematica, Inc.

LEVEL 1

| | | |
|---|---|---|
| CRSNO | CRSNAME | CCMM |

LEVEL 2 (REPEATING)

| | |
|---|---|
| PHASE | INDEX |

FIELD NAMES

CRSNO: COURSE CDP DESIGNATION

CRSNAME: COURSE NAME

CCMM: COURSE CONTROL MODEL MANAGER

PHASE: PHASE OF COURSE

INDEX: DESCRIPTOR TAG FOR EACH PHASE OF COURSE

- STAGE OF LEARNING
- TASK STRUCTURE ELEMENT
- JOB CLASS
- CONTENT TYPE AND SUBSET

FIGURE IV-2. EXAMPLE COURSE ABBREVIATED DATA BASE STRUCTURE

LEVEL 1

| | | |
|---|---|---|
| RATE/ RANK | NEC/ NOBC | DESCRIPTIVE DATA |

LEVEL 2 (REPEATING)

| | |
|---|---|
| TASK ID | INDEX |

FIELD NAMES

RATE/RANK: ENLISTED RATING AND GRADE OR OFFICER RANK

NEC/NOBC: NAVAL ENLISTED CLASSIFICATION OR NAVAL OFFICER BILLET CODE

DESCRIPTIVE DATA: RATE/RANK NAME OR NEC/NOBC NAME

TASK ID: JOB/TASK DESIGNATION

INDEX: DESCRIPTIVE TAG FOR EACH JOB/TASK

- TYPE OF SKILL
- TASK STRUCTURE ELEMENT
- TASK SUPPORT CHARACTERISTICS

FIGURE IV-3. EXAMPLE JOB ABBREVIATED DATA BASE STRUCTURE

Job Abbreviated Data Base Structure. As with the course abbreviated data base, the job abbreviated data base will be used to search job/task entities which match descriptors formulated from the taxonomies for the job/task entity class. The recommended additional predevelopment study in Section I of this report should provide the final specifications for data base design. A preliminary recommended structure is outlined in Figure IV-3.

Equipment (Vehicle Type) Abbreviated Data Base Structure. The inventory of equipments used within naval training would be maintained in the third abbreviated data base. Descriptive tags would contain 1) vehicle type, 2) instructional function, 3) utilization functions, 4) class of training objective, and 5) where used data. Specifications for the data base structure are intended to be defined in the recommended additional predevelopment study identified in Section I of this report.

DESCRIPTION STRUCTURING PROGRAM (DSP). The objective, inputs, processing functions, and outputs for the DSP are outlined as follows.

Objective. The DSP establishes a new project region within the project file section of the ETAM Working Data Base. It accepts the total range of descriptive data on the new project (proposal training innovation) and formats it for subsequent processing. It also accepts major data subsets associated with the project which will include: (1) experimental studies with descriptions and resultant data; (2) risk reduction implementation projects with descriptions, resource requirements, schedules, and impacts upon overall project success; (3) alternative project descriptions; and (4) unique costing data. All major data subsets will be associated to the overall project under analysis through special relational tables. The table structure will allow cross-referencing of data subsets for subsequent updating and restructuring of selected data. All data will be edited by the DSP and default data assignments will be made, if possible, for any missing data. Input to the DSP will define the initial processing sequence and output requirements.

Input. Project file initialization and most updating will be performed via card input. The major input data sets will be:

1. Project descriptive data

2. Alternative projects descriptive data

3. Risk reduction project data

4. Cost models input factors

5. Decision tree paraemters

6. Job control instructions.

Processing Functions. The DSP will accept input data sets and job control instructions. All input will be edited for missing and/or potentially erroneous data. Job control instructions must identify the manner in which missing and erroneous data input will be handled; the DSP will perform the necessary

processing. The required file management routines will be called and assigned to process the input which may be new data or replacement data. Once data sets have been assigned with edited and default data inserted, a project table will be created which identifies all data sets related to the primary project being proposed.

Outputs. Two major output data sets result from processing the DSP. One outlines errors and default data assignments. The other presents the requested and generated job sequence instructions to the Executive Control System to control subsequent processing.

RANGE-OF-EFFECT PROGRAM (REP). The objectives, inputs, processing functions, and outputs for the REP are outlined as follows:

Objective. The two primary objectives of the REP are, 1) to create the necessary set of data base search parameters for obtaining the entities (e.g., courses, jobs) to which the innovation has potential application, and 2) to structure the benefit pattern used by the Assessment Program in calculating the decision variables.

Input. Project descriptive data from the project file will provide the target applications for the proposed innovation. This will establish the initial descriptor content. Benefit estimates and the empirical data will define benefit patterns and allocation rules for further modifying the search parameters.

Processing Functions. The appropriate abbreviated data base will be searched based upon the target application and the descriptor index will be presented for the review of the assessor. A conversion table will translate numeric indices to appropriate elements of the taxonomies related to the entity class for the target application. These same tables will permit the assessor to continually work with English language descriptors during the descriptive index refinement process. Routines within the User Interactive Program (UIP) will prompt the assessor and select taxonomic menus to guide this refinement process. Multiple indices may be developed if improvements of the taxonomic menus are OR'd together. Once the descriptor indices have been formulated, the appropriate abbreviated data base will be searched to obtain all entities which match.

Allocation rules are for the purpose of further refining the list of selected entities. For example, if courses having a length of one week or more can benefit from the proposed innovation, this would become an additional selector factor when the list of entities is forwarded to the Navy data base controlling function for extraction of the full range of attributes associated with the entities. The assessor must determine if the additional selectors are to be used to limit the number of entities extracted, or whether they should be applied to the total set of extracted entities once they have been loaded in the extracted data section of the ETAM Working Data Base. This determination would be based upon whether the entities eliminated by the selector would ever be brought into the Assessment Program analysis from a change in allocation rules.

A final processing function of the REP is the formulation of the benefit pattern used to input various routines with the Assessment Program. The ETAM procedures for Tasks 4, 5, and 6 should provide sufficient guidance on the content and format. Some benefit patterns will involve directly costable functions (i.e., straight displaceable costs) such as in the case where equipment is eliminated or replaced.

Output. The Range-of-Effect Program develops an output tape containing a list of entities and selector factors to be used in searching existing Navy data bases to obtain the full attribute set for each entity matched. The second output will be a table of variables, degree of change, importance, confidence, etc., which will represent the benefits pattern to be used within the Assessment Program. Allocation rules which were not used in generating selector factors on the entity extraction tape will also be stored for use by the Assesment Program.

ASSESSMENT PROGRAM (AP). The objectives, inputs, processing functions, and outputs for the AP are outlined as follows.

Objective. The AP provides the data manipulation and computational capability for generating costs, benefit quantities, decision variables, and sensitivity factors. These become the key inputs to the decision maker. The AP will have the capability of aggregating and weighting entities either for inputting cost models or resulting from processing by a cost model. Decision variables calculated on aggregated data will be obtained from either a cost-benefits analysis using a decision tree framework, or from a financial return-on-investment analysis.

Input. Job control instructions passed to the Executive Control System will guide the initial processing sequence for the AP, thus the input factors selected will be a function of these instructions. Additional processing instructions will be provided by the assessor through input to the User Interactive Program. Each routine (training cost model, job cost model, decision tree generator, etc.) will require a set of data variables which will be stored in the extracted data section of the ETAM Working Data Base. Each routine will also have provision for the generation or selection of default data in the cases where information is missing. The individual requirements for the routines with the AP are outlined in the "processing functions" section which follows.

Processing Functions. The processing design should be guided by the ETAM Procedures, Task 6 and 7. The processing routines within the AP are:

1. Training Cost Model
2. Job Cost Model
3. Equipment Cost Model
4. Decision Tree Evaluator
5. Economic Analysis Routine
6. Sensitivity Analysis Routine
7. Aggregation Routine.

As previously mentioned, each routine will perform the data editing and default data selection for its respective data sets.

Training Cost Model. The Navy Training Analysis and Evaluation Group, Orlando, Florida, had developed a model for costing training requirements as a part of a TECEP Model (Training Effectiveness-Cost Effectiveness Prediction Technique) for evaluating training media. The basic logic of this model was incorporated into the Training Cost Model specified for ETAM. A program listing, flowcharts, and sample outputs from this program are included at the end of this section. Several features were incorporated into the model which are intended to suggest sophistication which may be introduced into a final developed program.

1. Extensive input data editing and default data specification.

2. Linkage between the cost model and the output of a previously developed Training Process Flow Model.

3. User selectable policies for equipment purchases and equipment depreciation.

4. Selectable output reports.

5. Output format design compatible with CRT display to facilitate any conversion from the present batch to an interactive system with display capability.

Job Cost Model. The cost model recommended here provides a consistency with the proposed task descriptor discussed as a part of the job abbreviated data base. Figure IV-4 shows the Job/Task Cost Flow as it relates to the tasks which were matched with the search descriptors formulated in the Range-of-Effect Program. Those naval personnel who perform the tasks would have been extracted from a Navy personnel data base and stored in the extracted data section of the ETAM Working Data Base. Allocation rules (which have not already been applied in limiting the entities extracted) may provide further selectivity in terms of "who performs task," or may be applied later in the costing sequence. For example, an innovation may apply only to tasks which are performed with a frequency of less than one per month. Thus, certain tasks will be eliminated at this subsequent stage. Figure IV-4 shows the major cost determination paths. Each would require that job data beyond what is presently available be maintained.

Path 1 requires "time per task" and "task frequency" data which, multiplied together, provide a "change in performance time" which can be ascribed to the nnovation. Performance time is converted into numbers of personnel which are now costable using personnel cost factors. A Billet Cost Model presently under development for the Bureau of Naval Personnel can be used or will have generated cost factors for making the determinations of total costs along this path. A description of the Billet Cost Model with a list of the variables used in calculating billet costs is reproduced at the end of this section of the report.

Path 2 provides for cost determination when the innovation impacts errors which are made in the performance of a job or task. Errors can be defined as any deviation from criterion performance. At the present time, the costing of this path is visualized as a manual activity requiring a study of the specific error types affected by the innovation, and the determination of costs associated with the errors.

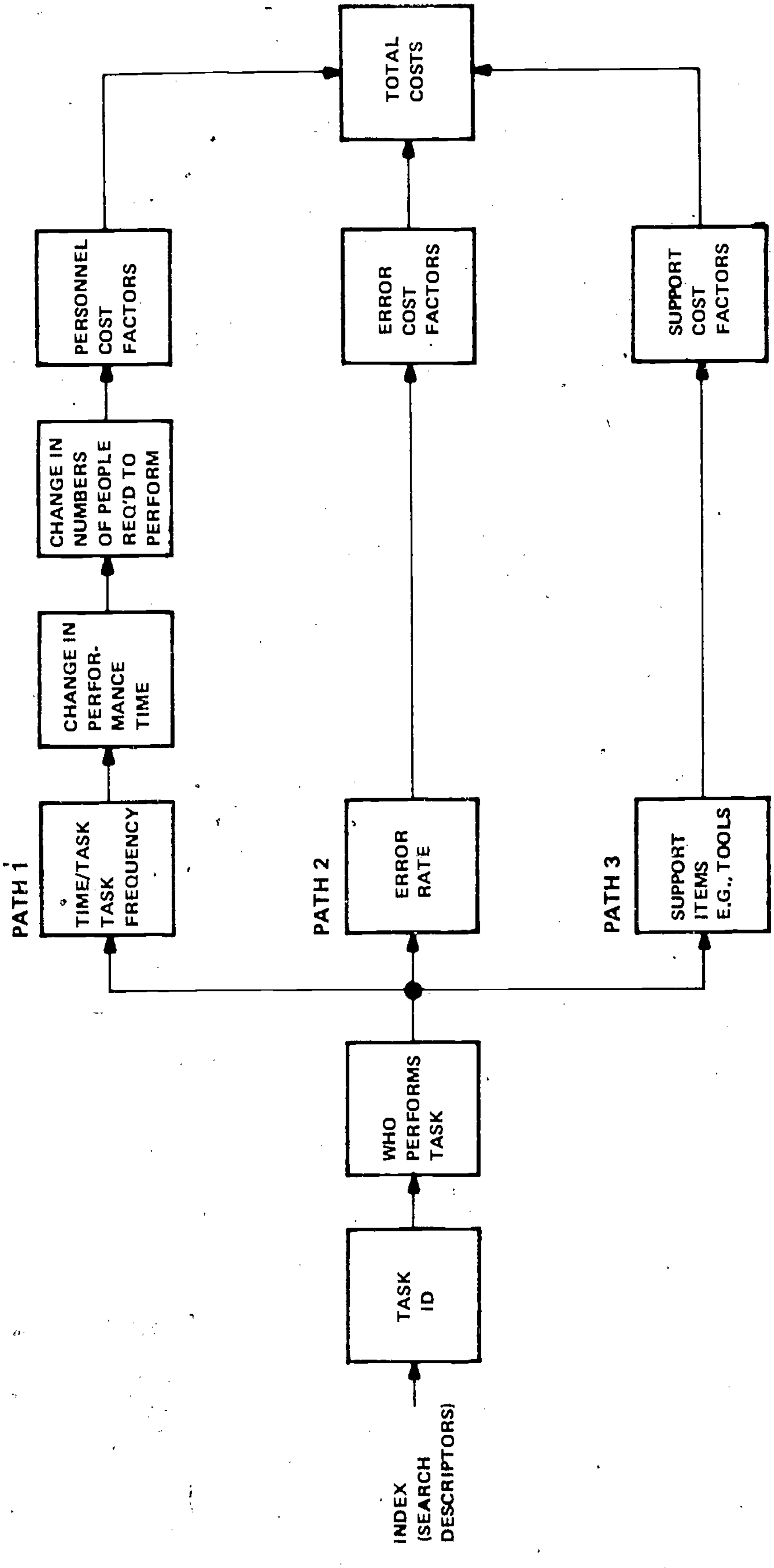


FIGURE IV-4. JOB/TASK COST FLOW

Path 3 is for assessing costs associated with job support functions. This would include facilities, tools, test equipment, etc., all of which support the job performance. Estimating the quantities affected by the innovation is again visualized as a manual activity, perhaps requiring a specific study. Costs for many of the job support items would be readily available through the appropriate naval activity responsible for their procurement and/or maintenance.

The approach to job cost modeling outlined here precludes a need for extensive parametric studies which would be required if variables at the next lower level of detail were introduced. There are, however, existing models that will be used for costing certain subsets of personnel of of performance activities. An Air Force study* looked at several alternative methodologies and cost models for determing the cost of on-the-job training. Thus, if an innovation was targeted at changing this job component (as in the Scenario Number One in Section V of this report), a similar approach might be taken in determining the cost effects.

Equipment Cost Model. The "instructional vehicle" route in the Range-of-Effect Task 5, is taken when the innovation is concerned with a straight cost displacement effect. The data base accessed for obtaining attributes of equipments should have cost factors available. The model for determining equipment cost would be similar to the equipment handling portion of the Training Cost Model. Relevant variables would be:

Equipment purchase cost
Purchase policy
Equipment maintenance cost
Life of equipment
Depreciation policy.

Decision Tree Evaluator. The decision tree evaluation routine performs the necessary calculations required to fold back the tree and determine the value of the decision variable. A program for performing such an evaluation is presently in use within DOD. The Decision Tree Language System* was used to program the standard decision tree developed for ETAM. A copy of the program, as well as copies of several program runs using various features of the program, are contained at the end of this section of the report.

The inputs to the decision tree evaluation will be able to be entered directly in the batch mode or interactively to the User Interaction Program. The inputs to this routine are:

Outcomes A through D
Success Probabilities I, U through Z
Risk Package Cost.

*Samers, B. N., Dunham, A. D. and Nordhauser, F. 1974. The Development of a Methodology for Estimating the Cost of Air Force On-the-Job Training. Report No. AFHRL-TR-74-34, Contract F41609-72-C-0048, Hq. Air Force Human Resources Laboratory, Brooks AFB, Texas.

**A program developed by SRI (Stanford Research Institute), Menlo Park, Ca, is available on the DARPA Network (ARPA/HRRO, Arlington, Va)

The program written as a part of this study does not contain the facility for incorporating more than one risk reduction package, however, this addition can be easily made.

Economic Analysis Routine. Since the ETAM procedures in Section III, Task 7, of this report provide sufficient guidance for this routine, and since there are undoubtedly a number of computer programs available for making these types of calculations, no additional design specifications are included here.

Sensitivity Analysis Routine. Two sensitivity analysis routines are required. One is used with the decision tree where the decision variable is evaluated for its sensitivity to each variable included in the tree outcomes (A through D), to the success probabilities, and to the risk reduction package(s) cost. As is outlined in the ETAM procedures in Section III, Subtask 06.07, the results of the sensitivity analysis will be:

Break-even value
Decision change (from/to)
Sensitivity factor
Probability factor.

The mean value and confidence range for each variable are the inputs to the sensitivity analysis routine.

A second sensitivity analysis routine (which can actually be developed as a subroutine of the first) will treat rate-of-return and present value decision variables as the dependent variables, and will allow a sensitivity calculation to be performed using each benefit variable and discount-rate as independent variables. A report similar to that proposed for the sensitivity analysis on the decision tree should be generated. ETAM procedures, Subtask 07.04 should be referred to for design guidance.

Aggregation Routine. The assessment program must have the facility for summing the results of evaluating multiple entities. For example, if the innovation impacts fifty courses, each course would be processed through the training cost model, and the results aggregated through this routine. Similar aggregations would be performed for jobs, equipments, etc.

Output. The AP routines generate output data sets which can be accessed by the report selection, graphic report generation, and output structuring routines within the User Interactive Program. The ETAM procedures in Section III contain samples of most reports which will result from AP routines.

USER INTERACTIVE PROGRAM (UIP). The objectives, inputs, processing functions, and output for the UIP are outlined as follows:

Objective. The purpose of the UIP is to maintain control over all processing functions and input and output both batch and interactive. It serves as the Executive Control for the programs, routines, and data bases. It also controls interaction with the assessor by performing editing, prompting, data retrieval, and output formatting. In this section, a general description of the routines within the UIP is provided, however, final design specifications require additional study as recommended in Section I of this report.

Inputs. Inputs to the UIP can originate from several sources. Job control instructions from the DSP generate the calling sequence for processing the program routines. These can be overridden by terminal input. Both the job control instructions and terminal inputted commands are analyzed and processed by ~~the~~ Executive Control System within the UIP. Input data sets for major routines are accessible through the UIP in order that data changes can be made when formulating "what if" type questions. The UIP also accesses these data sets, as well as any output data sets from the routines, to perform data retrieval and output report structuring.

Processing Functions. The primary processing function of the UIP is to handle communications and control for data handling and processing. An Executive Control System containing a skeleton monitor and communications monitor is the focal point for this function. The following functions are also performed by the UIP.

1. Data input and input editing. This function is performed for input via the terminal.

2. Prompting. A number of prompting routines including assistance ("help") to the user, will guide the assessor in data input and retrieval, processing control, and output structuring.

3. Output reporting. The UIP processes the data sets outputted from the various routines, structuring the data into standard report formats as outlined in the ETAM procedures in Section III of this report.

Output. The major outputs are data exception reports from the data editing function, prompting instructions to the assessor when operating interactively, an interaction log which provides a record of terminal requests, graphic type reports (if feasible, based upon the results of the study recommended in Section I of this report), and standard output reports.

DATA BASE MANAGEMENT PROGRAM (DBMP). Standard routines within this program perform initial data base loading, data base editing and updating, and data dumping. As a part of the data base maintenance function, error and activity, and maintenance reports will be provided to the user. These programs operate upon the elected data base management system.

TRAINING COST MODEL

- Program Listing
- Flowcharts
- Sample Output Reports

04/23/75 INPUT LISTING AUTOFLOW CHART SET -

FORTRAN MODULE (LIST)

CARD NO **** CONTENTS ****

```
C      ****************************************************************
C      *              PROGRAM - TRAINING COST MODEL                   *
C      *              TECEP COST MODEL ADAPTATIONS FOR ETAM BY L. DUFFY *
C      *              DATE - 4/23/75                                  *
C      *                                                              *
C      ****************************************************************
C
C      PROGRAM SETUP
C
       REAL INTSPO,IMDOEV,MSCSPO,MSCSTO,IMOMNT,INSTSL,INFLAT,INRATE
       REAL NSTUD,NTRAV,NINSTR,NADMIN,NFACIL,NSUPPL,NMISC,NEQUIP,NIMD
       REAL ISTUD,ITRAV,IINSTR,IADMIN,IFACIL,ISUPPL,IMISC,IEQUIP,IIMD
       INTEGER GRAD,PURCHF,AEQUIP,DEPF
       INTEGER DIGIT(20) /1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,
     1                     17,18,19,20/
       LOGICAL RPT1,RPT2,RPT3,RPT4,RPT5,RPT6,RPTT,LAST
       DIMENSION STUD(20),GRAD(20),STUDMN(20),SMWRRC(20),ADB(20),PSP(20)
       DIMENSION RINSTR(20),RADMIN(20),REQUIP(20),RFACIL(20),IMDMNT(20)
       DIMENSION RSUPPL(20),RMISC(20),CSTUD(20),CTRAV(20),CINSTR(20)
       DIMENSION CADMIN(20),CEQUIP(20),PEQUIP(20),PDEP(20),AEQUIP(20)
       DIMENSION COPMT(20),CFACIL(20),CIMDMT(20),CSUPPL(20)
       DIMENSION CMISC(20),DISCNT(20),INFLAT(20),CGRAD(20),CSTIN(20)
       DIMENSION CSP(20),MATA(100),MATB(100),COPTOT(20),MGRAD(20)
       DIMENSION ADBX(20)
       COMMON/NOGOP/NOGO,K,MATA,MATB
C
C      PROGRAM INITIALIZATION
C
    10 AASIN = 0.0
       AADB  = 0.0
       TINSTR= 0.0
       TADMIN= 0.0
       TEQUIP= 0.0
       TFACIL= 0.0
       TMDMNT= 0.0
       TSUPPL= 0.0
       TMISC = 0.0
       TPEQUP= 0.0
       TAEQUP= 0.0
       DATA COURSE /'NONE'/
       TPEQUP= 0.0
       AAEQUP= 0.0
       PURCHF= 99999
       DEPF  = 99999
       RVEQ  = 0.0
       NSTUD = 0.0
       DSTUD = 0.0
       ISTUD = 0.0
       FSTUD = 0.0
       NTRAV = 0.0
       DTRAV = 0.0
       ITRAV = 0.0
       FTRAV = 0.0
       NINSTR= 0.0
       DINSTR= 0.0
       IINSTR= 0.0
       FINSTR= 0.0
       NADMIN= 0.0
       DADMIN= 0.0
       IADMIN= 0.0
       FADMIN= 0.0
       NFACIL= 0.0
       DFACIL= 0.0
       IFACIL= 0.0
       FFACIL= 0.0
       NSUPPL= 0.0
       DSUPPL= 0.0
       ISUPPL= 0.0
       FSUPPL= 0.0
       NMISC = 0.0
       DMISC = 0.0
       IMISC = 0.0
       FMISC = 0.0
       NEQUIP= 0.0
       DEQUIP= 0.0
       IEQUIP= 0.0
       FEQUIP= 0.0
       NIMD  = 0.0
       DIMD  = 0.0
       IIMD  = 0.0
       FIMD  = 0.0
       DADB  = 0.0
       SADB  = 0.0
       NOGO  = 0
       IGRAD = 0
       IPSP  = 0
       JADB  = 0
       ARATE = 99999.
       RCRATE= 99999.
       ARCYTN= 99999.
       WSCHIP= 99999.
       TSPOSO= 99999.
       PESP  = 99999.
       INTSPO= 99999.
       AMTSPO= 99999.
       EQTSPO= 99999.
       LOFEQ = 99999.
       SQFTST= 99999.
       SQFTIN= 99999.
       SQFTAM= 99999.
       IMDOEV= 99999.
       PUIMD = 99999.
       UPDATE= 99999.
       SUPSPO= 99999.
       SUPSTO= 99999.
       MSCSPO= 99999.
       MSCSTD= 99999.
       STUDSL= 99999.
       STCSTI= 99999.
```

04/23/75 INPUT LISTING AUTOFLOW CHART SET -

CARD NO **** CONTENTS ****

```
      STCST2= 99999.
      INSTSL= 99999.
      AOMSL = 99999.
      EQUNTC= 99999.
      PCTPCH= 99999.
      CPSQFT= 99999.
      CIMO  = 99999.
      EVIN  = 99999.
      CSUPP = 99999.
      CMIS  = 99999.
      BRATE = 99999.
      INRATE= 99999.
      N     = 99999.
      TLENGH= 99999.
      K     = 1
      DO 20 I=1,20
      CSTUB(I) = 0.0
      CTRAV(I) = 0.0
      CINSTR(I)= 0.0
      CAOMIN(I)= 0.0
      CEQUIP(I)= 0.0
      CFACIL(I)= 0.0
      CIMONT(I)= 0.0
      CSUPPL(I)= 0.0
      CMISC(I) = 0.0
      COPTOT(I)= 0.0
      CGRAO(I) = 0.0
      CSTIN(I) = 0.0
      CSP(I)   = 0.0
      PDEP(I)  = 0.0
      AEQUIP(I)= 0.0
      STUO(I)  = 0.0
      AOB(I)   = 0.0
      PSP(I)   = 0.0
      RINSTR(I)= 0.0
      RAOMIN(I)= 0.0
      REQUIP(I)= 0.0
      PEQUIP(I)= 0.0
      AEQUIP(I)= 0.0
      RFACIL(I)= 0.0
      IMONNT(I)= 0.0
      RSUPPL(I)= 0.0
      RMISC(I) = 0.0
      AOBX(I)  = 0.0
      GRAO(I)  = 99999.
      COPMT(I) = 99999.
   20 CONTINUE
C
C     READ INPUT DATA
C
      NAMELIST/TECHF/ COURSE,N,ARATE,TLENGH,RCRATE,ARCYTM,WSCHOP,TSPOSD,
     1INTSPO,ANTSPO,EQTSPO,PURCHF,DEPF,LOFEQ,SQFTST,SQFTIN,SQFTAM,INODEV
     2,PUIMO,UPOATE,SUPSPO,SUPSTO,MSCSFO,MSCSTO,PESP
      NAMELIST/COSTF/STUOSL,STCST1,STCST2,INSTSL,ADMSL,EQUNTC,PCTPCN,CPS
     1QFT,CIMO,EVIN,CSUPP,CMIS,ORATE,INRATE
      NAMELIST/OIMOF/GRAO,COPMT
      READ(5,TECHF)
      READ(5,COSTF)
      READ(5,OIMOF)
      READ(5,6000) RPT1,RPT2,RPT3,RPT4,RPT5,RPT6,RPT7,LAST
 6000 FORMAT (8L1)
      IF (N.NE.99999) GO TO 30
C
C     READ TPF MODEL DATA
C
   25 READ (10,6020,END=30) COURSX,NX,ARATEX,TLENGX,RCRATX,ARCYTX,MGRAO(
     11),MGRAD(2),MGRAO(3),AOBX(1),AOBX(2),AOBX(3)
 6020 FORMAT (A4,I2,F4.3,F4.1,F4.3,F4.1,3I5,3F5.1)
      IF (COURSX.NE.COURSE) GO TO 25
      N        = NX
      ARATE    = ARATEX
      TLENGH   = TLENGX
      RCRATE   = RCRATX
      ARCYTM   = ARCYTX
      DO 28 I=1,N
   28 GRAO(I)  = MGRAO(I)
C
C     READ MISSING DATA ANALYSIS AND DEFAULT ROUTINES
C
   30 IF (N.GT.0.AND.N.LE.20) GO TO 40
      N     = 20
      CALL MISSNG (30,1)
   40 IF (ARATE.GE.0..AND.ARATE.LT.1.) GO TO 50
      ARATE = 0.0
      CALL MISSNG (40,1)
   50 IF (TLENGH.GT.0..AND.TLENGN.LT.200.) GO TO 60
      CALL MISSNG (50,0)
   60 IF (RCRATE.GE.0..AND.RCRATE.LT.1.) GO TO 70
      RCRATE= .5*ARATE
      CALL MISSNG (60,1)
   70 IF (ARCYTM.GE.0..AND.ARCYTM.LT.200.) GO TO 90
      IF (RCRATE.EQ.0.) GO TO 80
      IF (TLENGH.LT.2.) GO TO 80
      CALL MISSNG (70,0)
      GO TO 90
   80 ARCYTM= 0.0
      CALL MISSNG (70,1)
   90 IF (WSCHOP.GT.0..AND.WSCHOP.LE.52.) GO TO 100
      WSCHOP= 50.0
      CALL MISSNG (90,1)
  100 IF (TSPOSO.GE.0..AND.TSPOSO.LT.1.) GO TO 110
      TSPOSD= 0.0
      CALL MISSNG (100,1)
  110 IF (PESP.GE.0..AND.PESP.LE.1.) GO TO 120
      PESP  = 0.1
      CALL MISSNG (110,1)
  120 IF (INTSPO.GE.0..AND.INTSPO.LE.1.) GO TO 130
      INTSPO= 0.0
      CALL MISSNG (120,1)
  130 IF (ANTSPO.GE.0..AND.ANTSPO.LE.1.) GO TO 140
      ANTSPO= 0.0
      CALL MISSNG (130,1)
```

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CARD NO **** CONTENTS ****

```
  140 IF (EQTSPO.GE.0..AND.EQTSPO.LE.1.) GO TO 160
      IF (EQUNTC.NE.99999..AND.EQUNTC.NE.0.) GO TO 150
      IF (LOFEQ.NE.99999.AND.LOFEQ.NE.0) GO TO 150
      EQTSPO= 0.0
      CALL MISSNG (140,1)
      GO TO 160
  150 CALL MISSNG (140,0)
  160 IF (PURCHF.GE.1.AND.PURCHF.LT.10) GO TO 170
      PURCHF= 1
      CALL MISSNG (160,1)
  170 IF (DEPF.GE.1.AND.DEPF.LT.10) GO TO 180
      DEPF  = 1
      CALL MISSNG (170,1)
  180 IF (LOFEQ.GE.1.AND.LOFEQ.LE.50) GO TO 200
      IF (EQTSPO.NE.0.) GO TO 190
      IF (EQUNTC.NE.99999..AND.EQUNTC.NE.0.) GO TO 190
      LOFEQ = N
      CALL MISSNG (180,1)
      GO TO 200
  190 CALL MISSNG (180,0)
  200 IF (SQFTST.GE.0..AND.SQFTST.LT.1000.) GO TO 210
      SQFTST= 0.0
      CALL MISSNG (200,1)
  210 IF (SQFTIN.GE.0..AND.SQFTIN.LT.1000.) GO TO 220
      SQFTIN= 0.0
      CALL MISSNG (210,1)
  220 IF (SQFTAM.GE.0..AND.SQFTAM.LT.1000.) GO TO 230
      SQFTAM= 0.0
      CALL MISSNG (220,1)
  230 IF (IMODEV.GE.0..AND.IMODEV.LT.1000.) GO TO 250
      IF (PUIMO.GT.0..AND.PUIMO.LE.1.) GO TO 240
      IF (UPDATE.GT.0..AND.UPDATE.LE.1.) GO TO 240
      IMODEV= 0.0
      CALL MISSNG (230,1)
      GO TO 250
  240 CALL MISSNG (230,0)
  250 IF (PUIMO.GT.0..AND.PUIMO.LE.1.) GO TO 270
      IF (IMODEV.NE.0.) GO TO 260
      IF (UPDATE.GT.0..AND.UPDATE.LE.1.) GO TO 260
      PUIMO = 1.0
      CALL MISSNG (250,1)
      GO TO 270
  260 CALL MISSNG (250,0)
  270 IF (UPDATE.GE.0..AND.UPDATE.LE.1.) GO TO 290
      IF (IMODEV.NE.0.) GO TO 280
      IF (PUIMO.GT.0..AND.PUIMO.LT.1.) GO TO 280
      UPDATE= 0.0
      CALL MISSNG (270,1)
      GO TO 290
  280 CALL MISSNG (270,0)
  290 IF (SUPSPO.GE.0..AND.SUPSPO.LT.1000.) GO TO 300
      SUPSPO= 0.0
      CALL MISSNG (290,1)
  300 IF (SUPSTO.GE.0..AND.SUPSTO.LT.1000.) GO TO 310
      SUPSTO= 0.0
      CALL MISSNG (300,1)
  310 IF (MSCSPO.GE.0..AND.MSCSPO.LT.1000.) GO TO 320
      MSCSPO= 0.0
      CALL MISSNG (310,1)
  320 IF (MSCSTO.GE.0..AND.MSCSTO.LT.1000.) GO TO 330
      MSCSTO= 0.0
      CALL MISSNG (320,1)
  330 IF (STUDSL.GE.0..AND.STUDSL.LT.50000.) GO TO 340
      STUDSL= 0.0
      CALL MISSNG (330,1)
  340 IF (STCST1.GE.0..AND.STCST1.LT.10000.) GO TO 350
      STCST1= 0.0
      CALL MISSNG (340,1)
  350 IF (STCST2.GE.0..AND.STCST2.LT.10000.) GO TO 360
      STCST2= 0.0
      CALL MISSNG (350,1)
  360 IF (INSTSL.GE.0..AND.INSTSL.LT.50000.) GO TO 370
      INSTSL= 0.0
      CALL MISSNG (360,1)
  370 IF (ADMSL.GE.0..AND.ADMSL.LT.50000.) GO TO 380
      ADMSL = 0.0
      CALL MISSNG (370,1)
  380 IF (EQUNTC.GE.0..AND.EQUNTC.NE.99999.) GO TO 400
      IF (EQTSPO.NE.0.) GO TO 390
      EQUNTC= 0.0
      CALL MISSNG (380,1)
      GO TO 400
  390 CALL MISSNG (380,0)
  400 IF (PCTPCH.GE.0..AND.PCTPCH.LE.1.) GO TO 410
      PCTPCH= 0.0
      CALL MISSNG (400,1)
  410 IF (CPSQFT.GE.0..AND.CPSQFT.NE.99999.) GO TO 420
      CPSQFT= 0.0
      CALL MISSNG (410,1)
  420 IF (CIMO.GE.0..AND.CIMO.LT.50000.) GO TO 430
      CIMO  = 0.0
      CALL MISSNG (420,1)
  430 IF (EVIM.GE.0..AND.EVIM.LT.1.) GO TO 440
      EVIM  = 0.0
      CALL MISSNG (430,1)
  440 IF (CSUPP.GE.0..AND.CSUPP.NE.99999.) GO TO 450
      CSUPP = 0.0
      CALL MISSNG (440,1)
  450 IF (CMIS.GE.0..AND.CMIS.NE.99999.) GO TO 460
      CMIS  = 0.0
      CALL MISSNG (450,1)
  460 IF (DRATE.GE.0..AND.DRATE.LT.1.) GO TO 470
      DRATE = 0.10
      CALL MISSNG (460,1)
  470 IF (INRATE.GE.0..AND.INRATE.LT.1.) GO TO 480
      INRATE= 0.08
      CALL MISSNG (470,1)
  480 IF (GRAD(N).GE.0..AND.GRAD(N).NE.99999.) GO TO 490
      CALL MISSNG (480,0)
  490 IF (COPMT(N).GE.0..AND.COPMT(N).NE.99999.) GO TO 510
      DO 500 I=1,N
  500 COPMT(I) = 0.0
```

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CARD NO **** CONTENTS ****

```
          CALL MISSNG (490,1)
      510 IF (NOSO.EQ.1) GO TO 960
          IF (N.GE.20) GO TO 518
          INDEX5   = N+1
          DO 515 I=INDEX5,20
          COPMT(I) = 0.0
      515 GRAD(I)  = 0
      518 CONTINUE
C
C         MODEL EQUATIONS - TECHNICAL FACTORS
C
          UINSTR    = TLENGH*INODEV*PUINO*40.0
          CUINO     = UINSTR*CINO
          RVIN      = CUINO*EVIN
          DO 520 I=1,N
          STUD(I)   = GRAD(I)/(1.0-ARATE)
          IGRAD     = IGRAD+GRAD(I)
          AASIN     = AASIN+STUD(I)
          STUDMW(I)= (TLENGH*STUD(I))*(1.0-.5*ARATE)
          SHWRAC(I)= RCRATE*STUD(I)*ARCYTM
          AOB(I)    = (STUDMW(I)+SHWRAC(I))/WSCHOP
          DAOB      = DAOB + (AOB(I)-AOBX(I))
          SAOB      = SAOB + AOB(I)
          AAOB      = AAOB+AOB(I)
          PSP(I)    = ((AOB(I)/(1.0-TSPOSD))*(1.0+PESP))
          IPSP      = IPSP+PSP(I)
          RINSTR(I)= PSP(I)*INTSPO
          TINSTR    = TINSTR+RINSTR(I)
          RADMIN(I)= PSP(I)*AMTSPO
          TADMIN    = TADMIN+RADMIN(I)
          REQUIP(I)= PSP(I)*EQTSPO
          TEQUIP    = TEQUIP+REQUIP(I)
          RFACIL(I)= PSP(I)*(SQFTST+INTSPO*SQFTIN+AMTSPO*SQFTAM)
          TFACIL    = TFACIL+RFACIL(I)
          IMDMNT(I)= UINSTR*UPDATE
          TMDMNT    = TMDMNT+IMDMNT(I)
          RSUPPL(I)= PSP(I)*SUPSPO+STUD(I)*SUPSTD
          TSUPPL    = TSUPPL+RSUPPL(I)
          RMISC(I)  = PSP(I)*MSCSPO+STUD(I)*MSCSTD
          JAOB      = JAOB+AOBX(I)
      520 TMISC     = TMISC+RMISC(I)
          IF (DAOB.LT.0.) DAOB=DAOB*(-1.)
          IAOB      = ((DAOB/SAOB)+.5)*100
          IF (IAOB.GT.5.AND.JAOB.NE.0) CALL MISSNG (520,IAOB)
          AASIN     = AASIN/N
          AGRAD     = IGRAD/N
          AAOB      = AAOB/N
          APSP      = IPSP/N
          AINSTR    = TINSTR/N
          AADMIN    = TADMIN/N
          AEQUP     = TEQUIP/N
          AFACIL    = TFACIL/N
          AIMDMT    = TMDMNT/N
          ASUPPL    = TSUPPL/N
          AMISC     = TMISC/N
C
C         THIS ROUTINE CALCULATES EQUIPMENT PURCHASE AND DEPRECIATION
C         SCHEDULES FROM USER SELECTED POLICY OPTIONS
C
C                         - PURCHASE POLICIES ANALYSIS
C
          GO TO (530,540,550,560,570,580,590,600,610),PURCHF
C
C                                   POLICY 1 - PURCHASE TOTAL AVERAGE RQMTS
C                                              IN FIRST YEAR OF EQUIP LIFE
      530 CONTINUE
          DO 534 I=1,N,LOPEQ
          TEMP1 = 0.0
          INDEX1= LOPEQ+I-1
          DO 532 J=I,INDEX1
          TEMP1 = REQUIP(J)+TEMP1
      532 CONTINUE
          PEQUIP(I)= TEMP1/LOPEQ
      534 CONTINUE
          GO TO 620
C                                   POLICY 2 - PURCHASE TOTAL PERCENT OF MAXIMUM
C                                              RQMTS IN FIRST YEAR OF EQUIP LIFE
      540 CONTINUE
          DO 544 I=1,N,LOPEQ
          TEMP1 = 0.0
          INDEX1= LOPEQ+I-1
          DO 542 J=I,INDEX1
          IF (TEMP1.LT.REQUIP(J)) TEMP1=REQUIP(J)
      542 CONTINUE
          PEQUIP(I)= TEMP1*PCTPCH
      544 CONTINUE
          GO TO 620
C                                   POLICY 3 - PURCHASE UP TO AVERAGE RQMTS BUT
C                                              NOT EXCEEDING RQMTS IN YR OF PURCH
      550 CONTINUE
          DO 558 I=1,N,LOPEQ
          TEMP1 = 0.0
          INDEX1= LOPEQ+I-1
          DO 552 J=I,INDEX1
          TEMP1 = REQUIP(J)+TEMP1
      552 CONTINUE
          PEQUIP(I)= TEMP1/LOPEQ
          IF (PEQUIP(I).LE.REQUIP(I)) GO TO 558
          TEMP1 = PEQUIP(I)
          INDEX1= LOPEQ+I-1
          DO 556 J=I,INDEX1
          IF (TEMP1.LE.0.) GO TO 556
          IF (TEMP1.GT.REQUIP(J)) PEQUIP(J)=REQUIP(J)
          IF (TEMP1.LE.REQUIP(J)) PEQUIP(J)=TEMP1
          TEMP1 = TEMP1-PEQUIP(J)
      556 CONTINUE
      558 CONTINUE
          GO TO 620
C                                   POLICY 4 - PURCHASE UP TO PCT OF MAX RQMTS BUT
C                                              NOT EXCEEDING RQMTS IN YR OF PURCH
      560 CONTINUE
          DO 568 I=1,N,LOPEQ
```

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```
          TEMP1 = 0.0
          INOEX1= LOFEQ+I-1
          DO 562 J=I,INOEX1
          IF (TEMP1.LT.REQUIP(J)) TEMP1=REQUIP(J)
      562 CONTINUE
          PEQUIP(I)= TEMP1*PCTPCH
          IF (PEQUIP(I).LE.REQUIP(I)) GO TO 568
          TEMP1 = PEQUIP(I)
          INOEX1= LOFEQ+I-1
          OO 566 J=I,INOEX1
          IF (TEMP1.LE.O.) GO TO 566
          IF (TEMP1.GT.REQUIP(J)) PEQUIP(J)=REQUIP(J)
          IF (TEMP1.LE.REQUIP(J)) PEQUIP(J)=TEMP1
          TEMP1 = TEMP1-PEQUIP(J)
      566 CONTINUE
      568 CONTINUE
          GO TO 620
      570 GO TO 530
      580 GO TO 530
      590 GO TO 530
      600 GO TO 530
      610 GO TO 530
C
C                        - OEPRECIATION POLICIES ANALYSIS
C
      620 GO TO (630,640,650,660,670,680,690,700,710) , OEPF
C
C                        POLICY 1 - OEPRECIATE LINEARLY OVER
C                                   LIFE OF EQUIPMENT
      630 CONTINUE
          TEMP2      = LOFEQ
          OO 632 I=1,LOFEQ
          TEMP1      = I
          POEP(I)    = TEMP1/TEMP2
      632 CONTINUE
          GO TO 730
C                        POLICY 2 - OEPRECIATE BY SUM-OF-DIGITS
C                                   OVER LIFE OF EQUIPMENT
      640 CONTINUE
          SUM        = 0.0
          DO 642 I=I,LOFEQ
          SUM        = SUM+1
      642 CONTINUE
          POEP(1)    = (LOFEQ)/SUM
          OO 644 I=2,LOFEQ
          PDEP(I)    = (LOFEQ-I)/SUM+POEP(I-I)
      644 CONTINUE
          GO TO 730
C                        POLICY 3 - SET DEPRECIATION SCHEOULE
C                                   TO FULLY DEPRECIATEO ALL YEARS
      650 CONTINUE
          OO 652 I=1,LOFEQ
          PDEP(I)    = 1.0
      652 CONTINUE
          GO TO 730
      660 GO TO 630
      670 GO TO 630
      680 GO TO 630
      690 GO TO 630
      700 GO TO 630
      710 GO TO 630
C
C                        - COST FACTORS .
C
      730 L          = N+1
          IF (L.GT.20) GO TO 750
          OO 740 I=L,20
          GRAD(I)    = 0
      740 COPMT(L) = 0.0
      750 CONTINUE
          TOTAEQ     = 0.0
          OO 790 I=1,N
          CSTUD(I) = ((STUOMM(I)+SMWRRC(I))/52)*STUOSL
          CTRAV(I) = STUO(I)*(STCST1+STCST2*(1.0-.5*ARATE))
          CINSTR(I)= RINSTR(I)*INSTSL
          CAOMIN(I)= RAOMIN(I)*AOMSL
          TPEQUP     = TPEQUP+PEQUIP(I)
          INOEX4= PEQUIP(I)+0.5
          PEQUIP(I)= INDEX4
          CEQUIP(I)= PEQUIP(I)*EQUNTC
          LIFERV     = I+LOFEQ-N-1
          IF (LIFERV.LE.O) GO TO 760
          RVEQ       = RVEQ+CEQUIP(I)*PDEP(LIFERV)
      760 CONTINUE
          TOTAEQ     = TOTAEQ+PEQUIP(I)
          AEQUIP(I)= TOTAEQ
          TAEQUP     = TAEQUP+AEQUIP(I)
          LOBSLT     = I-LOFEQ
          IF (LOBSLT.LE.O) GO TO 770
          TOTAEQ     = TOTAEQ-PEQUIP(LOBSLT)
          AEQUIP(I)= TOTAEQ
      770 CEQUIP(I)= CEQUIP(I)+AEQUIP(I)*COPMT(I)
          CFACIL(I)= RFACIL(I)*CPSQFT
          CIMOMT(I)= IMOMNT(I)*CIMO
          IF (I.GT.1) GO TO 775
          CIMOMT(1)= CIMOMT(1)+CUIMO
      775 CSUPPL(I)= RSUPPL(I)*CSUPP
          CMISC(I) = RMISC(I)*CMIS
C
C                        - COST SUMMARIZATION
C
          OISCNT(I)= (2.0+ORATE)/(2.0*(1.0+DRATE)**I)
          INFLAT(I)= (2.0*(1.0+INRATE)**I)/(2.0+INRATE)
          NSTUD      = NSTUO+CSTUO(I)
          OSTUO      = OSTUO+CSTUO(I)*OISCNT(I)
          ISTUD      = ISTUO+CSTUD(I)*INFLAT(I)
          FSTUO      = FSTUD+CSTUO(I)*INFLAT(I)*DISCNT(I)
          NTRAV      = NTRAV+CTRAV(I)
          DTRAV      = DTRAV+CTRAV(I)*OISCNT(I)
          ITRAV      = ITRAV+CTRAV(I)*INFLAT(I)
          FTRAV      = FTRAV+CTRAV(I)*INFLAT(I)*OISCNT(I)
          NINSTR     = NINSTR+CINSTR(I)
```

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CARD NO **** CONTENTS ****

```
      DINSTR   = DINSTR+CINSTR(I)*DISCNT(I)
      IINSTR   = IINSTR+CINSTR(I)*INFLAT(I)
      FINSTR   = FINSTR+CINSTR(I)*INFLAT(I)*DISCNT(I)
      NADMIN   = NADMIN+CADMIN(I)
      DADMIN   = DADMIN+CADMIN(I)*DISCNT(I)
      IADMIN   = IADMIN+CADMIN(I)*INFLAT(I)
      FADMIN   = FADMIN+CADMIN(I)*INFLAT(I)*DISCNT(I)
      NFACIL   = NFACIL+CFACIL(I)
      DFACIL   = DFACIL+CFACIL(I)*DISCNT(I)
      IFACIL   = IFACIL+CFACIL(I)*INFLAT(I)
      FFACIL   = FFACIL+CFACIL(I)*INFLAT(I)*DISCNT(I)
      NSUPPL   = NSUPPL+CSUPPL(I)
      DSUPPL   = DSUPPL+CSUPPL(I)*DISCNT(I)
      ISUPPL   = ISUPPL+CSUPPL(I)*INFLAT(I)
      FSUPPL   = FSUPPL+CSUPPL(I)*INFLAT(I)*DISCNT(I)
      NMISC    = NMISC+CMISC(I)
      DMISC    = DMISC+CMISC(I)*DISCNT(I)
      IMISC    = IMISC+CMISC(I)*INFLAT(I)
      FMISC    = FMISC+CMISC(I)*INFLAT(I)*DISCNT(I)
      IF (I.NE.N) GO TO 780
      CEQUIP(I)=CEQUIP(I)-RVEQ
      CIMOMT(I)=CIMOMT(I)-RVIM
  780 NEQUIP   = NEQUIP+CEQUIP(I)
      DEQUIP   = DEQUIP+CEQUIP(I)*DISCNT(I)
      IEQUIP   = IEQUIP+CEQUIP(I)*INFLAT(I)
      FEQUIP   = FEQUIP+CEQUIP(I)*INFLAT(I)*DISCNT(I)
      NIMO     = NIMO+CIMOMT(I)
      DIMO     = DIMO+CIMOMT(I)*DISCNT(I)
      IIMO     = IIMO+CIMOMT(I)*INFLAT(I)
      FIMO     = FIMO+CIMOMT(I)*DISCNT(I)*INFLAT(I)
      COPTOT(I)= CSTUD(I)+CTRAV(I)+CINSTR(I)+CADMIN(I)+CFACIL(I)
     1          +CIMOMT(I)+CSUPPL(I)+CMISC(I)+CEQUIP(I)
      CGRAD(I) = COPTOT(I)/GRAD(I)
      CSTIN(I) = COPTOT(I)/STUD(I)
  790 CSP(I)   = COPTOT(I)/PSP(I)
      APEQUP   = TFEQUP/N
      AAEQUP   = TAEQUP/N
      NFACIL   = NFACIL*FACOST
      DFACIL   = DFACIL*FACOST
      IFACIL   = IFACIL*FACOST
      FFACIL   = FFACIL*FACOST
      SNADC=NSTUD+NTRAV+NINSTR+NADMIN+NFACIL+NSUPPL+NMISC+NEQUIP+NIMO
      SDADC=DSTUD+DTRAV+DINSTR+DADMIN+DFACIL+DSUPPL+DMISC+DEQUIP+DIMO
      SIADC=ISTUD+ITRAV+IINSTR+IADMIN+IFACIL+ISUPPL+IMISC+IEQUIP+IIMO
      SFADC=FSTUD+FTRAV+FINSTR+FADMIN+FFACIL+FSUPPL+FMISC+FEQUIP+FIMO
      GNADC=SNADC/IGRAD
      GDADC=SDADC/IGRAD
      GIADC=SIADC/IGRAD
      GFADC=SFADC/IGRAD
      UNADC=SNADC/(AASIN*N)
      UDADC=SDADC/(AASIN*N)
      UIADC=SIADC/(AASIN*N)
      UFADC=SFADC/(AASIN*N)
      PNADC=SNADC/IPSP
      PDADC=SDADC/IPSP
      PIADC=SIADC/IPSP
      PFADC=SFADC/IPSP
      DRATE = DRATE*100.
      INRATE= INRATE*100.
C
C     WRITE INPUT TECHNICAL FACTORS
C
  900 IF (.NOT.RPT1) GO TO 910
      WRITE (6,1000) COURSE,DRATE,N,INRATE,(GRAD(I),I=1,10),
     1               (GRAD(I),I=11,20),ARATE,TSPOSD,TLENGH,PESP,RCRATE,
     2               EDTSPD
 1000 FORMAT ('1',20X,'COURSE COST ANALYSIS',/,1X,'INPUT:',/,3X,
     1         'COURSE NUMBER   - ',A4,25X,'DISCOUNT RATE  - ',F4.1,
     2         ' PERCENT',/,3X,'PLANNING PERIOD - ',I2,27X,
     3         'INFLATION RATE - ',F4.1,' PERCENT',//,1X,
     4         'INPUT TECHNICAL FACTORS:',/,3X,'PLNG YR','    1      2',
     5         '      3      4      5      6      7      8      9    ',
     6         '10',/,3X,'GRADS-',10(1X,I6),//,3X,'PLNG YR','   11    ',
     7         '12     13     14     15     16     17     18     19',
     8         '     20',/,3X,'GRADS-',10(1X,I6),//,3X,
     9         'ATTRITION RATE (PCT)    -       ',F3.2,8X,
     1         'TIME STUD POS DOWN (PCT) -      ',F3.2,/,3X,
     A         'TRAINING LENGTH (WKS)   - ',F5.1,9X,
     B         'PCT EXTRA STUD POSITIONS -      ',F3.2,/,3X,
     C         'RECYCLE RATE (PCT)      -       ',F3.2,8X,
     D         'EQUIP/STUD POS RATIO     -      ',F4.2)
      WRITE (6,1010) ARCYTM,LOFEQ,WSCHOP,CMODEV,INTSPO,PUIMO,
     3               AMTSPO,UPDATE,SQFTST,EVIM,SQFTIN,SUPSPO,SQFTAM,
     4               SUPSTO,PURCHP,MSCSPO,DEPP,MSCSTO
 1010 FORMAT (3X,
     E         'AVE. RECYCLE TIME (WKS)-  ',F4.1,9X,
     F         'LIFE OF EQUIPMENT            -  ',I2,/,3X,
     G         'WEEKS SCHOOL OPERATES   -  ',F4.1,9X,
     H         'COURSE DEV HRS/COURSE HR - ',F5.1,/,3X,
     I         'INSTR/STUD POS RATIO    -     ',F4.2,7X,
     J         'PCT COURSE REQUIRING DEV.-    ',F4.2,/,3X,
     K         'ADMIN/STUD POS RATIO    -     ',F4.3,7X,
     L         'PCT INSTR MAT. MAINTAINED-     ',F3.2,/,3X,
     M         'SQ FEET/STUDENT POS.    - ',F6.2,8X,
     N         'PCT INSTR MAT. RMNG VALUE-     ',F3.2,/,3X,
     O         'SQ FEET/INSTR. POS.     - ',F6.2,8X,
     P         'SUPPLIES/STUDENT POSITION- ',F5.1,/,3X,
     Q         'SQ FEET/ADMIN POS.      - ',F6.2,8X,
     R         'SUPPLIES/STUDENT             - ',F5.1,/,3X,
     S         'PURCHASE POLICY         -      ',I1,11X,
     T         'MISC/STUDENT POSITION        - ',F5.1,/,3X,
     U         'DEPRECIATION POLICY     -      ',I1,11X,
     V         'MISC/STUDENT                 - ',F5.1)
C
C     WRITE INPUT COST FACTORS
C
  910 IF (.NOT.RPT2) GO TO 920
      WRITE (6,1001) COURSE,DRATE,N,INRATE,(COPMT(I),I=1,10),
     1               (COPMT(I),I=11,20),STUDSL,CIMO,STCST1,CSUPP,STCST2,
     2               CMIS,INSTSL,PCTPCH,ADMSL,CPSQFT,EQUNTC
 1001 FORMAT ('1',20X,'COURSE COST ANALYSIS',/,1X,'INPUT:',/,3X,
     1         'COURSE NUMBER   - ',A4,25X,'DISCOUNT RATE  - ',F4.1,
```

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```
     6              GDAOC,GIAOC,GFAOC,UNAOC,UOAOC,UIAOC,UFAOC,PNAOC,
     7              POAOC,PIAOC,PFAOC
 1002 FORMAT ('1',28X,'COURSE COST ANALYSIS',/,1X,'INPUT:',/,3X,
     1        'COURSE NUMBER   - ',A4,25X,'DISCOUNT RATE  - ',F4.1,
     2        ' PERCENT',/,3X,'PLANNING PERIOD - ',I2,27X,
     3        'INFLATION RATE - ',F4.1,' PERCENT',//,1X,
     A        'OUTPUT COST RESULTS:',10X,
     4        'NON-DISC    DISCOUNTED  NON-DISC    DISCOUNTED',/,31X,
     5        'CONSTANT $  CONSTANT $  CURRENT $   CURRENT $',/,3X,
     6        'STUDENT SALARIES',10X,4(2X,F10.0),/,3X,
     7        'STUDENT TRAVEL',12X,4(2X,F10.0),/,3X,
     8        'INSTRUCTOR SALARY',9X,4(2X,F10.0),/,3X,
     9        'ADMINISTRATIVE SALARY',5X,4(2X,F10.0),/,3X,
     1        'EQUIPMENT',17X,4(1X,F11.0),/,3X,
     A        'FACILITIES',16X,4(1X,F11.0),/,3X,
     B        'INSTRUCTIONAL MATERIALS',3X,4(2X,F10.0),/,3X,
     C        'SUPPLIES',18X,4(2X,F10.0),/,3X,
     D        'MISCELLANEOUS',13X,4(2X,F10.0),//,3X,
     E        'TOTAL OPERATIONAL',9X,4(1X,F11.0),//,3X,
     F        'COST PER GRADUATE',8X,4(4X,F8.2),/,3X,
     G        'COST PER STUDENT INPUT',3X,4(4X,F8.2),/,3X,
     H        'COST PER STUDENT POSITION',4(4X,F8.2))
C
C     WRITE ANNUAL COST RESULTS
C
  950 IF (.NOT.RPT6) GO TO 960
      WRITE (6,1004) COURSE,DRATE,N,INRATE,(DIGIT(I),I=1,5),
     1               (CSTUD(I),I=1,5),(CTRAV(I),I=1,5),
     2               (CINSTR(I),I=1,5),(CADMIN(I),I=1,5),
     3               (CEQUIP(I),I=1,5),(CFACIL(I),I=1,5),
     4               (CIMDMT(I),I=1,5),(CSUPPL(I),I=1,5),
     5               (CMISC(I),I=1,5),(COPTOT(I),I=1,5),
     6               (CGRAD(I),I=1,5),(CSTIN(I),I=1,5),
     7               (CSP(I),I=1,5)
      IF (N.LE.5) GO TO 960
      WRITE (6,1004) COURSE,DRATE,N,INRATE,(DIGIT(I),I=6,10),
     1               (CSTUD(I),I=6,10),(CTRAV(I),I=6,10),
     2               (CINSTR(I),I=6,10),(CADMIN(I),I=6,10),
     3               (CEQUIP(I),I=6,10),(CFACIL(I),I=6,10),
     4               (CIMDMT(I),I=6,10),(CSUPPL(I),I=6,10),
     5               (CMISC(I),I=6,10),(COPTOT(I),I=6,10),
     6               (CGRAD(I),I=6,10),(CSTIN(I),I=6,10),
     7               (CSP(I),I=6,10)
      IF (N.LE.10) GO TO 960
      WRITE (6,1004) COURSE,DRATE,N,INRATE,(DIGIT(I),I=11,15),
     1               (CSTUD(I),I=11,15),(CTRAV(I),I=11,15),
     2               (CINSTR(I),I=11,15),(CADMIN(I),I=11,15),
     3               (CEQUIP(I),I=11,15),(CFACIL(I),I=11,15),
     4               (CIMDMT(I),I=11,15),(CSUPPL(I),I=11,15),
     5               (CMISC(I),I=11,15),(COPTOT(I),I=11,15),
     6               (CGRAD(I),I=11,15),(CSTIN(I),I=11,15),
     7               (CSP(I),I=11,15)
      IF (N.LE.15) GO TO 960
      WRITE (6,1004) COURSE,DRATE,N,INRATE,(DIGIT(I),I=16,20),
     1               (CSTUD(I),I=16,20),(CTRAV(I),I=16,20),
     2               (CINSTR(I),I=16,20),(CADMIN(I),I=16,20),
     3               (CEQUIP(I),I=16,20),(CFACIL(I),I=16,20),
     4               (CIMDMT(I),I=16,20),(CSUPPL(I),I=16,20),
     5               (CMISC(I),I=16,20),(COPTOT(I),I=16,20),
     6               (CGRAD(I),I=16,20),(CSTIN(I),I=16,20),
     7               (CSP(I),I=16,20)
 1004 FORMAT ('1',28X,'COURSE COST ANALYSIS',/,1X,'INPUT:',/,3X,
     1        'COURSE NUMBER   - ',A4,25X,'DISCOUNT RATE  - ',F4.1,
     2        ' PERCENT',/,3X,'PLANNING PERIOD - ',I2,27X,
     3        'INFLATION RATE - ',F4.1,' PERCENT',//,1X,
     4        'OUTPUT COST RESULTS:  (NON-DISC CONSTANT $)',//,32X,
     5        'YEAR ',I2,'   YEAR ',I2,'   YEAR ',I2,'   YEAR ',I2,
     6        '   YEAR ',I2,//,3X,
     7        'STUDENT SALARIES          ',5(1X,F9.0),/,3X,
     8        'STUDENT TRAVEL            ',5(1X,F9.0),/,3X,
     9        'INSTRUCTOR SALARY         ',5(1X,F9.0),/,3X,
     A        'ADMINISTRATIVE SALARY     ',5(1X,F9.0),/,3X,
     B        'EQUIPMENT                 ',5(1X,F9.0),/,3X,
     C        'FACILITIES                ',5(1X,F9.0),/,3X,
     D        'INSTRUCTIONAL MATERIALS   ',5(1X,F9.0),/,3X,
     E        'SUPPLIES                  ',5(1X,F9.0),/,3X,
     F        'MISCELLANEOUS             ',5(1X,F9.0),/,3X,
     G        'TOTAL OPERATIONAL         ',5(1X,F9.0),/,3X,
     H        'COST PER GRADUATE         ',5(1X,F9.0),/,3X,
     I        'COST PER STUDENT INPUT    ',5(1X,F9.0),/,3X,
     J        'COST PER STUDENT POSITION ',5(1X,F9.0))
C
C     WRITE MISSING STATEMENT NUMBERS
C
  960 IF (.NOT.RPT7) GO TO 990
      IF (K.LE.1) GO TO 990
      WRITE (6,5000)
      K = K-1
      WRITE (6,5001) ((MATA(I),MATB(I)),I=1,K)
 5000 FORMAT ('1','                                MISSING DATA ANALYSIS')
 5001 FORMAT (1X,'MISSING DATA CODE = ',I6,4X,'CRIT CODE = ',I6)
  990 IF (.NOT.LAST) GO TO 10
      CONTINUE
      END
      SUBROUTINE MISSNG (NUMB,ICODE)
      DIMENSION MATA(100),MATB(100)
      COMMON/NOGOF/NOGO,K,MATA,MATB
      IF (ICODE.EQ.0) NOGO=1
      MATA(K)  = NUMB
      MATB(K)  = ICODE
      K        = K+1
      RETURN
      END
```

CHART TITLE - INTRODUCTORY COMMENTS

```
*****************************************************************
*          PROGRAM - TRAINING COST MODEL                        *
*          TECEP COST MODEL ADAPTATIONS FOR ETAM BY L. DUFFY    *
*          DATE - 4/23/75                                       *
*                                                               *
*****************************************************************
```

PROGRAM SETUP

PROGRAM INITIALIZATION

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CHART TITLE - PROCEDURES

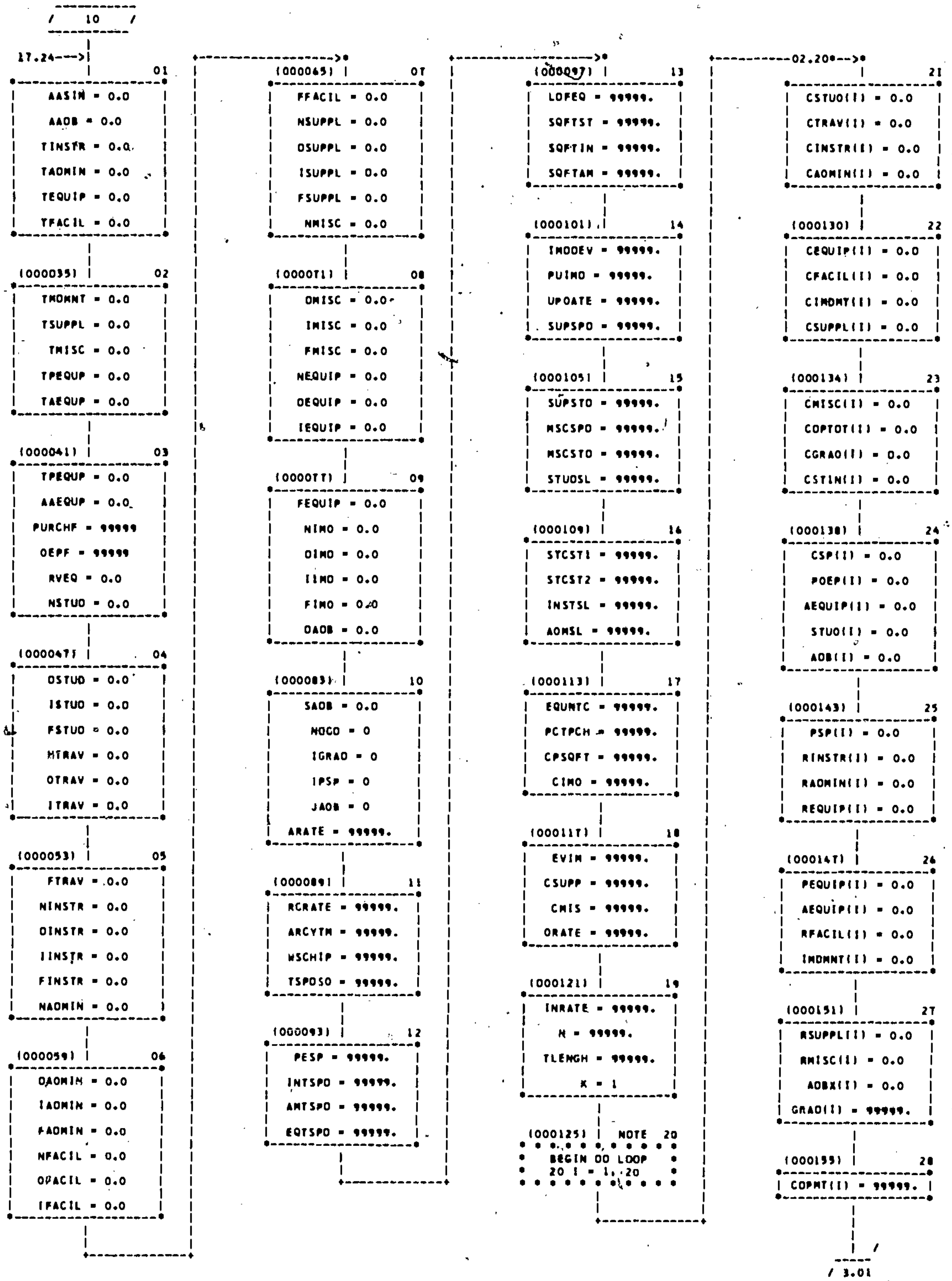


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CHART TITLE - PROCEDURES

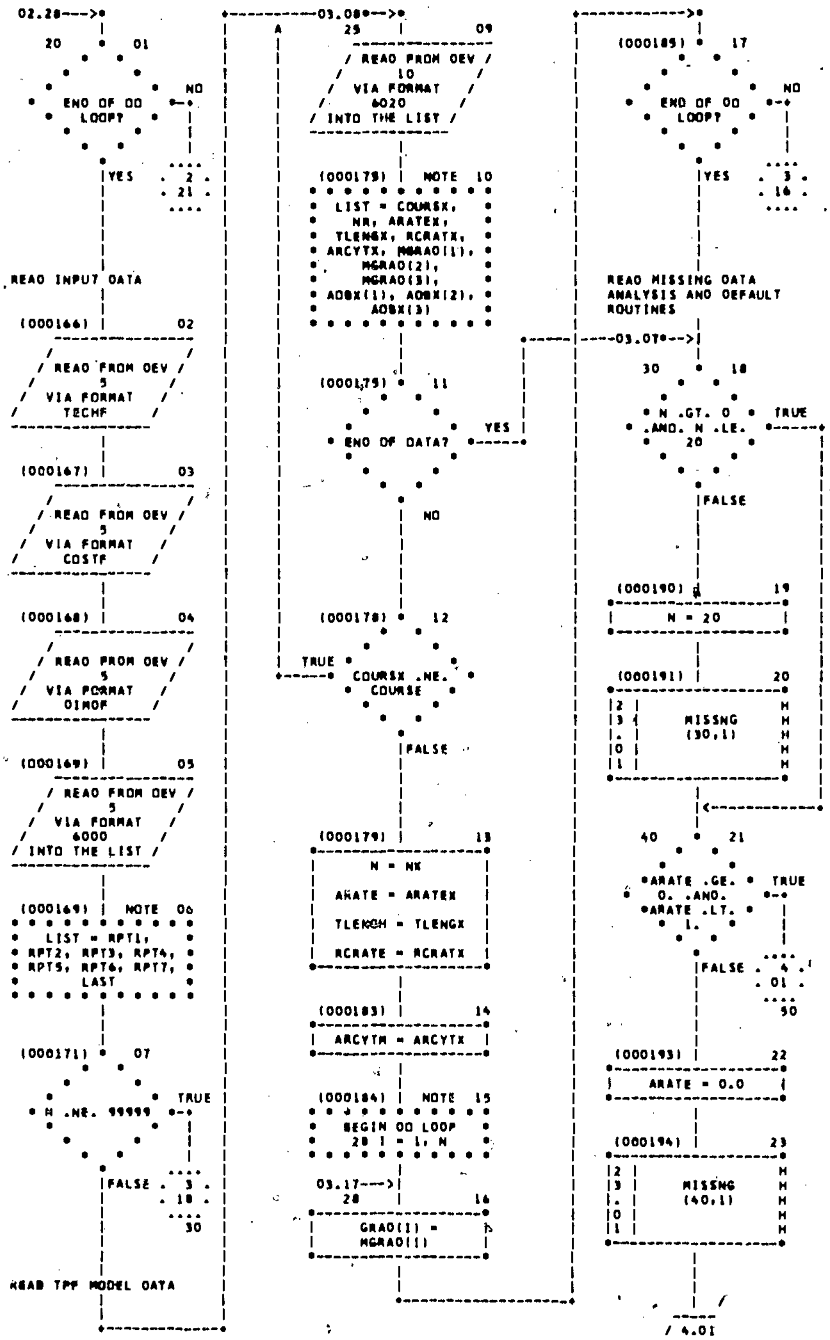




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CHART TITLE - PROCEDURES

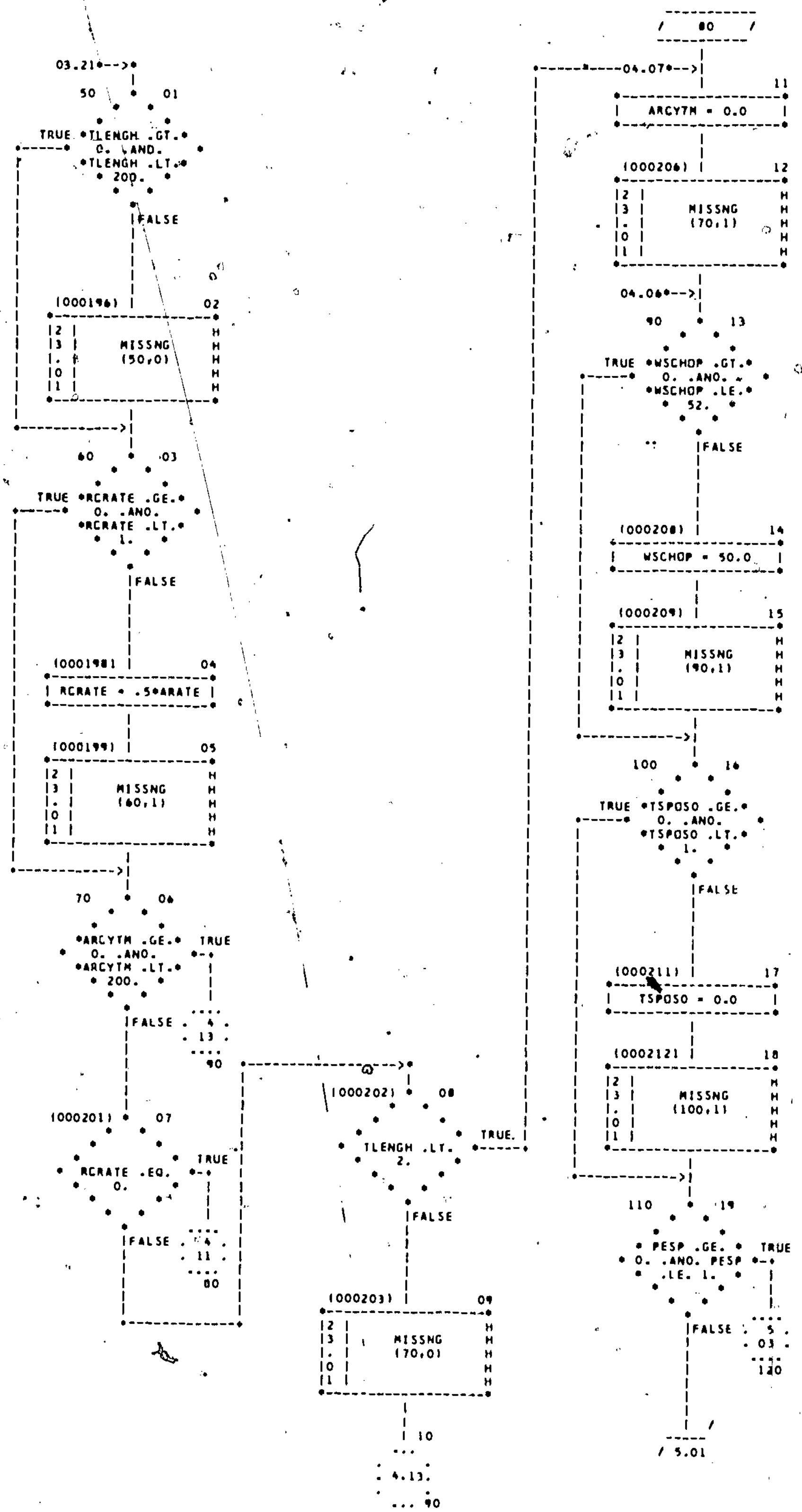


CHART TITLE - PROCEDURES

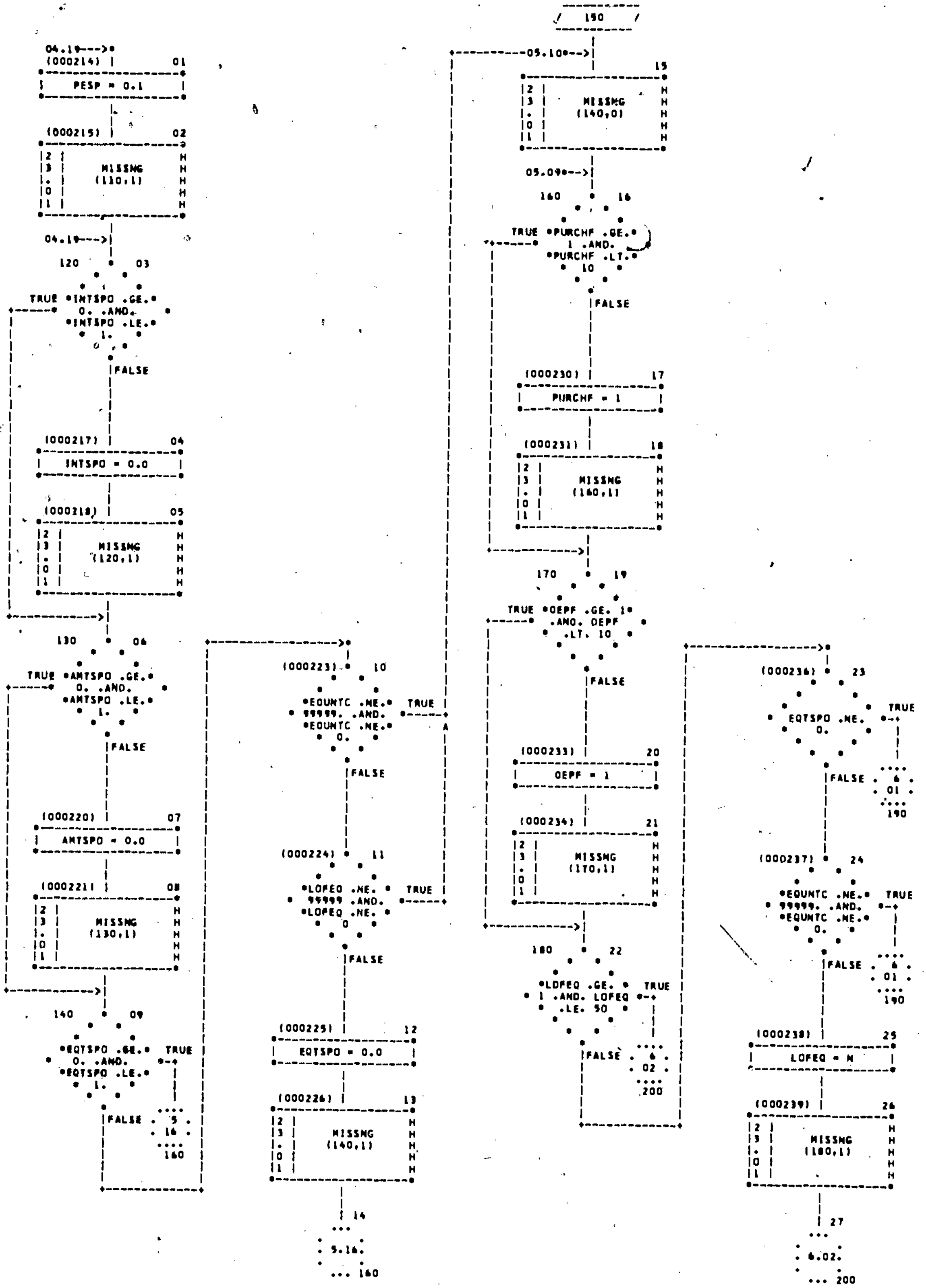


CHART TITLE - PROCEDURES

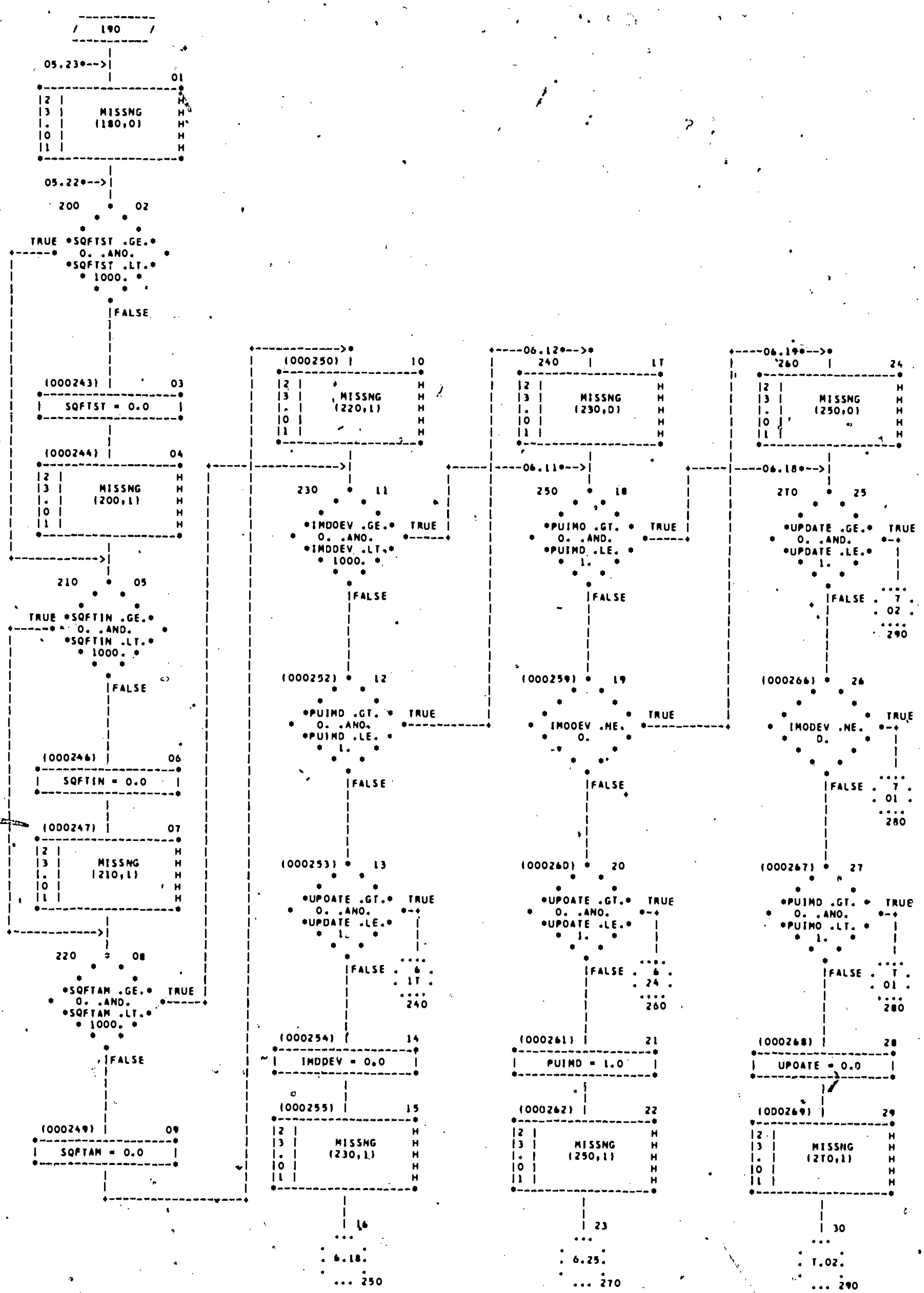
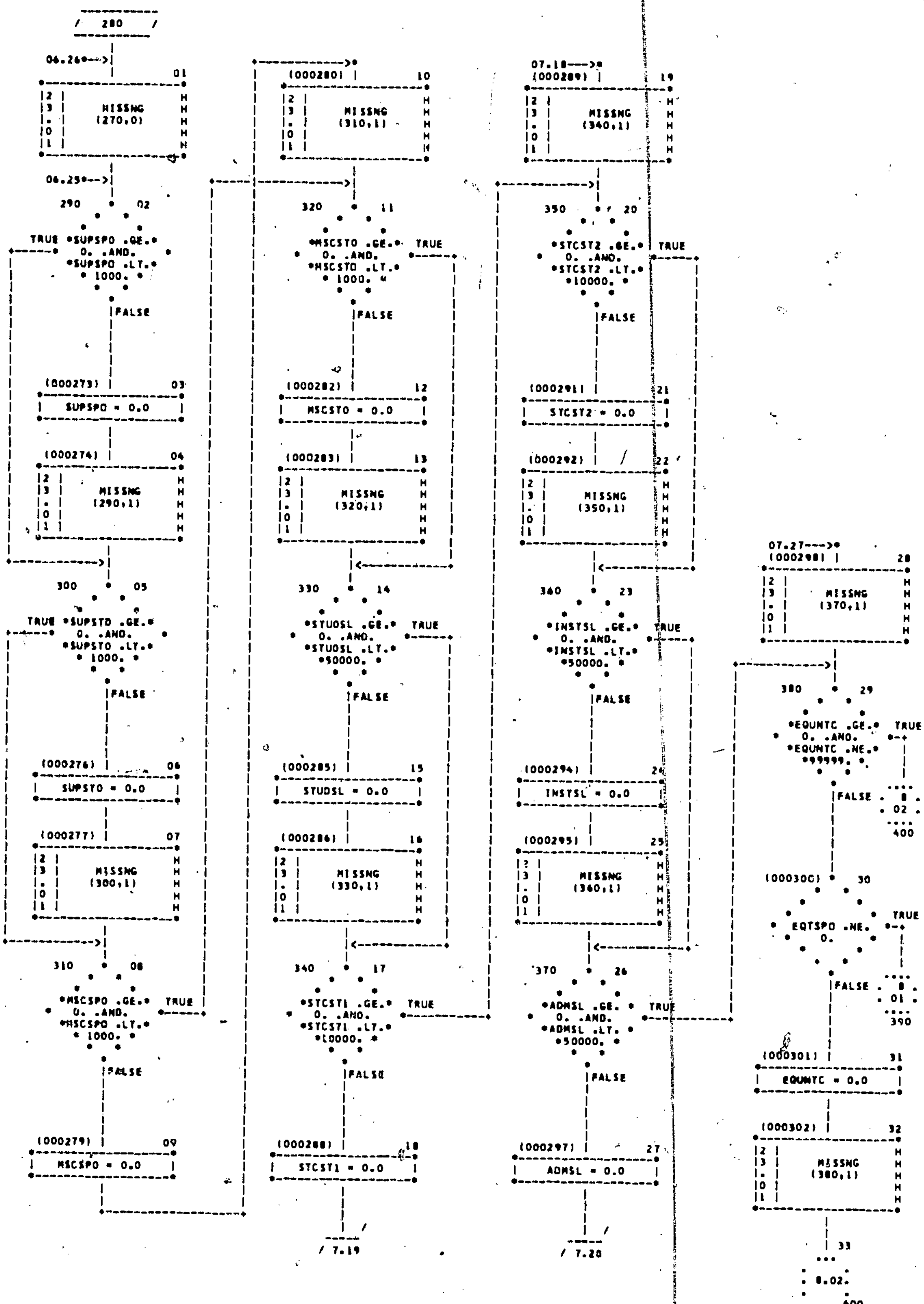


CHART TITLE - PROCEDURES



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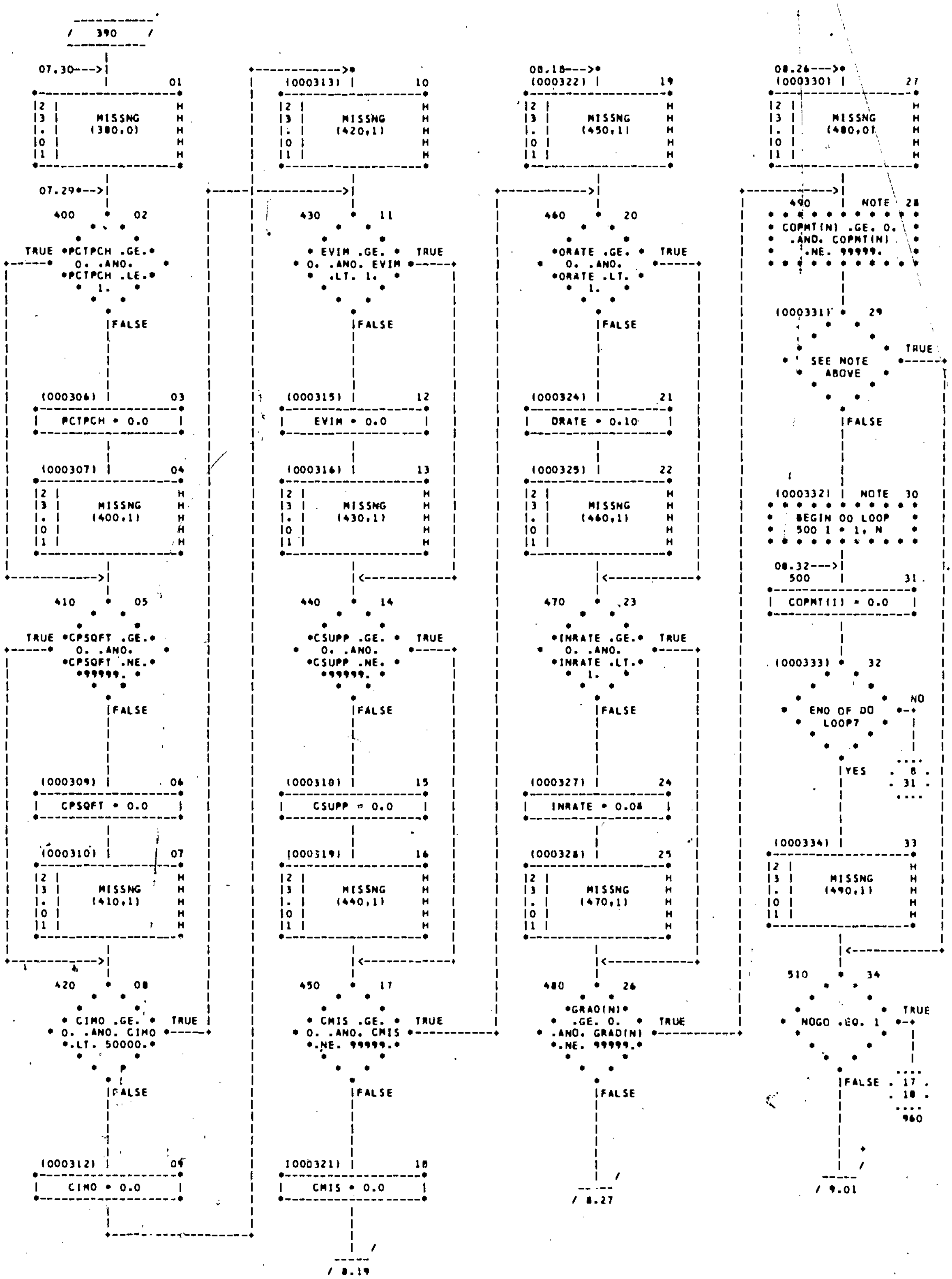




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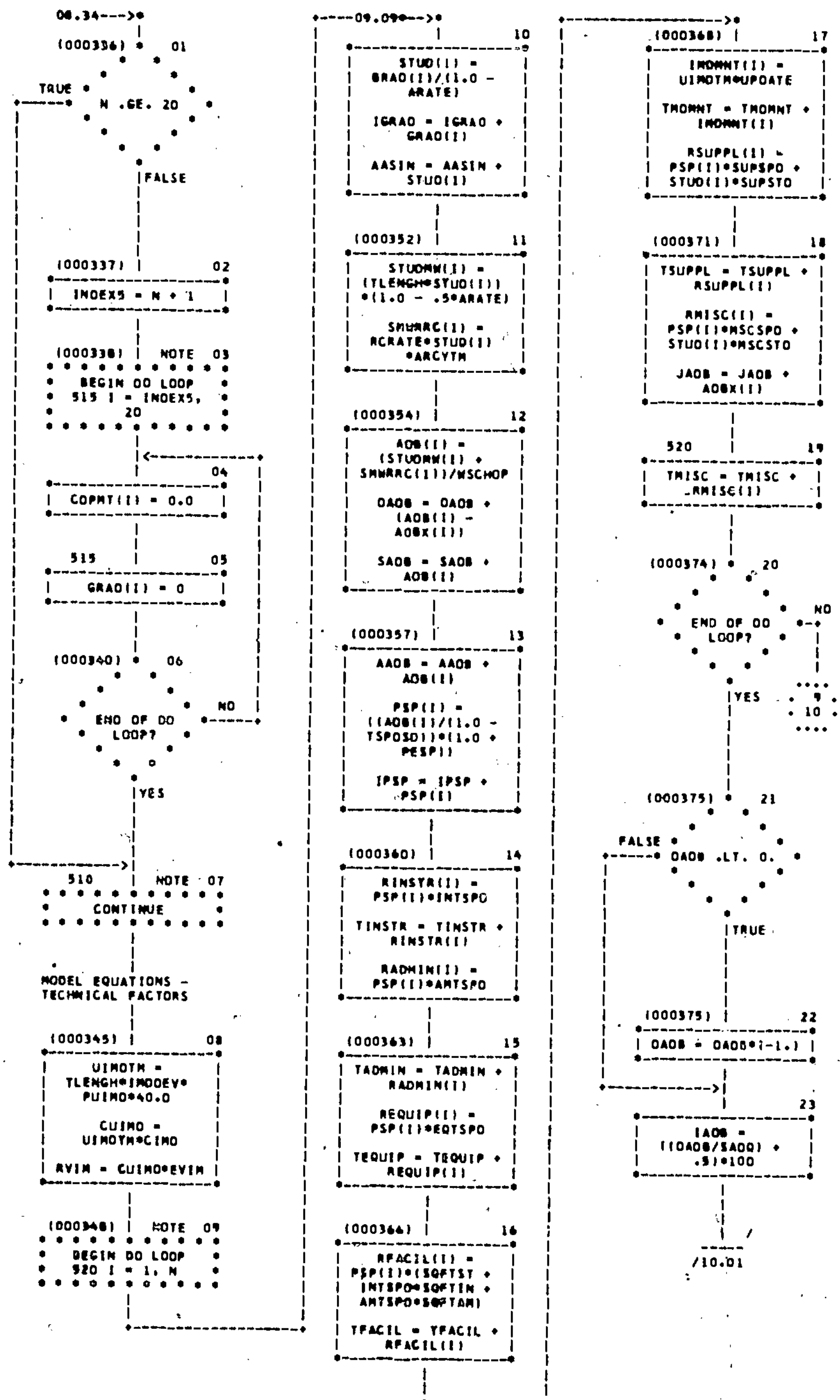

04/23/75 AUTOFLOW CHART SET PAGE 10

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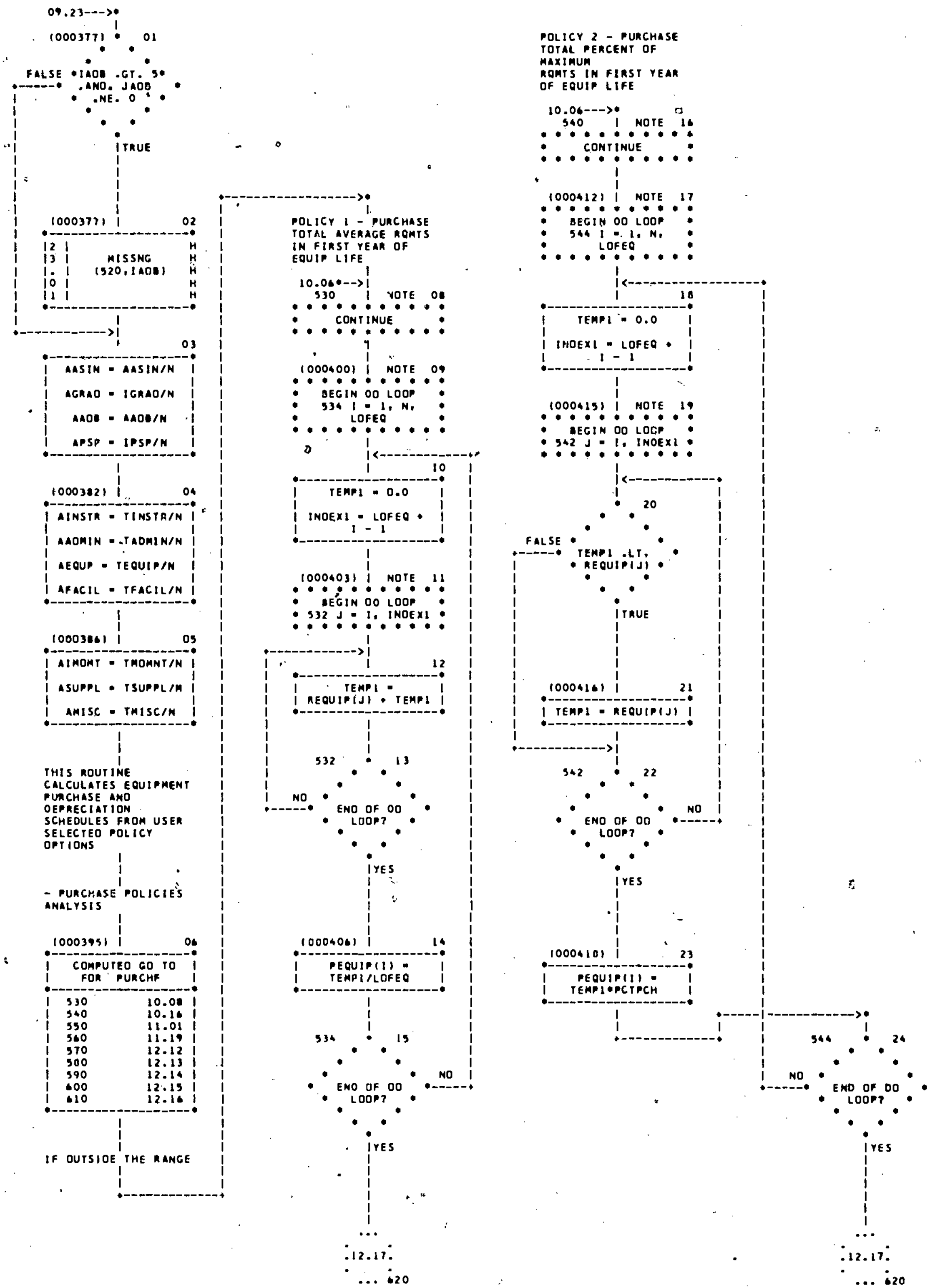




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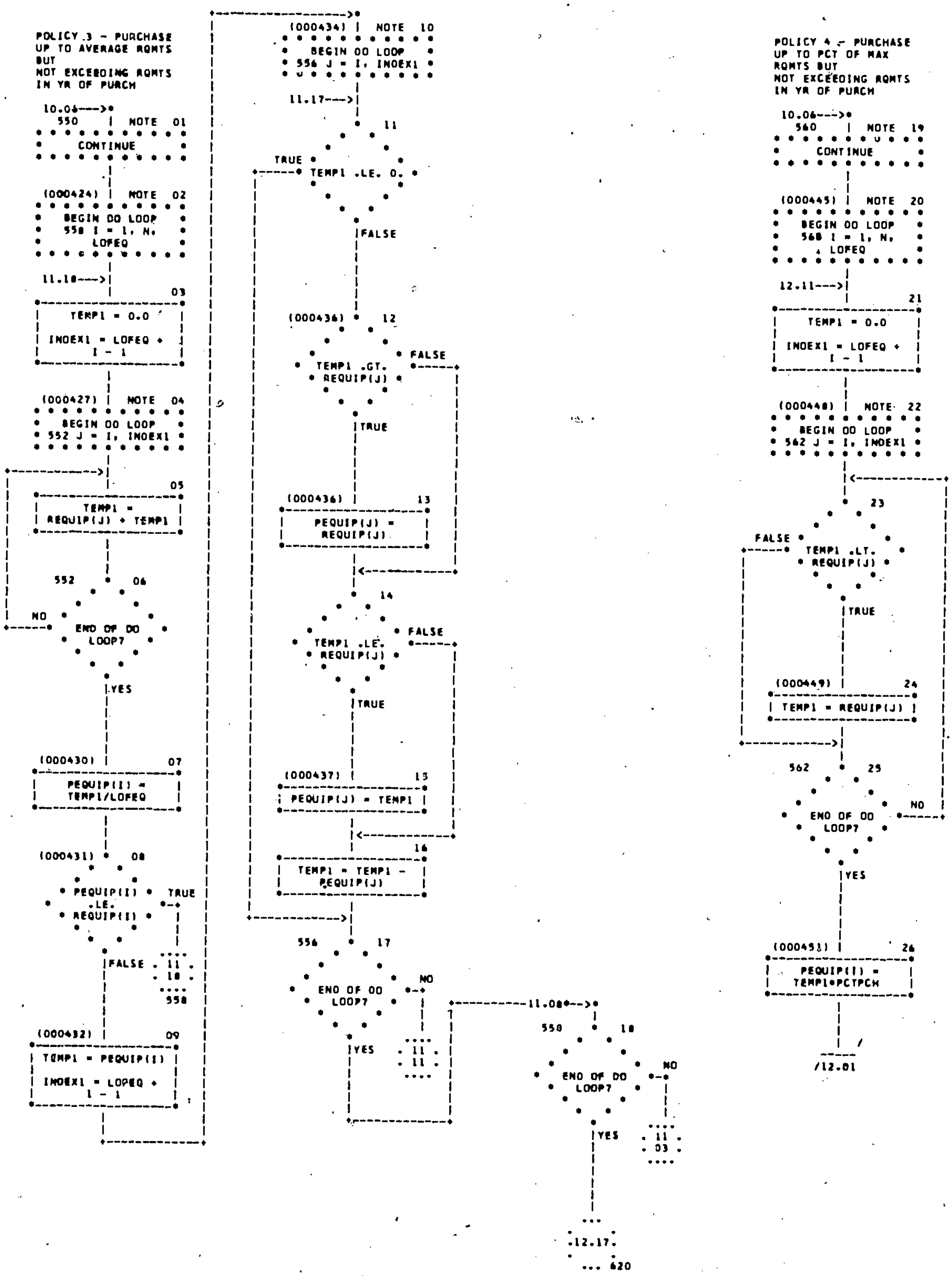




280

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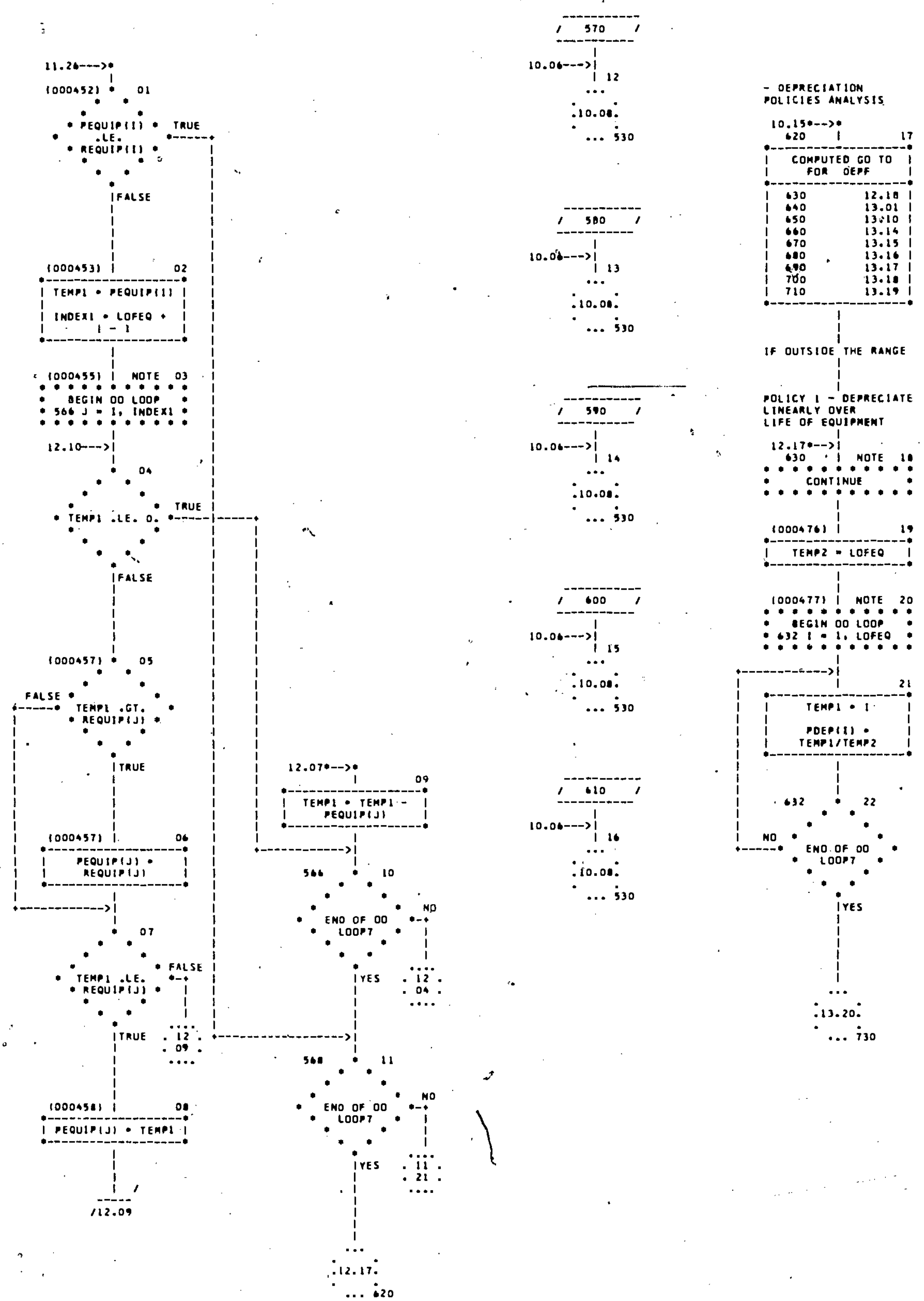

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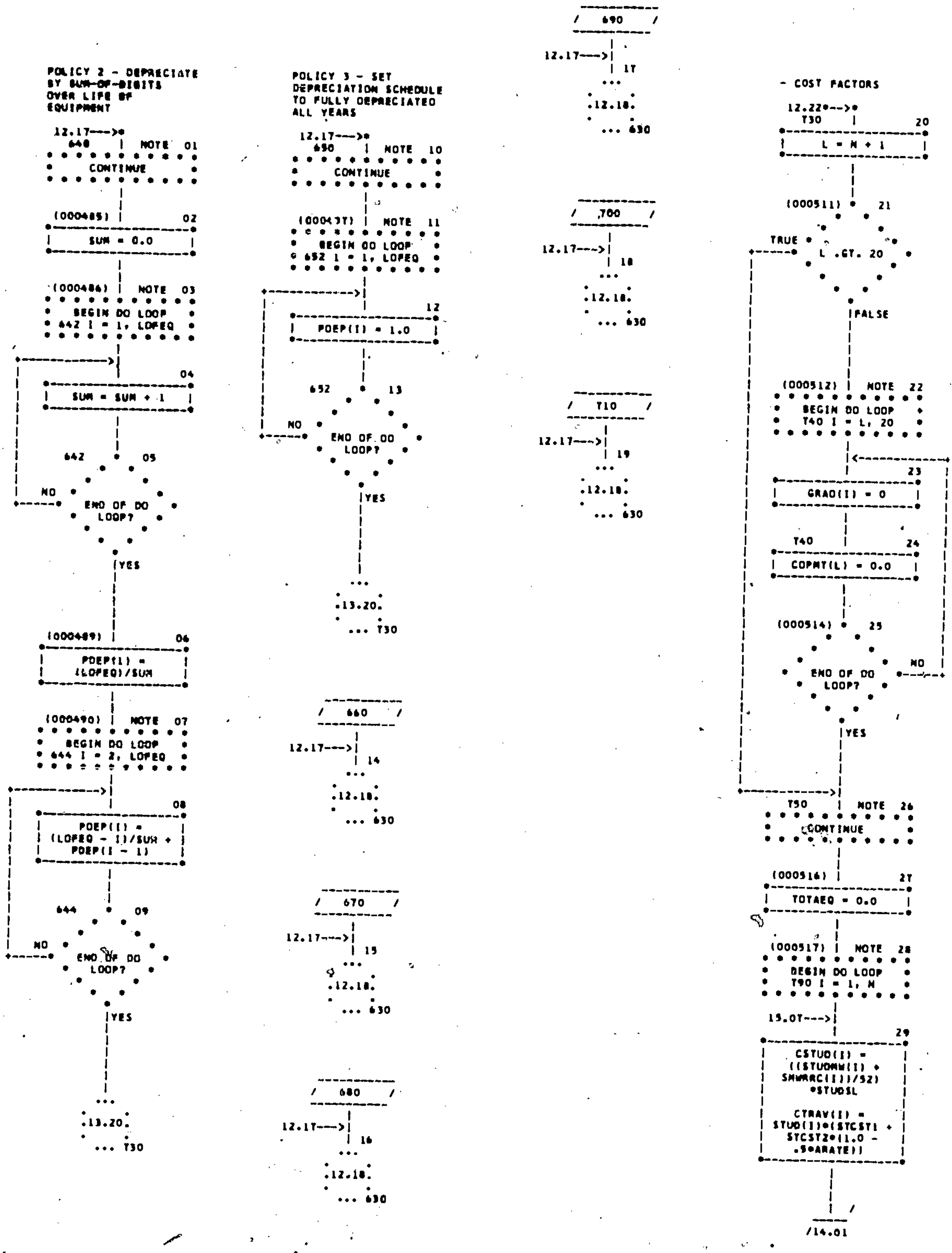

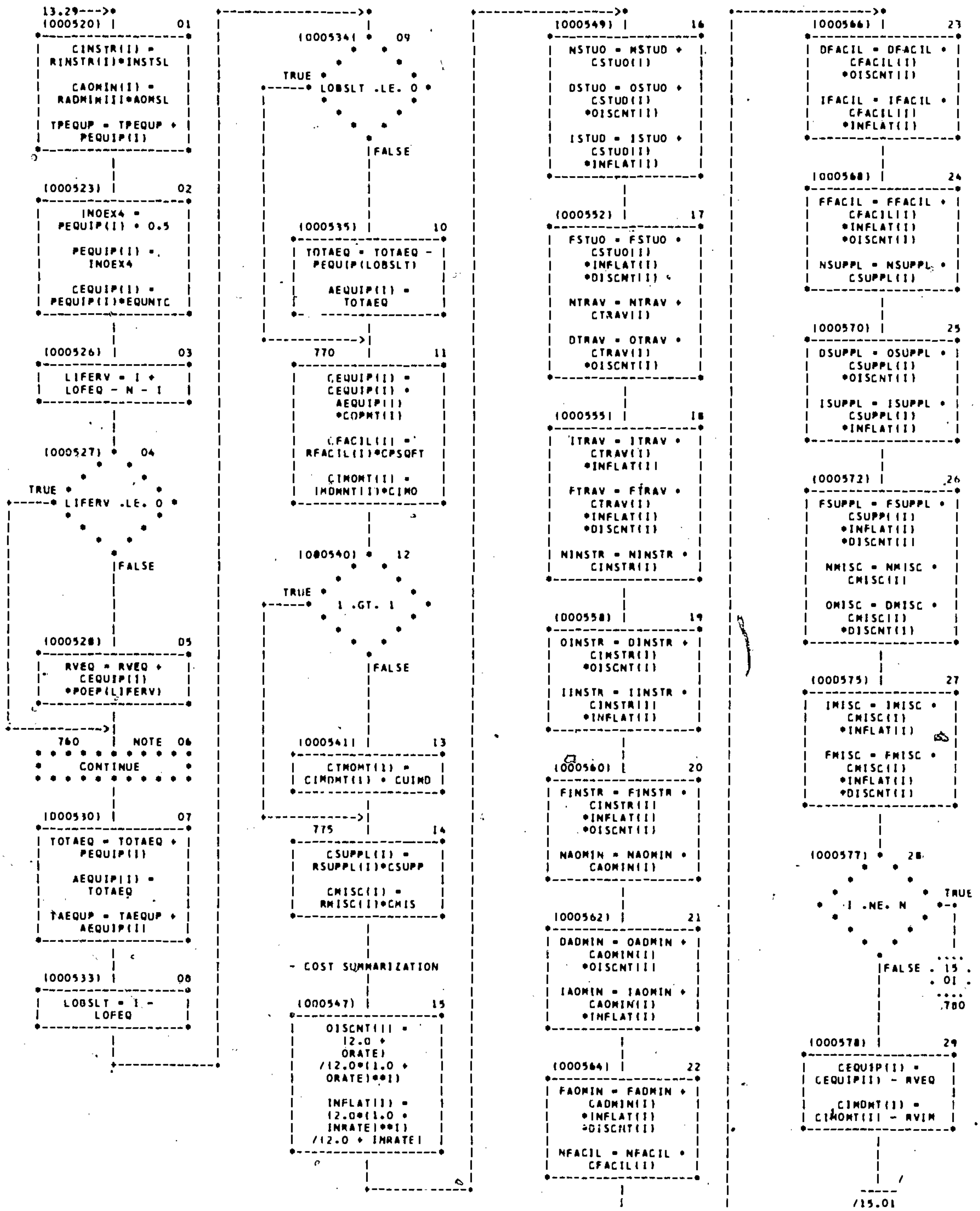
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(000520) 01
CINSTR(I) = RINSTR(I)*INSTSL
CAOMIN(I) = RAOMIN(I)*AOMSL
TPEQUP = TPEQUP + PEQUIP(I)
(000523) 02
INDEX4 = PEQUIP(I) + 0.5
PEQUIP(I) = INDEX4
CEQUIP(I) = PEQUIP(I)*EQUNTC
(000526) 03
LIFERV = I + LOFEQ - N - I
(000527) 04
TRUE
LIFERV .LE. 0
FALSE
(000528) 05
RVEQ = RVEQ + CEQUIP(I) *POEP(LIFERV)
760 NOTE 06
CONTINUE
(000530) 07
TOTAEQ = TOTAEQ + PEQUIP(I)
AEQUIP(I) = TOTAEQ
TAEQUP = TAEQUP + AEQUIP(I)
(000533) 08
LOBSLT = I - LOFEQ
(000534) 09
TRUE
LOBSLT .LE. 0
FALSE
(000535) 10
TOTAEQ = TOTAEQ - PEQUIP(LOBSLT)
AEQUIP(I) = TOTAEQ
770 11
CEQUIP(I) = CEQUIP(I) + AEQUIP(I) *COPMT(I)
CFACIL(I) = RFACIL(I)*CPSQFT
CIMOMT(I) = IMOMNT(I)*CIMO
(000540) 12
TRUE
I .GT. 1
FALSE
(000541) 13
CIMOMT(I) = CIMOMT(I) + CUIMO
775 14
CSUPPL(I) = RSUPPL(I)*CSUPP
CMISC(I) = RMISC(I)*CMIS
- COST SUMMARIZATION
(000547) 15
DISCNT(I) = (2.0 + DRATE) /(2.0*(1.0 + DRATE)**I)
INFLAT(I) = (2.0*(1.0 + INRATE)**I) /(2.0 + INRATE)
(000549) 16
NSTUD = NSTUD + CSTUD(I)
DSTUD = DSTUD + CSTUD(I) *DISCNT(I)
ISTUD = ISTUD + CSTUD(I) *INFLAT(I)
(000552) 17
FSTUD = FSTUD + CSTUD(I) *INFLAT(I) *DISCNT(I)
NTRAV = NTRAV + CTRAV(I)
DTRAV = DTRAV + CTRAV(I) *DISCNT(I)
(000555) 18
ITRAV = ITRAV + CTRAV(I) *INFLAT(I)
FTRAV = FTRAV + CTRAV(I) *INFLAT(I) *DISCNT(I)
NINSTR = NINSTR + CINSTR(I)
(000558) 19
DINSTR = DINSTR + CINSTR(I) *DISCNT(I)
IINSTR = IINSTR + CINSTR(I) *INFLAT(I)
(000560) 20
FINSTR = FINSTR + CINSTR(I) *INFLAT(I) *DISCNT(I)
NAOMIN = NAOMIN + CAOMIN(I)
(000562) 21
DAOMIN = DAOMIN + CAOMIN(I) *DISCNT(I)
IAOMIN = IAOMIN + CAOMIN(I) *INFLAT(I)
(000564) 22
FAOMIN = FAOMIN + CAOMIN(I) *INFLAT(I) *DISCNT(I)
NFACIL = NFACIL + CFACIL(I)
(000566) 23
DFACIL = DFACIL + CFACIL(I) *DISCNT(I)
IFACIL = IFACIL + CFACIL(I) *INFLAT(I)
(000568) 24
FFACIL = FFACIL + CFACIL(I) *INFLAT(I) *DISCNT(I)
NSUPPL = NSUPPL + CSUPPL(I)
(000570) 25
DSUPPL = DSUPPL + CSUPPL(I) *DISCNT(I)
ISUPPL = ISUPPL + CSUPPL(I) *INFLAT(I)
(000572) 26
FSUPPL = FSUPPL + CSUPPL(I) *INFLAT(I) *DISCNT(I)
NMISC = NMISC + CMISC(I)
DMISC = DMISC + CMISC(I) *DISCNT(I)
(000575) 27
IMISC = IMISC + CMISC(I) *INFLAT(I)
FMISC = FMISC + CMISC(I) *INFLAT(I) *DISCNT(I)
(000577) 28
I .NE. N
TRUE
FALSE
15 01 780
(000578) 29
CEQUIP(I) = CEQUIP(I) - RVEQ
CIMOMT(I) = CIMOMT(I) - RVIM
/15.01

CHART TITLE - PROCEDURES

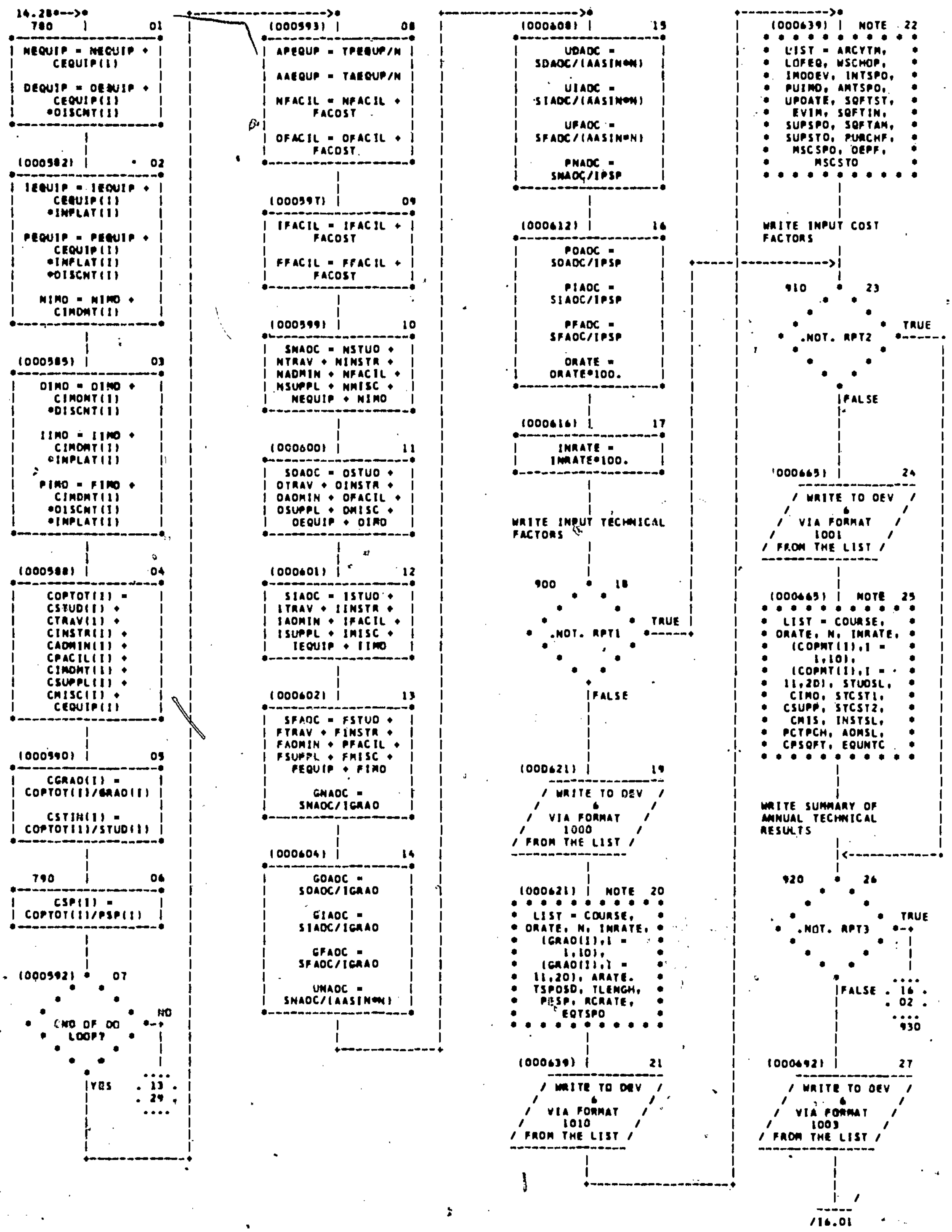




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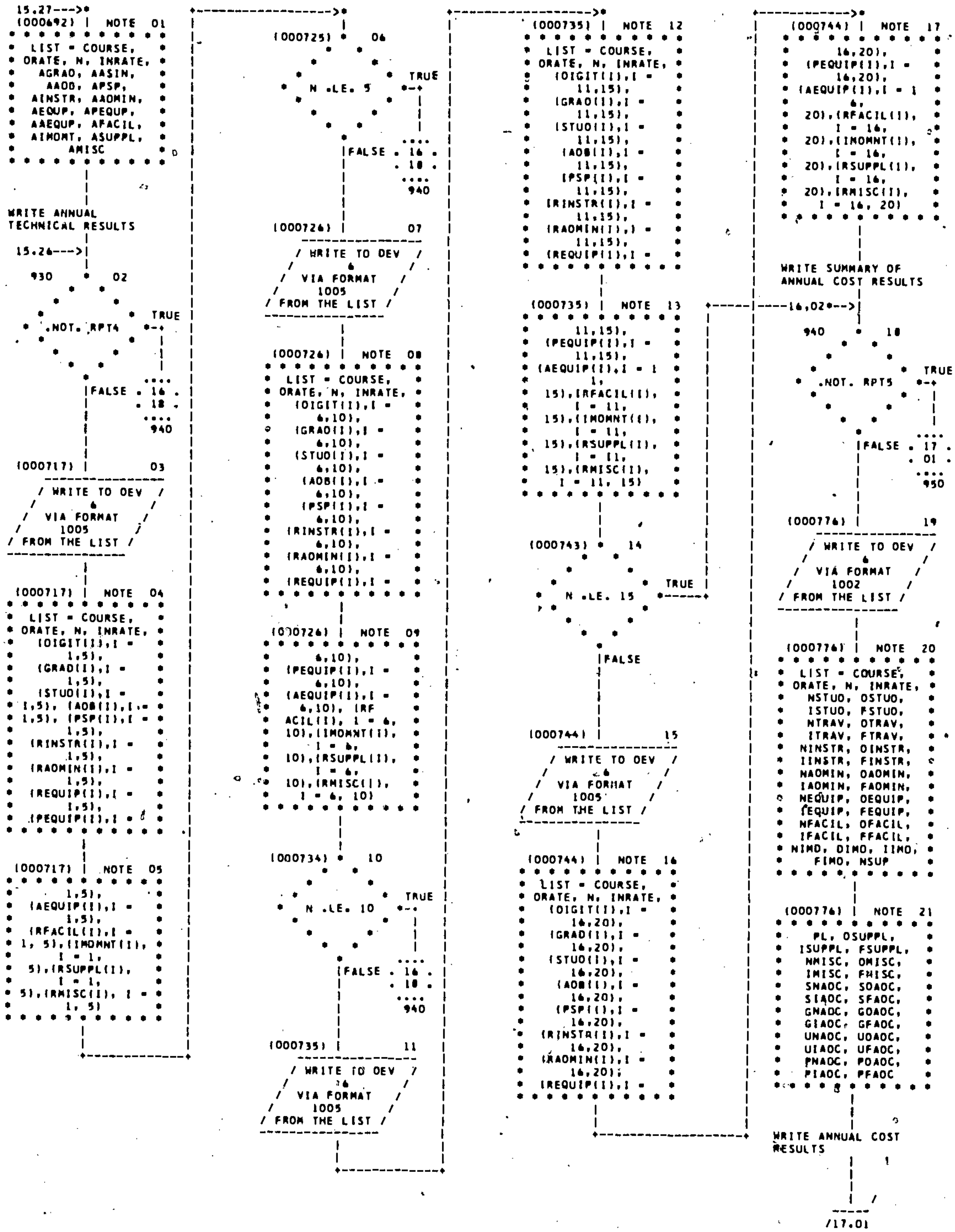
CHART TITLE - PROCEDURES



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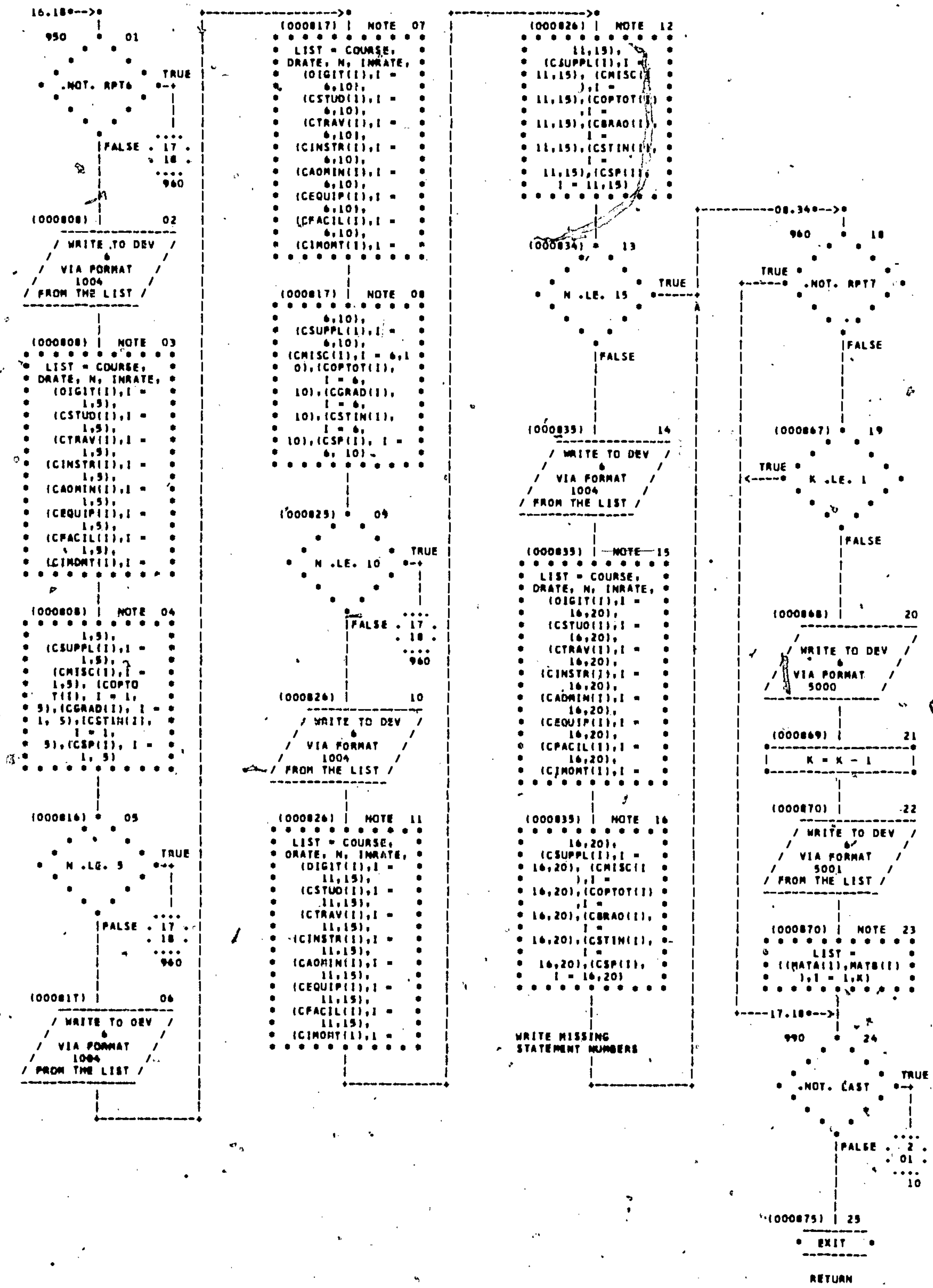


CHART TITLE - SUBROUTINE MISSNG(NUMB,ICODE)

```
                    -----------
                   /  MISSNG  /
                   -----------
                        |
              03.20*--> |
                        |
                        *     01
                      *   *
                    *       *
           FALSE  *           *
        *-------* ICODE .EQ. 0  *
        |         *           *
        |           *       *
        |             *   *
        |               *
        |               | TRUE
        |               |
        |               |
        |               |
        |   (000879)    |          02
        |    *--------------------*
        |    |      NDGO = 1      |
        |    *--------------------*
        |               |
        *-------------->|
                        |          03
             *--------------------*
             |   MATA(K) = NUMB   |
             |                    |
             |   MATB(K) = ICODE  |
             |                    |
             |     K = K + 1      |
             *--------------------*
                        |
                        |
            (000883)    |  04
                    ----------
                    *  EXIT  *
                    ----------
```

COURSE COST ANALYSIS

INPUT:

COURSE NUMBER - SEN1

PLANNING PERIOD - 8

DISCOUNT RATE - 10.0 PERCENT

INFLATION RATE - 6.0 PERCENT

INPUT TECHNICAL FACTORS:

| PLNG YR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| GRADS- | 10000 | 12000 | 14000 | 14000 | 13000 | 9000 | 8000 | 5000 | 0 | 0 |

| PLNG YR | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| GRADS- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | |
|---|---|---|---|
| ATTRITION RATE (PCT) - | .02 | TIME STUD POS DOWN (PCT) - | .01 |
| TRAINING LENGTH (WKS) - | 2.0 | PCT EXTRA STUD POSITIONS - | .05 |
| RECYCLE RATE (PCT) - | .10 | EQUIP/STUD POS RATIO - | 0.50 |
| AVE. RECYCLE TIME (WKS) - | 1.0 | LIFE OF EQUIPMENT - | 10 |
| WEEKS SCHOOL OPERATES - | 50.0 | COURSE DEV HRS/COURSE HR - | 25.0 |
| INSTR/STUD POS RATIO - | .050 | PCT COURSE REQUIRING DEV. - | 1.00 |
| ADMIN/STUD POS RATIO - | .010 | PCT INSTR MAT. MAINTAINED - | .20 |
| SQ FEET/STUDENT POS. - | 9.00 | PCT INSTR MAT. RMNG VALUE - | .40 |
| SQ FEET/INSTR. POS. - | 5.00 | SUPPLIES/STUDENT POSITION - | 1.0 |
| SQ FEET/ADMIN POS. - | 3.00 | SUPPLIES/STUDENT - | 1.0 |
| PURCHASE POLICY - | 2 | MISC/STUDENT POSITION - | 1.0 |
| DEPRECIATION POLICY - | 1 | MISC/STUDENT - | 1.0 |

```
                    COURSE COST ANALYSIS
INPUT:
  COURSE NUMBER    - SEN1                          DISCOUNT RATE  - 10.0 PERCENT
  PLANNING PERIOD  -  8                            INFLATION RATE -  6.0 PERCENT

INPUT COST FACTORS:
  PLNG YR   1      2      3      4      5      6      7      8      9     10
  O&MN-   200.   200.   200.   200.   200.   200.   200.   200.     0.     0.

  PLNG YR  11     12     13     14     15     16     17     18     19     20
  O&MN-     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.

  STUDENT SALARY (ANNUAL)- 11141.00     COST/HR OF INSTR MAT DEV   -   6.00
  STUD TRAVEL TO/FROM    -   228.00     SUPPLIES COST              -  10.00
  STUD TRAVEL IN COURSE  -     0.0      MISCELLANEOUS COST         -   0.0
  INSTR SALARY (ANNUAL)  - 16240.00     PCT MAX EQUIP PURCHASED    -    .90
  ADMIN SALARY (ANNUAL)  - 13500.00     FACILITY COST/SQ FOOT      -  25.00
  EQUIPMENT UNIT COST    -  5625.00
```

COURSE COST ANALYSIS

```
INPUT:
  COURSE NUMBER     - SEN1                    DISCOUNT RATE  - 10.0 PERCENT
  PLANNING PERIOD -   8                       INFLATION RATE -  6.0 PERCENT

OUTPUT TECHNICAL RESULTS:

  AVE. NO. OF GRADUATES RQD         -     10625.0
  AVE. NO. OF STUDENTS IN           -     10886.3
  AVE. AVERAGE ON BOARD             -       452.0
  AVE. NO. OF STUDENT POSITIONS     -       478.0
  AVE. NO. OF INSTRUCTORS RQD       -        24.0
  AVE. NO. OF ADMIN PERS RQD        -         4.8
  AVE. NO. OF EQUIPMENTS RQD        -       239.7
  AVE. ANNUAL EQUIP PURCHASES       -        35.5
  AVE. ANNUAL EQUIP AVAILABLE       -       284.0
  AVE. NO. SQUARE FEET RQD          -      4448.7
  AVE. INSTR. MAT. MAINT HR RQD     -       400.0
  AVE. NO. SUPPLIES RQD             -     11365.6
  AVE. NO. MISCELLANEOUS RQD        -     11365.6
```

COURSE COST ANALYSIS

INPUT:
COURSE NUMBER - SEN1
PLANNING PERIOD - 8

DISCOUNT RATE - 10.0 PERCENT
INFLATION RATE - 6.0 PERCENT

OUTPUT TECHNICAL RESULTS:

| | YEAR 1 | YEAR 2 | YEAR 3 | YEAR 4 | YEAR 5 |
|---|---|---|---|---|---|
| NO. OF GRADUATES RQD | 10000 | 12000 | 14000 | 14000 | 13000 |
| NO. OF STUDENTS IN | 10246. | 12295. | 14344. | 14344. | 13320. |
| AVERAGE ON BOARD | 425. | 510. | 596. | 596. | 553. |
| NO. OF STUDENT POSITIONS | 451. | 541. | 632. | 632. | 587. |
| NO. OF INSTRUCTORS RQD | 23. | 27. | 32. | 32. | 29. |
| NO. OF ADMIN PERS RQD | 5. | 5. | 6. | 6. | 6. |
| NO. OF EQUIPMENTS RQD | 226. | 271. | 316. | 316. | 293. |
| ANNUAL EQUIP PURCHASES | 284. | 0. | 0. | 0. | 0. |
| ANNUAL EQUIP AVAILABLE | 284 | 284 | 284 | 284 | 284 |
| NO. SQUARE FEET RQD | 4187. | 5024. | 5862. | 5862. | 5443. |
| NO. INSTR MAT MAINT HR RQD | 400. | 400. | 400. | 400. | 400. |
| NO. SUPPLIES RQD | 10697. | 12837. | 14976. | 14976. | 13906. |
| NO. MISCELLANEOUS RQD | 10697. | 12837. | 14976. | 14976. | 13906. |

COURSE COST ANALYSIS

INPUT:
COURSE NUMBER - SEN1
PLANNING PERIOD - 8

DISCOUNT RATE - 10.0 PERCENT
INFLATION RATE - 6.0 PERCENT

OUTPUT TECHNICAL RESULTS:

| | YEAR 6 | YEAR 7 | YEAR 8 | YEAR 9 | YEAR 10 |
|---|---|---|---|---|---|
| NO. OF GRADUATES RQD | 9000 | 8000 | 5000 | 0 | 0 |
| NO. OF STUDENTS IN | 9221. | 8197. | 5123. | 0. | 0. |
| AVERAGE ON BOARD | 383. | 340. | 213. | 0. | 0. |
| NO. OF STUDENT POSITIONS | 406. | 361. | 226. | 0. | 0. |
| NO. OF INSTRUCTORS RQD | 20. | 18. | 11. | 0. | 0. |
| NO. OF ADMIN PERS RQD | 4. | 4. | 2. | 0. | 0. |
| NO. OF EQUIPMENTS RQD | 203. | 180. | 113. | 0. | 0. |
| ANNUAL EQUIP PURCHASES | 0. | 0. | 0. | 0. | 0. |
| ANNUAL EQUIP AVAILABLE | 284 | 284 | 284 | 0 | 0 |
| NO. SQUARE FEET RQD | 3768. | 3350. | 2094. | 0. | 0. |
| NO. INSTR MAT MAINT HR RQD | 400. | 400. | 400. | 0. | 0. |
| NO. SUPPLIES RQD | 9627. | 8558. | 5349. | 0. | 0. |
| NO. MISCELLANEOUS RQD | 9627. | 8558. | 5349. | 0. | 0. |

# COURSE COST ANALYSIS

INPUT:
COURSE NUMBER - SEN1
PLANNING PERIOD - 8

DISCOUNT RATE - 10.0 PERCENT
INFLATION RATE - 6.0 PERCENT

OUTPUT COST RESULTS:

| | NON-DISC CONSTANT $ | DISCOUNTED CONSTANT $ | NON-DISC CURRENT $ | DISCOUNTED CURRENT $ |
|---|---|---|---|---|
| STUDENT SALARIES | 38736160. | 28078240. | 48046784. | 34042704. |
| STUDENT TRAVEL | 19856544. | 14393194. | 24629248. | 17450640. |
| INSTRUCTOR SALARY | 3114119. | 2257297. | 3862632. | 2736801. |
| ADMINISTRATIVE SALARY | 517742. | 375290. | 642186. | 455010. |
| EQUIPMENT | 1732400. | 1686556. | 1728172. | 1720636. |
| FACILITIES | 889749. | 644942. | 1103609. | 781943. |
| INSTRUCTIONAL MATERIALS | 14400. | 11093. | 17018. | 12989. |
| SUPPLIES | 909252. | 659080. | 1127800. | 799083. |
| MISCELLANEOUS | 0. | 0. | 0. | 0. |
| TOTAL OPERATIONAL | 65770320. | 48105632. | 81157392. | 57999760. |
| COST PER GRADUATE | 773.77 | 565.95 | 954.79 | 682.35 |
| COST PER STUDENT INPUT | 755.20 | 552.37 | 931.88 | 665.97 |
| COST PER STUDENT POSITION | 17167.92 | 12556.94 | 21184.39 | 15139.59 |

# COURSE COST ANALYSIS

INPUT:
COURSE NUMBER - SEN1
PLANNING PERIOD - 8

DISCOUNT RATE - 10.0 PERCENT
INFLATION RATE - 6.0 PERCENT

OUTPUT COST RESULTS: (NON-DISC CONSTANT $)

| | YEAR 1 | YEAR 2 | YEAR 3 | YEAR 4 | YEAR 5 |
|---|---|---|---|---|---|
| STUDENT SALARIES | 4557199. | 5468639. | 6380082. | 6380082. | 5924362. |
| STUDENT TRAVEL | 2336064. | 2803277. | 3270491. | 3270491. | 3036885. |
| INSTRUCTOR SALARY | 366367. | 439641. | 512914. | 512914. | 476278. |
| ADMINISTRATIVE SALARY | 60911. | 73093. | 85275. | 85275. | 79184. |
| EQUIPMENT | 1654300. | 56800. | 56800. | 56800. | 56800. |
| FACILITIES | 104676. | 125612. | 146547. | 146547. | 136079. |
| INSTRUCTIONAL MATERIALS | 2400. | 2400. | 2400. | 2400. | 2400. |
| SUPPLIES | 106971. | 128365. | 149759. | 149759. | 139062. |
| MISCELLANEOUS | 0. | 0. | 0. | 0. | 0. |
| TOTAL OPERATIONAL | 9188885. | 9097823. | 10604266. | 10604266. | 9851048. |
| COST PER GRADUATE | 919. | 758. | 757. | 757. | 758. |
| COST PER STUDENT INPUT | 897. | 740. | 739. | 739. | 740. |
| COST PER STUDENT POSITION | 20366. | 16803. | 16788. | 16788. | 16795. |

COURSE COST ANALYSIS

INPUT:
COURSE NUMBER - SEN1
PLANNING PERIOD - 8

DISCOUNT RATE - 10.0 PERCENT
INFLATION RATE - 6.0 PERCENT

OUTPUT COST RESULTS: (NON-DISC CONSTANT $)

| | YEAR 6 | YEAR 7 | YEAR 8 | YEAR 9 | YEAR 10 |
|---|---|---|---|---|---|
| STUDENT SALARIES | 4101479. | 3645758. | 2278599. | 0. | 0. |
| STUDENT TRAVEL | 2102458. | 1868851. | 1168032. | 0. | 0. |
| INSTRUCTOR SALARY | 329731. | 293094. | 183184. | 0. | 0. |
| ADMINISTRATIVE SALARY | 54820. | 48729. | 30455. | 0. | 0. |
| EQUIPMENT | 56800. | 56800. | -262700. | 0. | 0. |
| FACILITIES | 94209. | 83741. | 52338. | 0. | 0. |
| INSTRUCTIONAL MATERIALS | 2400. | 2400. | -2400. | 0. | 0. |
| SUPPLIES | 96274. | 85577. | 53485. | 0. | 0. |
| MISCELLANEOUS | 0. | 0. | 0. | 0. | 0. |
| TOTAL OPERATIONAL | 6838166. | 6084946. | 3500992. | 0. | 0. |
| COST PER GRADUATE | 760. | 761. | 700. | 0. | 0. |
| COST PER STUDENT INPUT | 742. | 742. | 683. | 0. | 0. |
| COST PER STUDENT POSITION | 16840. | 16858. | 15519. | 0. | 0. |

JOB COST MODEL

- Description of Billet Cost Model*
- Billet Cost Model Variables

*Reproduced from documentation on the Navy Military Manpower Billet Cost Data for Life Cycle Planning Purpose provided by the Bureau of Naval Personnel.

DESCRIPTION OF BILLET COST MODEL

INTRODUCTION. The Chief of Naval Personnel has developed the data in this publication for use in computing the life-cycle costs for major Navy weapon systems (ships, aircraft, etc.). These data are provided to civilian contractors competing for and/or participating in the formulation of weapon system design and procurement, and are used by the Navy and the Office of the Secretary of Defense in the evaluation of contractor proposals. In addition, they are used for many other management purposes, wherever the projected costs of military manpower are significant.

Manpower billet costs, as defined by the DOD Manpower Cost Model Study Group, include the total cost to the U.S. Government of manning an established operational military billet, or a military billet which would be established within a proposed system. These costs are presented as annual costs for both officer and enlisted personnel and are used in costing the life-cycle of the system under consideration. Manpower billet costs differ significantly from appropriation-oriented personnel costs which are used for budget planning purposes, since they contain values which are not taken into account in appropriation-oriented costs. For example, the values established within the formula for the purpose of costing the "down time" of personnel in service schools, and the values developed to reflect the effect of "continuance rates" are not contained in personnel cost data used for budget plannning purposes.

Manpower billet cost data contained in this publication are not complete costs, but reflect mainly the cost to the Navy and the Department of Defense.

Manpower Billet Costs are developed for both officer and enlisted personnel. The costs are computed in a manner which results in an "operational billet cost per year" for all operational billets in the Navy with the exception of flag billets and paygrade E-1 billets. In order to compute these costs, the Chief of Naval Personnel has developed a Billet Cost Model. Basic pay data included in this publication are based on January 1973 Pay Tables. A summary description of the major cost elements within the Billet Cost Model is contained in Section III. This general desription is applicable to both officer and enlisted billets, and is provided as an explanation of billet costing. It is presented in terms of enlisted billets to simplify the explanation.

It is planned to revise the publication annually to include changes in the cost elements brought about by military pay raises, changes in training costs, etc.

DISCUSSION. Manpower costs are accrued from operational billets. An operational billet is best described as a job position which is being filled at all times by personnel in an operational status. All other personnel such as students, patients, prisoners, or personnel in a transient status are not occupying operational billets. Manpower related costs incurred during operational times are considered in the model formulae as "UP" costs, and costs incurred during nonoperational times are known as "DOWN" costs. DOWN costs include pay related cost, (when incurred in the DOWN status) and an apportionment of support and certain one-time occurring costs, such as procurement

(recruiting) costs, based upon the length of the DOWN time. The concept is that DOWN costs represent a manpower resource investment cost which the Navy must make in order to obtain future operational service. Therefore, all DOWN costs are amortized over future operational billet years.

One major element of cost to the U.S. Government which must be apportioned to operational billets is that related to retirement costs which occur after career men finish their operational duty. The total cost of retirement per individual (called the principal value of retirement) is developed on the basis of life expectancy data. This cost, computed on the basis of average age at the time of retirement from specific grades, is distributed by the model back (in time) over the operational billet years. Several methods of distributing this cost have been developed and tested. The one found to be the best for billet costing purposes and used in this model is the method which distributes the principal value of retirement as a fixed percentage of active base pay. This method was approved for billet costing by CNO, OP-90E11/pas Ser 620P90 of 22 April 1969.

A primary factor characterizing manpower billet costs is that these data are to reflect the total cost to the U.S. Government, not just to the Navy or the Department of Defense, of manning an established operational military billet, or a military billet which would be established within a proposed system. The costs developed by the model results in an "operational billet cost per year" for all operational billets in the Navy except flag billets and paygrade E-1 billets.

In developing life-cycle costs, the Model views the manpower picture as a flow of men through each rating as well as through each billet. They are procured, training, utilized and, as time passes, they are lost through non-reenlistment, death, retirement or other attrition factors. Manpower costs are thus computed from initial procurement to the end of retirement and charged to an active duty base of twenty-five operational billet years.

Each rating is viewed by the Model as a flow of men through a pipeline. The pipeline is divided into year-long intervals and all costs incurred by the rating in each interval are noted. During the interval, some men are lost through various leaks in the pipeline, e.g., nonreenlistment, change in rating, death, etc. No attempt is made to analyze these leaks. The only criterion of consideration is the quantity of men entering the next interval. The relative number of men is considered because the actual number affects only the total cost and not the cost per man/billet. Accordingly, the flow is normalized such that one man retires at the end of the career span, i.e., twenty-five years. Thus, normalization is a function of the flow rate in a given rating and varies with the different ratings. It dictates that the number of men which must be introduced into the pipeline the first year to produce one man retiring at the end fluctuates significantly.

In summary, the Billet Cost Model is quite flexible. It accounts for the many variables which make up life-cycle operations costs. It determines which cost element applies to all ratings by year of service or grade or which cost element applies to a particular rating. As each element is identified by a card in the model, a value is added to each appropriate rating packet as constant $ by year or constant $ by grade. A detailed list of cost items presently being used is shown in the Billet Cost Model Data Summary.

The preliminary computations to obtain the input data cards for the model are external to the model. The model will accept numbers up to six digits. The precomputations and source of data have been kept as a matter of routine so that future cost changes can be incorporated on an "as-required" or "as-occurred" basis. Moreover, there is no fixed number of rating packets that must be run at one time. This allows for experimentation with a single rating packet or a group of rating packets. A hypothetical rating can be created by defining a new rating XXX and preparing a cost/statistical profile the same as a regular rating. The hypothetical rating can be run by itself or with a regular rating to obtain a comparison of results. Similarly, either the enlisted or officer decks can be run separately.

MANPOWER BILLET COST MODEL DATA DESCRIPTION. This section contains a brief summary description of some representative cost elements within the Billet Cost Model. While it is not a complete list, it indicates the range of data used to develop billet costs. Since actual values are subject to significant change, only general data are given.

Grade Costs

Sources: Budget FY 1972 Military Personnel, Navy
Budget FY 1972 Operations & Maintenance, Navy

These costs include the following, computed for each officer and enlisted pay grade:

Family Separation Allowance
"Q" Allotment
Quarters Allowance BAQ
Sea and Foreign Duty Pay
Tuition Assistance and Dependent Schools.

Annual Costs

Sources: Budget FY 1972 Military Personnel, Navy
SECNAV Task Force on Navy/Marine Corps Personnel Retention, Vol. X

Includes annual costs such as:

Clothing Allowance
Death Gratuity
Commissary
Exchange
Medical Costs
Subsistence Allowance, etc.

Base Pay

Source: DOD Military Pay and Allowances Entitlement Manual (as changed).

Hazardous Duty Pay (Aviation and Submarine)

Source: DOD Military Pay and Allowances Entitlements Manual.

Continuance Rates

Source: BuPers Master Personnel Tapes.

Average Length of Service to Advance

Source: Pers-A12 for enlisted
Pers-A11 for officers

Constant Dollar Cost by Grade

Sources: Navy and Marine Corps Military Personnel Statistics, NAVPERS 15658
Proficiency Pay List, Report E-170
Manual of Navy Enlisted Classifications, NAVPERS 15105
Budget 1972 Military Personnel, Navy

Includes cost items that can be identified by Rating and Grade, such as:

Proficiency Pay
Hazardous Duty Pay (non-crew)
Flight Deck Duty Pay.

Transportation Costs

Source: Budget FY 1972 Military Personnel, Navy

These costs are divided into four categories: accession travel, change of station travel, training travel and separation travel. Computations are done separately for enlisted and officer personnel and data are included only where appropriate.

Constant Dollar Cost by Year of Service

Sources: DOD Military Pay and Allowances Entitlements Manual
BuPers Instruction 1133.18C
Pers-A12

Includes cost items that can be identified by Rating and Grade and Year of Service, such as Reenlistment Bonus and Continuation Pay.

Median Length of Service

Sources: BuPers Report E 159H Report of Enlisted Personnel on Active Duty
Pers-A11
Officer Management Simulation Model

School Training Costs

Sources: Computed by Occupational Standards Division, Naval Personnel Program Support Activity, Washington, D.C., for enlisted.
For officers, data procured from Pers-A11 and OP-992E.

Includes all costs related to school training, including procurement costs as a part of initial training.

| INDEX OF COST ITEMS | PROGRAM | ALL ENLISTED | | | | EACH RATING PACKET | | | | ALL OFFICERS | | | | EACH RATING PACKET | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *BP | *HP | *YR | *GR | PRO | REN | SCH | TRV | *BP | *HP | *YR | *GR | PRO | REN | SCH | TRV |
| BASE PAY TABLE | | X | | | | | | | | X | | | | | | | |
| CLOTHING ALWS – INITIAL | | | | X | | | | | | | | X | | | | | |
| – BASIC | | | | X | | | | | | | | | | | | | |
| – STANDARD | | | | X | | | | | | | | | | | | | |
| – SPECIAL E-7 | X | | | | | | | | | | | | | | | | |
| COMMAND AND ADMINISTRATION | | | | X | | | | | | | | X | | | | | |
| COMMISSARY | | | | X | | | | | | | | X | | | | | |
| DEATH GRATUITY | | | | X | | | | | | | | X | | | | | |
| DENTAL PAY | | | | | | | | | | | | | | X | | | |
| DEPENDENT SCHOOL | | | | | X | | | | | | | | | | | | |
| DISABILITY PAY | | | | X | | | | | | | | X | | | | | |
| EXCHANGE | | | | X | | | | | | | | X | | | | | |
| FAMILY SEPARATION | | | | | X | | | | | | | | X | | | | |
| FICA - GOVT. CONTRIBUTION | X | | | | | | | | | | | | | | | | |
| HAZARDOUS DUTY - AIRCREW & SUB | | | X | | | | | | | | X | | | | | | |
| HAZARDOUS DUTY - NON-CREW | | | | | | X | | | | | | | | X | | | |
| INTEREST ON DEPOSITS | | | | X | | | | | | | | X | | | | | |
| INSURANCE - FHA HOUSING | | | | X | | | | | | | | X | | | | | |
| MEDICAL COSTS | | | | X | | | | | | | | X | | | | | |
| MEDICAL/VETERINARIAN PAY | | | | | | | | | | | | | | X | | | |
| MESSING/SUBSISTENCE ALWS | | | | X | | | | | | | | X | | | | | |
| OVERSEAS STATION ALLOWANCE | | | | X | | | | | | | | X | | | | | |
| PERSONNEL PROCUREMENT | | | | | | | | X | | | | | | | | X | |
| PROFICIENCY PAY | | | | | | X | | | | | | | | | | | |
| "Q" ALLOTMENT | | | | | X | | | | | | | | | | | | |
| QUARTERS ALWS | | | | | X | | | | | | | | X | | | | |
| QUARTERS – SINGLE (BARRACKS) | | | | X | | | | | | | | X | | | | | |
| QUARTERS – MARRIED (HOUSING) | | | | X | | | | | | | | X | | | | | |
| RECREATIONAL FACILITIES | | | | X | | | | | | | | X | | | | | |
| REENLISTMENT/CONTINUANCE PAY | | | | | | | X | | | | | | | | X | | |
| RESPONSIBILITY PAY | | | | | | | | | | | | | | X | | | |
| RETIREMENT PAY | X | | | | | | | | | | | | | | | | |
| SCHOOL TRAINING | | | | | | | | X | | | | | | | | X | |
| SEA AND FOREIGN DUTY PAY | | | | | X | | | | | | | | X | | | | |
| SERVICEMANS GROUP LIFE INS | | | | X | | | | | | | | X | | | | | |
| SETTLEMENT COSTS | X | | | | | | | | | | | | | | | | |
| SEVERENCE/READJUSTMENT PAY | | | | | | | | | | | | X | | | | | |
| TRAVEL/TRANSPORTATION | | | | | | | | | X | | | | | | | | X |
| TUITION AID | | | | | X | | | | | | | | X | | | | |
| UNEMPLOYMENT COMPENSATION | | | | X | | | | | | | | X | | | | | |

DECISION TREE EVALUATOR

- Tree Format With Nodes and Variable Designators
- ETAM Decision Tree Format

  Program Listing

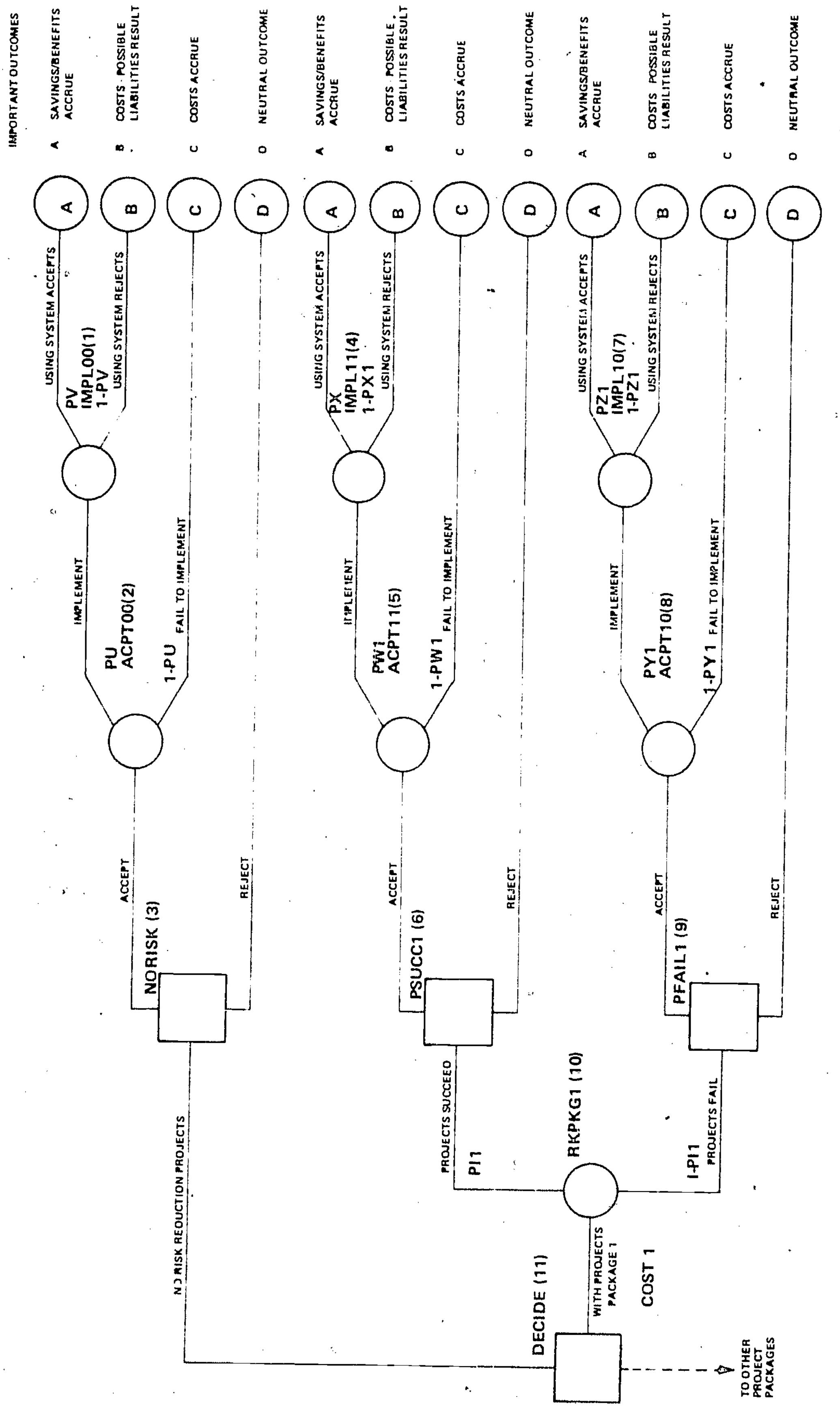
  Run CTREE

  Run Command

  Gamma Command

  List Command

  Gamma Command




ETAM DECISION TREE FORMAT - NODE AND VARIABLE DESIGNATORS

# ETAM DECISION TREE FORMAT*

```
C:   ETAM DECISION TREE FORMAT
GENERATION
TYPE PR(2),TE(2), DE(2)
NODE DECIDE,DE
  VAL(1)=6HDECIDE
  IVAL(2)=1
  NEXT NORISK
  NEXT RKPKG1,COST1
  END
NODE NORISK,DE
  VAL(1)=6HNORISK
  IVAL(2)=2
  NEXT ACPT00
  NEXT -,D
  END
NODE ACPT00,PR
  VAL(1)=HACPT00
  IVAL (2)=3
  NEXT IMPL00,PU
  NEXT -,1.-PU,C
  END
NODE IMPL00,PR
  VAL(1)=6HIMPL00
  IVAL(2)=4
  NEXT -,PV,A
  NEXT -,1.-PV,B
  END
NODE RKPKG1,PR
  VAL(1)=6HRKPKG1
  IVAL(2)=5
  NEXT PSUCC1,PI1
  NEXT PFAIL1,1.-PI1
  END
NODE PSUCC1,DE
  VAL(1)=6HPSUCC1
  IVAL (2)=6
  NEXT ACPT11
  NEXT -,D
  END
NODE ACPT11,PR
  VAL(1)=6HACPT11
  IVAL(2)=7
  NEXT IMPL11,PW1
  NEXT -,1.-PW1,C
  END
NODE IMPL11,PR
  VAL(1)=6HIMPL11
  IVAL(2)=8
  NEXT -,PX1,A
  NEXT -,1.-PX1,B
  END
```

*Developed using SRI (Stanford Research Institute) tree language system, SRI, Menlo Park, California 94025.

```
NODE PFAIL1,DE
  VAL (1)=6HPFAIL1
  IVAL (2)=9
  NEXT ACPT10
  NEXT -,C
  END
NODE ACPT10,PR
  VAL(1)=6HACPT10
  IVAL (2)=10
  NEXT IMPL10,PY1
  NEXT -,1.-PY1,C
  END
NODE IMPL10,PR
  VAL(1)=6HIMPL10
  IVAL(2)=11
  NEXT -,PZ1,A
  NEXT -,1.-PZ1,B
  END
C:  INPUT STATEMENTS
WRITE (5,84)
READ(5,85)A
READ(5,85)B
READ(5,85)C
READ(5,85)D
READ(5,85)COST1
READ(5,85)PI1
READ(5,85)PU
READ(5,85)PV
READ(5,85)PW1
READ(5,85)PX1
READ(5,85)PY1
READ(5,85)PZ1
84    FORMAT (46H ENTER A B C D COST1 PI1 PU PV PW1 PX1 PY1 PZ1)
85    FORMAT (F8.2)
START DECIDE
END
```

```
.......
.RUN CTREE(31,76)

                    ****************************************
                    *    DECISION TREE EVALUATION SYSTEM   *
                    *          PREPARED FOR ARPA            *
                    *   BY THE SRI DECISION ANALYSIS GROUP *
                    ****************************************

    TREE LANGUAGE FILE:  NAVAL

    FORTRAN FILE:FNORT
    FORTRAN:   NFORT.F4
    LOADING

    NFORT 8K CORE
    EXECUTION

    TREE FILE:  NTREE

    ENTER A B C D COST1 PI1  PU  PV  PW1  PX1  PY1  PZ1

    28.0
    -3.8
    -.5
    0.0
    -11.1
    .95
    .75
    .50
    .85
    .90
    .75
    .50

    TREE FILE:NTREE

    TREE HAS              11 NODES
```

COMMAND:RUN

LOTTERY , ACTIVE NODE PRINTOUTS, STARTING NODE, OK ?YES

CERTAIN EQUIV. OF STARTING NODE: 9.3183998

SELECTED DECISION: RKPKG ALTERNATIVE 2 NODE NO. 10

ANALYSIS OF ALTERNATIVES

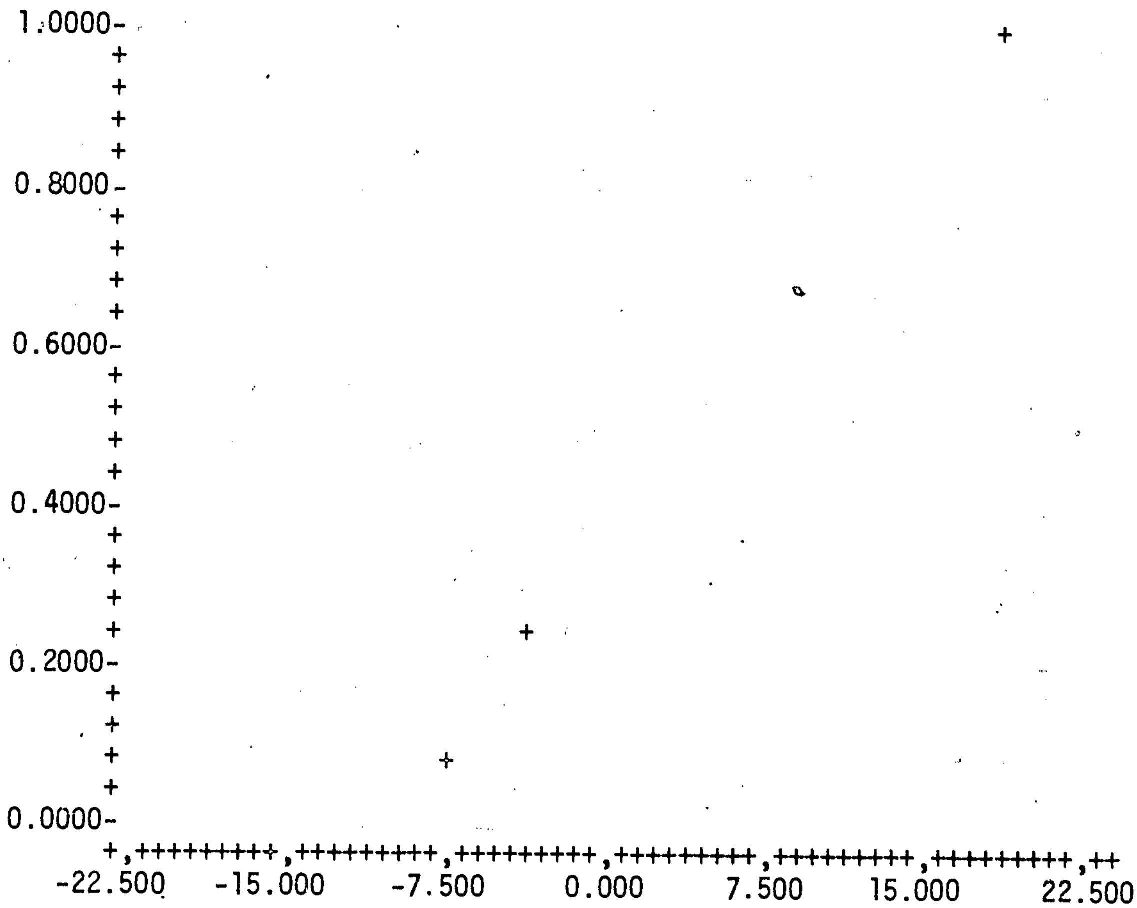
| NAME | ALT. | NODE NO. | CERTAIN EQUIVALENT |
|---|---|---|---|
| NORIS | 1 | 3 | 8.9500000 |
| RKPKG | 2 | 10 | 9.3183998 |

| NODE NO. | NODE NAME | SUCCESSOR DEC-ISION | SUCCESSOR NODE NO. | NODE NAME | ROLLBACK VALUE |
|---|---|---|---|---|---|
| 11 | DECID | 2 | 10 | RKPKG | 9.318400 |
| 10 | RKPKG | | | | 20.41840 |
| 9 | PFAIL | 1 | 8 | ACPT1 | 8.950000 |
| 8 | ACPT1 | | | | 9.950000 |
| 7 | IMPL1 | | | | 12.10000 |
| 6 | PSUCC | 1 | 5 | ACPT1 | 21.02200 |
| 5 | ACPT1 | | | | 21.02200 |
| 4 | IMPL1 | | | | 24.82000 |

LOTTERY ON ALL REWARDS IN TREE.

LOTTERY MIN= -14.900000 MAX= 16.900000
MEAN= 9.3184000 SD= 13.001403

| LOTTERY VALUE | PROBABILITY | CUMULATIVE |
|---|---|---|
| -14.90000 | 0.09950 | 0.09950 |
| -11.60000 | 0.15500 | 0.25450 |
| 16.90000 | 0.74550 | 1.00000 |



COMMAND: GAMMA

RISK AVERSION COEF.=.02

COMMAND:RUN

GAMMA= 0.20000000E-01, LOTTERY , ACTIVE NODE PRINTOUTS, STARTING NODE, OK ?YES

CERTAIN EQUIV. OF STARTING NODE: 7.4712394

SELECTED DECISION: RKPKG ALTERNATIVE 2 NODE NO. 10

ANALYSIS OF ALTERNATIVES

| NAME | ALT. | NODE NO. | CERTAIN EQUIVALENT |
|---|---|---|---|
| NORIS | 1 | 3 | 6.8869030 |
| RKPKG | 2 | 10 | 7.4712394 |

| NODE NO. | NODE NAME | DEC-ISION | SUCCESSOR NODE NO. | SUCCESSOR NODE NAME | ROLLBACK VALUE |
|---|---|---|---|---|---|
| 11 | DECID | 2 | 10 | RKPKG | 7.471239 |
| 10 | RKPKG | | | | 18.57124 |
| 9 | PFAIL | 1 | 8 | ACPT1 | 6.886903 |
| 8 | ACPT1 | | | | 6.886903 |
| 7 | IMPL1 | | | | 9.613395 |
| 6 | PSUCC | 1 | 5 | ACPT1 | 19.26884 |
| 5 | ACPT1 | | | | 19.26884 |
| 4 | IMPL1 | | | | 28.74201 |

```
COMMAND:LIST

FORWARD OR BACKWARD: FORWARD
NODE  DECID NO.     11 TYPE DEC
  ATTR:  1.0000000
  SUCCESSOR    3
  SUCCESSOR   10 ATTR: -11.100000

NODE  RKPKG NO.     10 TYPE CHA
  ATTR:  5.0000000
  SUCCESSOR    6 ATTR: 0.95000000
  SUCCESSOR    9 ATTR: 0.49999997E-01

NODE  PFAIL NO.      9 TYPE DEC
  ATTR:  9.0000000
  SUCCESSOR    8
  SUCCESSOR    0 ATTR:-0.50000000

NODE  ACPT1 NO.      8 TYPE CHA
  ATTR:  10.000000
  SUCCESSOR    7 ATTR: 0.75000000
  SUCCESSOR    0 ATTR: 0.25000000      -0.50000000

NODE  IMPL1 NO.      7 TYPE CHA
  ATTR:  11.000000
  SUCCESSOR    0 ATTR: 0.50000000      28.000000
  SUCCESSOR    0 ATTR: 0.50000000      -3.8000000

NODE  PSUCC NO.      6 TYPE DEC
  ATTR:  6.0000000
  SUCCESSOR    5
  SUCCESSOR    0 ATTR: 0.0000000

NODE  ACPT1 NO.      5 TYPE CHA
  ATTR:  7.0000000
  SUCCESSOR    4 ATTR: 0.85000000
  SUCCESSOR    0 ATTR: 0.15000000      -0.50000000

NODE  IMPL1          4 TYPE CHA
  ATTR:  8.0000000
  SUCCESSOR    0 ATTR: 0.90000000      28.000000
  SUCCESSOR    0 ATTR: 0.10000000      -3.800000

NODE  NORIS NO.      3 TYPE DEC
  ATTR:  2.0000000
  SUCCESSOR    2
  SUCCESSOR    0 ATTR: 0.0000000

NODE  ACPTO NO.      2 TYPE CHA
  ATTR:  3.0000000
  SUCCESSOR    1 ATTR: 0.75000000
  SUCCESSOR    0 ATTR: 0.25000000      -0.50000000
NODE  IMPLO NO.      1 TYPE CHA
  ATTR:  4.0000000
  SUCCESSOR    0 ATTR: 0.50000000      28.000000
  SUCCESSOR    0 ATTR: 0.50000000      -3.8000000
```

COMMAND:GAMMA

RISK AVERSION COEF.=0

COMMAND:RUN

LOTTERY , ACTIVE NODE PRINTOUTS, STARTING NODE, OK?YES

CERTAIN EQUIV. OF STARTING NODE: 9.3193998

SELECTED DECISION: RKPKG ALTERNATIVE 2 NODE NO. 10

ANALYSIS OF ALTERNATIVES

| NAME | ALT. | NODE NO. | CERTAIN EQUIVALENT |
|---|---|---|---|
| NORIS | 1 | 3 | 8.9500000 |
| RKPKG | 2 | 10 | 9.3183998 |

| NODE NO. | NODE NAME | DEC-ISION | SUCCESSOR NODE NO. | SUCCESSOR NODE NAME | ROLLBACK VALUE |
|---|---|---|---|---|---|
| 11 | DECID | 2 | 10 | RKPKG | 9.318400 |
| 10 | RKPKG | | | | 20.41840 |
| 9 | PFAIL | 1 | 8 | ACPT1 | 9.950000 |
| 8 | ACPT1 | | | | 8.950000 |
| 7 | IMPL1 | | | | 12.10000 |
| 6 | PSUCC | 1 | 5 | ACPT1 | 21.02200 |
| 5 | ACPT1 | | | | 21.02200 |
| 4 | IMPL1 | | | | 24.82000 |

# SECTION V

# SCENARIO EXAMPLES

This section contains examples of applying ETAM to all or part of the recommended process for evaluating a training innovation. The first scenario takes a proposed innovation from the innovator's description through the series of ETAM tasks. The results of each task are presented as a general, but not complete, model for the analytic and decision process. The remaining scenarios are treatments of subsets of the assessment process which were felt to require further elaboration. Also, some sample innovations have been included to which ETAM procedures might be applied.

## SCENARIO NUMBER ONE - 3-D PROCEDURAL TRAINER

The innovator experimented with a 3-D simulator for replacing actual operational laboratory training equipment used in certain training tasks. The innovator's description of his preliminary work is presented as the starting point for the scenario. The reviewer should be aware of the following aspects of the approach to presenting this scenario material.

1. Inconsistencies in the Task 1 description are deliberately introduced to simulate realisms. Actual people don't always see the real versus fancied benefit or liability of the product, even when the data stare them in the face. This is one of the values of formal ETAM which sheds light on all of it.

2. The present scenario is an abstract of what might, in real life, be a lot of text. But it should be evident that text, other than the context of what appears here, would be superfluous and even obscuring.

3. The major kind of data that might have been added would have been historical field experiences showing how poorly most people do on procedures, and the high error rates almost universally associated with procedural tasks.

INNOVATOR'S DESCRIPTION. The innovator prepared the following write-up as an input to the analysis and decision process.

EXHIBIT: 3-D SIMULATION OF EQUIPMENT TO TEACH EQUIPMENT PROCEDURES

Description

On-the-job evaluation of operators and maintenance personnel shows a general inadequacy in the performance of routinized procedures such as turn on, calibration, checkout, operation, and so forth. This leads to inefficient performance and many errors.

But the use of actual equipment in training exercises is expensive in many ways. The cost of the equipment, plus its maintenance and calibration for training, limits the number which is practical for training

EXHIBIT: 3-D SIMULATION OF EQUIPMENT TO TEACH EQUIPMENT PROCEDURES (Continued)...

purposes. Furthermore, an instructor must usually be present for each one or pair of students working on equipment so that the correctness of each step can be verified, or to provide guidance and interpretation when things go wrong, either because of student error or equipment failure. The combination of these costs may limit student practice on the equivalent of hands-on procedure to a few hours, rather than the dozens of hours necessary for a reliable proficiency.

This innovation consists of using a dummy shell of the equipment, but with all indicators and controls having an appearance of being operational. Controls are manipulable. External test points on which to attach test equipment probes are presented and "functional."

The internals of the mockup consist of circuits which feed impulses to a programmed computer. The latter returns equipment indications suitable to the control activations. In addition, the program generates corrective feedback to the student. This is presented on a nearby screen. The screen can present only static images, but it can display a given wave shape in response to a given situation and action.

Several comparative studies had the following results:

1. The experimental group was given the same overall number of lab sessions and lab hours as the control group -- the use of live equipment was by the control group. In the experimental group, each student had a teaching mockup which he used throughout the lab periods, except for the final performance test which was made on two pieces of live equipment and monitored by the instructor.

   The experimental group's performance on a scale which combined scores on speed and errors, with a high weighting on errors, was judged to be 40% superior to the performance of the control group.

   Retest a month later, showed the experimental group to be 60% superior to the control group. These scores suggested an estimated reduction in on-the-job training from four weeks to one week in order to acquire acceptable operational efficiency.

   Tests six months after incumbents were on the job showed 30% of the experimental group as "outstanding" in performance on the subject tasks, whereas only 5% of the control group was judged outstanding in their job performance. There were similar superiorities of the experimental over the control subjects at other levels of evaluation.

   During training, there was 1% attrition in the experimental group and 7% in the control group.

EXHIBIT: 3-D SIMULATION OF EQUIPMENT TO TEACH EQUIPMENT PROCEDURES (Continued)...

2. Cost analysis. Development plus operational costs of the experimental device netted out to $10 per student hour. The costs for the actual hardware (control condition) netted out to $9 per student hour. These costs were based on a 5-year spread.

   (One liability in the experimental device, the operating mockup, was the need to run one pass of pilot students through the device in actual training conditions in order to properly debug its operation. For this class, the ordinary complement of actual equipments had to be available as backup for training while the mockup trainers were being debugged.)

   In the control group, one instructor was necessary for every four students, while in the experimental group, one instructor was sufficient for a class of 20 to 25 students.

<u>Problem</u>

A large investment would have to be made by the Navy to develop the technology for the mockup trainer. It could be connected by telephone to a central computer. The ultimate costs for units of this device could be drastically reduced if they could be used in very large numbers in a large range of job tasks. (The cost analysis figure for the device, cited above as $10, assumed a minimum of a thousand of the devices in use by the Navy at the end of 5 years. A large investment in development funds might have a good chance of reducing the cost per student hour below the $9 stated above.)

It is, therefore, important to determine the widest potential range-of-effect for this training function.

TASK 1 - FORMALIZE THE DESCRIPTION OF THE INNOVATION. The innovator expands his description of the innovation by referring to the Task 1 procedures. The assessor-consultant may participate in this phase, however, this is not a necessity. A sample Descriptive Data Sheet prepared by the innovator might appear as follows. Task and subtask references are identified where appropriate.

EXHIBIT: DESCRIPTIVE DATA SHEET

<u>NAME OF THE INNOVATION</u>
<u>3-D Procedural Trainer</u>

<u>OBJECTIVES AND SUMMARY DESCRIPTION</u> (01.01)

The objective is to increase the efficiency and retentivity of the learning of operating procedures on electronic equipment. The device consists of the shell of the electronic gear on which the procedures are to be learned. Within this shell, special circuits are hooked up to a computer which simulates the behavior of the equipment to the

EXHIBIT: DESCRIPTIVE DATA SHEET (Continued)...

actions of the student, but also provides corrective and other instructional guidance. The computer is programmable so as to adapt to the learning objectives.

DELIVERY SYSTEM (01.02)

The innovation centers around a delivery system for procedures learning. The trainer displaces the operational live equipment that is used for instructional purposes and the instructional manuals that guide the student in his learning the procedure.

Instructional Process

The device enables the student to perform manual procedures with actual displays and controls and their relationships. He also gets instructional feedback and guidance from an auxiliary display screen controlled by the computer. The student actually learns by doing the task, with supplemental individualized help and direction controlled by the responses he has already made, and should be making next. This should result in faster learning, better remembering, and higher procedural level skill. The device is a form of simulator.

JOBS AND TASKS (01.03)

Of primary relevance are those jobs that deal with the external displays and controls of intact electronic equipment. This may include test equipment and operator training in sequential procedures on the equipment such as turn on, start up, checkout, and operation. Also, maintenance tasks done on the outside of the intact electronic equipment such as checkout, alignment, and so forth.

Equipment Orientation

Electronic equipment. No restrictions on equipment type.

Work Function

Sequential procedures: reading indicators; activating controls as prescribed in sequence; recognizing deviations from "normal" and taking specified action.

Operational Environment

Any lab environment: no physical motion; normal temperatures. The student is unstressed except as may be artifically induced by verbal means. Space used by the trainer is practically equivalent to that used by operational equipment for training.

EXHIBIT: DESCRIPTIVE DATA SHEET (Continued)...

STUDENT ATTRIBUTES (01.04)

May help slow learners of routine tasks. Student attribute factors are not a major target of the innovation.

Prior Training and Experience

The trainer could be an efficient way of providing refresher training, but this has not been investigated as a justification.

Attitudes and Motivations

These should be improved as a by-product of the student getting impersonal, individual, and continuous practice rather than waiting around for the instructor's attention, or making mistakes and not knowing what he did incorrectly for substantial periods of time. The student may, early in learning the task, get a proper sense of pace which can be forced by the programming of the instructional guidance.

Aptitudes

These may be affected, but only as a by-product of other factors. The trainer can reduce the dependence of instructor and student on the student's ability to learn symbolic materials which may not be highly correlated with his ability to learn the procedures by actual physical operations.

Social Factors

No intended influence.

Setbacks and Attrition

The reduction of these is a secondary target.

Student Evaluation

A continuous, objective record of the errors made by the student is maintained. This should be superior to instructor evaluations. The device may be used to keep the student practicing until the desired performance criterion is reached.

EMPIRICAL DATA (01.05)

Study performed on two pieces of equipment.

EXHIBIT: DESCRIPTIVE DATA SHEET (Continued)...

## Quantitative Benefits

Measured Results

Control: Normal training operations.

Exper: Use of innovation on same equipments, same procedures to be learned.

Results: Tested on live equipment after equal hours of elapsed time.

1. Immediately after training: Exper were 40% superior.
2. Retest one month later: Exper 60% superior. (Equivalent to reducing OJT from 4 weeks to 1 week.)
3. Test six months after on job:

   Exper: 30% rated "outstanding" on job.

   Contr: 5% rated as "outstanding."
4. Attrition

   Exper: 1%

   Contr: 7%

Criterion Variables for Measuring Training Effectiveness

Validity and completeness in level of proficiency.

Target: Higher level of operational proficiency in procedures performance.

## Quantitative Costs

Estimated operation costs for innovation, 8 years: $7.00 per student hour.

Present operating cost for training: $8.50 per student hour.

Exper: One instructor per 20 students.

Contr: One instructor per 4 students.

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EXHIBIT: DESCRIPTIVE DATA SHEET (Continued)...

Estimates of Magnitudes of Benefits/Savings under Actual Conditions

80% reduction in attrition rate.

75% savings in OJT per incumbent.

Reduction in standby and spare equipment.

Decreases in mission failures.

ESTIMATES OF THE PRACTICAL IMPORTANCE OF THE TRAINING PRODUCT (01.06)

Practical procedural proficiency: crucial importance to operations.

RESOURCE REQUIREMENTS FOR FURTHER STUDY (01.07)

Technical development: $12 million over 3 years.

Empirical studies: $ 3 million over 3 years.

TASK 2 - DEVELOP/EXAMINE ALTERNATIVES TO THE INNOVATION. The development of alternatives may require extensive study, reference to the literature, and consultation with experts. In this scenario, the assessment should be performed in two steps. First, alternatives generated should be considered against the same objectives as the original proposal (3-D Trainer). Second, any additional benefits specific to the alternative should be identified and assessed. The following briefly describes an alternative to the 3-D Trainer. If this should become an important consideration in the decision process, it will be subjected to the same descriptive procedure (Task 1) and analysis as the original proposal.

EXHIBIT: INNOVATION ALTERNATIVES

CMI Display Terminals

Microfiche frames, random selection by computer.

Get high mediated-performance proficiency.

Then final training on live equipment.

Major Advantage

All technology in place.

Attrition reduction from 7% to 5%.

Student/instructor ratio increased from 4 to 5.

EXHIBIT: INNOVATION ALTERNATIVES (Continued)...

Major Liability

Slight cost increase ($4,375.00 to $5,000.00).

TASK 3 - MAKE PRELIMINARY FEASIBILITY PROFILE. The following risk statements were selected from the list appearing in each of the major potential risk categories. They are applicable to the 3-D Procedural Trainer.

EXHIBIT: PRELIMINARY FEASIBILITY PROFILE (Statements of Risk)

IMPORTANCE TO NAVY MISSION (03.01)

Of moderate importance.

ORGANIZATIONAL COMPATIBILITY (03.02)

Irrelevant to Navy command and career structures.

GOALS/POLICY COMPATIBILITY (03.03)

Support of policy to increase practical skill levels.

STATE OF THE ART (03.04)

Moderate probability of success with some continued R&D effort.

Problems:

1. Hardware linkages of equipment to computer sensors.
2. Simulation of temporal response to operation actions.
3. Reliability of hardware/software performance.
4. Lead time needed to program the training functions on device.

FUNDING (03.05)

Large or very large investment to bring the innovation to an operational level of implementation (near maximum that can be committed to one project).

TECHNICAL SUPPORT (03.06)

Some difficulty in getting R&D talent and implementation talent.

ATTITUDINAL ACCEPTANCE (03.07)

Moderate but temporary resistance by instructional community, especially if there will be difficulties in operation, equipment reliability, or system availability and responsiveness.

EXHIBIT: INNOVATION ALTERNATIVES (Continued)...

Student acceptance.

PRELIMINARY FEASIBILITY PROFILE SUMMARY (03.08)

Figure V-1 summarizes the analysis from 03.01 through 03.07, showing the innovation as moderately risky with a number of risk reduction projects and associated dollars required to bring the implementation and use of the innovation to an acceptable level of risk.

Task 4 - PERFORM ANALYTIC FEASIBILITY ASSESSMENT. The preliminary assessment of risks performed in Task 3 is refined at this point; success probabilities are determined, projects are costed, and a decision variable is calculated based upon the tangible factors. The following are examples of results from Task 4 procedures applied to the analysis of the 3-D Procedural Trainer.

EXHIBIT: ANALYTIC FEASIBILITY ASSESSMENT

POTENTIALLY HIGH RISK AREAS (04.01)

State of the Art (SA)

SA1. Training laboratory locations will present some problems in tying student stations to a remote computer facility. Present technology permits line lengths of up to 2000 feet to be driven at reasonable cost. Some facilities are a half-mile from the computer site. R&D efforts should be devoted to finding a technology capable of driving lines up to one mile at reasonable cost.

SA2. Present computational speeds would cause delays of up to 4 seconds in responding to operation actions. This may affect student acceptance of the device, but more so, may impair the learning of certain operational procedures where a sequence of actions must be learned and where more rapid feedback may be essential. An assessment (study) of the approximate amount of training taking place on actual equipment, which requires faster response that is now possible, should be made. Additional study should also be directed at determining student attitude effects, especially as they might relate to decreased learning effectiveness.

SA3. Availability of student trainers will be the key to achieving desired objectives. Present computer reliability would appear to indicate an availability of between 90% and 95%. It must be determined if sufficient training contingency plans can be adopted to cope with this level of reliability.

SA4. The proposed trainer is general purpose and its uniqueness to the training situation will primarily result from

| RISK DEGREE / RISK ITEM | UNACCEPTABLY HIGH RISK OR OF TRIVIAL IMPORTANCE | MODERATE RISK OR OF MODERATE IMPORTANCE | NO RISK OR OF SUBSTANTIAL IMPORTANCE | SUPPORTIVE OR OF HIGH OR CRUCIAL IMPORTANCE | COMMENTS, NATURE OF RISK, ETC. | NUMBER OF RISK REDUCTION PROJECTS REQ.'D AND IDENTIFIED | ESTIMATED PROJECT COSTS |
|---|---|---|---|---|---|---|---|
| IMPORTANCE TO PROJECTED NAVY MISSION | | XX | | | | | |
| ORGANIZATIONAL COMPATIBILITY | | | XX | | | 0 | 0 |
| GOALS/POLICY COMPATIBILITY | | | | XX | | 0 | 0 |
| STATE-OF-THE-ART | | XX | | | HARDWARE LINKAGES & REL. TEMP. RESP. SIMULATION PROG. LEAD TIME | 4 | 11,000K |
| R&D FUNDING REQUIREMENTS | | XX | | | NEAR MAXIMUM FOR SINGLE PROJECT | 0 | 0 |
| TECHNICAL SUPPORT REQUIREMENT | | XX | | | SOME DIFFICULTY OBTAINING R&D IMPLEMENTATION TALENT | 0 | 0 |
| ATTITUDINAL ACCEPTANCE | | XX | | | TEMPORARY RESISTANCE BY INSTRUCTIONAL COMMUNITY | 1 | 55K |
| OVERALL PROFILE AND TOTAL PROJECTS AND DOLLARS | | XX | | | | 5 | 11,100K |

FIGURE V-1. SUMMARIZED PRELIMINARY FEASIBILITY PROFILE

EXHIBIT: ANALYTIC FEASIBILITY ASSESSMENT (Continued)...

programming the interrelationships between operator controls and feedback signals (lights, meters, etc.). Programming time was assessed for the experimental application, but no specific techniques (e.g., high level language, subroutine libraries, etc.) were analyzed for speeding the preparation of programs. A major study should be undertaken to investigate possible techniques for improving programming efficiency.

Attitudinal Acceptance (AA)

AA1. Acceptance of the instructional community will, to a great extent, be a function of successfully overcoming the risk items stated above. Excessive system downtime or slow response time could seriously impact student acceptance. Appropriate orienting presentations should be prepared to help overcome resistance of administrators and students.

SUCCESS PROBABILITIES (04.02)

Implementation Risks 75% (65% to 85%)

SA1 - Hardware line linkages.

SA3 - Hardware/software reliability.

SA4 - Programming time.

User Acceptance Risks 50% (40% to 60%)

SA2 - Response delays.

SA3 - Hardware/software reliability.

AA1 - Improper user orientation.

IMPLEMENTATION PROJECTS (04.03)

Project Name

User Orientation for 3-D Trainer (AA1)

Abstract

Implementation of the 3-D Procedural Trainer throughout the training command will be accompanied by a great deal of resistance, especially at the command levels. One solution to this problem is to ensure that an adequate understanding of the device exists with officers and staff who will be responsible to manage the implementation and operation of these devices within their command. This will be

EXHIBIT: ANALYTIC FEASIBILITY ASSESSMENT (Continued)...

accomplished by developing a 15-minute color movie on the device, its features, and its application, for presentation to command level officers and staff personnel prior to the planning stage for one of these devices. Three persons will require a total of 12 man-months to develop the movie at an estimated cost of $54,215. Development will be scheduled to begin May 1976 and complete April 1977.

Objectives

Develop 15-minute color movie on 3-D Procedural Trainer.

Improve acceptance of users at command level.

Project Plan Milestones

| | |
|---|---|
| Prepare final implementation plan. | Jan 1976 |
| Obtain funding approval. | Mar 1976 |
| Recruit personnel. | Apr 1976 |
| Begin design-consultation trips. | May 1976 |
| Complete design. | Oct 1976 |
| Begin photography. | Nov 1976 |
| Complete photography. | Feb 1977 |
| Obtain prints. | Apr 1977 |
| Distribute prints for use. | May 1977 |

Preliminary Cost Estimate

(See Figure V-2.)

NOTE: The project description will be as detailed as required for documenting the project need.

REEVALUATE SUCCESS PROBABILITIES (04.04)

With successful accomplishment of the risk reduction projects, it is anticipated that success probabilities will be:

Implementation 85% (80% to 90%).

User Acceptance 90% (85% to 95%).

Project success is estimated at 95% (90% to 100%). If the project package fails, probabilities estimated in 04.02 will prevail.

PRELIMINARY
COST ESTIMATE

NEW [XXX] REVISED [ ]

| PROJECT | PROJECT NAME | PROJECT NO. | DATE |
|---|---|---|---|
| | USER ORIENTATION FOR 3-D TRAINER | 63941-AA-1 | 30 JULY 1975 |

**PERSONNEL**

| JOB | MAN MONTHS | COST/MAN MONTH | JOB COST | |
|---|---|---|---|---|
| MOVIE DESIGN LAYOUT (GS-12) | 6 | 1855.00 | 11130.00 | |
| PHOTOGRAPHY (PH6) | 4 | 1630.00 | 6520.00 | |
| ADMINISTRATIVE | 2 | 970.00 | 1940.00 | |
| | | | | $ 19590.00 |

**EQUIPMENT**

| DESCRIPTION | QUANTITY | UNIT COST | COST | |
|---|---|---|---|---|
| PROTOTYPE DEVICE FOR USE IN | 1 | 12400.00 | 12400.00 | |
| DESIGN OF SEQUENCES AND | | | | |
| FILMING | | | | |
| | | | | $ 12400.00 |

**SPACE**

| REASON | SQUARE FEET | COST/SQ. FT. | COST | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | $ |

**TRAVEL (NON-STUDENT)**

| FROM - TO - REASON | NO. OF TRIPS | COST/TRIP | COST | |
|---|---|---|---|---|
| MULTI-LOCATION TRAVEL FOR | 20 | 280.00 | 5600.00 | |
| CONSULTATION AND FILMING | | | | |
| | | | | |
| | | | | $ 5600.00 |

**STUDENTS**

| NO. OF STUDENTS - REASON | NO. OF DAYS | COST/STUDENT DAY | COST | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | $ |

**OTHER**

| DESCRIPTION | MAN MONTHS/QTY. | UNIT COST | COST | |
|---|---|---|---|---|
| PROCESSING AND REPRODUCTION | 1 | 5625.00 | 5625.00 | |
| OF 100 COPIES | 100 | 110.00 | 11000.00 | |
| | | | | |
| | | | | $ 16625.00 |

| | |
|---|---|
| TOTAL PROJECT COSTS | $ 54215.00 |

FIGURE V-2. RISK REDUCTION PROJECT COST ESTIMATE

EXHIBIT: ANALYTIC FEASIBILITY ASSESSMENT (Continued)...

PRELIMINARY RANGE-OF-EFFECT (04.05)

Preliminary Range of Courses

Based upon the experimental results in course XXXX, a preliminary review of similar type courses shows the following potential for application of the 3-D Procedural Trainer.

| Course | Course Length | Average Annual AOB |
|---|---|---|
| XXXX | 15 days | 6500 |
| YYY | 9 days | 1300 |
| (etc.) | | |

Major Cost Categories (Projected Differences)

| | |
|---|---|
| Student Salaries | +$ 480K (Savings) |
| Student Travel | +$ 360K (Savings) |
| Instructor Salary | +$ 4,375K (Savings) |
| Equipment | -$ 537K (Cost) |
| On-Job-Training | +$23,364K (Savings) |
| Net Savings | $28,042K |

NOTE: The above savings assume no risk reduction expenditures and that implementation is successful and there is user acceptance, so that the full eight years of savings are realized. This cost will be assigned to Decision Tree Outcome A. (See Figure V-3.)

Outcome B (Assumptions)

Two-year cycle for measuring user acceptance.

Existing plan will be implemented for final six years of planning period.

- Original equipment will be purchased.
- 3-D Trainers will be scrapped (no salvage value).

Anticipated Cost - $3,800K.

EXHIBIT: ANALYTIC FEASIBILITY ASSESSMENT (Continued)...

NOTE: Similar analyses would be performed for each outcome.

The savings and costs, as well as the estimated success probabilities, are placed on the decision tree diagram and folded back. The preliminary decision indicated would be to accept the proposal, assuming that the risk reduction projects involving continued study would be undertaken, and their costs considered in subsequent analyses. The decision tree is shown in Figure V-3.

TASK 5 - DETERMINE RANGE-OF-EFFECT. Feasibility has been examined over a limited range of potential application. The total range-of-effect for the 3-D Procedural Trainer is determined through the analytic steps of Task 5.

EXHIBIT: RANGE-OF-EFFECT ANALYSIS

CHOOSE MAJOR ROUTE FOR DETERMINING RANGE-OF-EFFECT (05.01)

Potential Displaceable Cost in Instructional Vehicles (Route 05.02)

Instructors.

Live equipment used for training purposes.

Procedure trainers.

Potential Outcome of Training in a Skill (Route 05.09)

Search strategy:

Determine relevant courses.

Derive identification of instructors and instructional devices.

DEVELOP BACKGROUND FOR TASK CONTENT TRAINING ANALYSIS (05.09)

IDENTIFY THE LEARNING OBJECTIVE (05.10)

See innovation description:

Practical skill training in routinized procedures applied externally to electronic equipment and maintenance.

MAKE PRELIMINARY EVALUATION OF BENEFIT IMPORTANCE (05.11)

Target training objective is extremely important.

Magnitudes of potential improvement are very substantial.

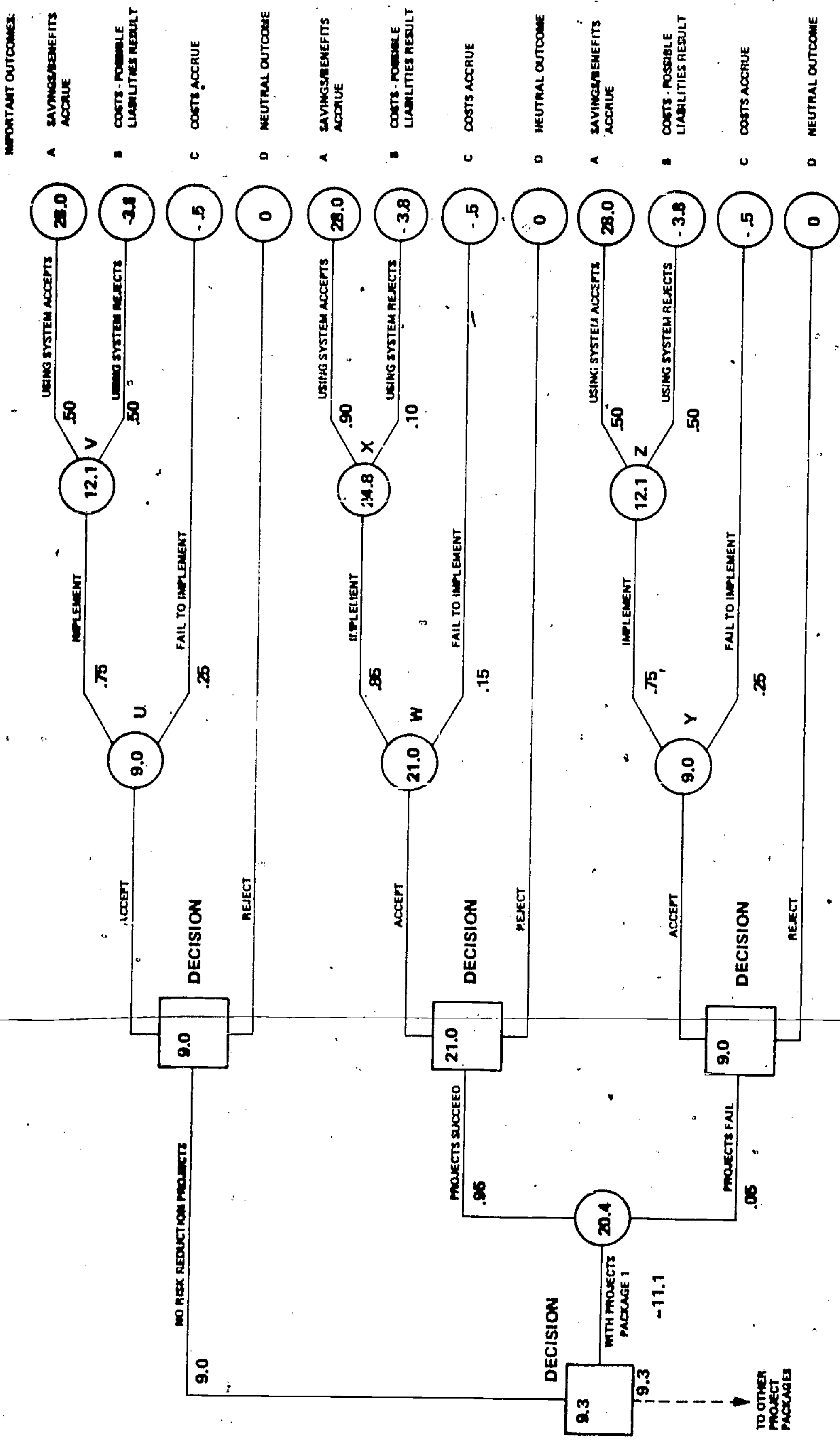


FIGURE V-3. DECISION TREE FOR ASSESSMENT OF TRAINING INNOVATION (3-D PROCEDURAL TRAINER ANALYZED OVER PRELIMINARY RANGE-OF-EFFECT)

EXHIBIT: RANGE-OF-EFFECT ANALYSIS (Continued)...

DETERMINE IF BENEFIT APPLIES TO SKILL OR KNOWLEDGE TRAINING (05.12)

This is practical skill training, so follow Route 05.13.

Type of skill: Electronic equipment, procedural.

SELECT TASK STRUCTURE ELEMENT OR TASK "FUNCTION" (05.13)

Include skill practice in procedural context of:

Goal-image

Scan-detect

Identify

Interpret

Manipulation of equipment controls.

Do not search on these elements; do search on procedures, operating and maintenance, on electronic equipment.

IDENTIFY RELEVANT JOBS/TASKS: CONTINUED SEARCH SPECIFICATIONS (05.14)

Job Class: Electronic equipment operations; maintenance.

Task Characteristics:

Equipment: Electronic, having manual procedures associated with it.

Tools: Test equipment for electronic equipment servicing and checkout.

Reference Information: Procedures, manuals of instruction.

Examples of Task Titles:

Start-up procedure

Checkout procedure

Operating procedure

Alignment procedure, adjustment procedure

Diagnostic or troubleshooting procedure, external.

EXHIBIT: RANGE-OF-EFFECT ANALYSIS (Continued)...

SELECT RELEVANT STAGE OF LEARNING: CONTINUED SEARCH SPECIFICATIONS (05.15)

Not orientation or familiarization or theory of operation.*

Not nomenclature and identifications.*

Mediated procedures.

Unusual task conditions (partial).

Automated performance (partial).

IDENTIFY COURSE RELEVANT TO INNOVATION (05.16)

AN/SRN-12 Omega Receiving Set Maintenance course.

Total training time: 2 weeks.

Practical training (lab work): 6 days.

IDENTIFY RELEVANT TRAINING UNIT(S) WITHIN COURSE (05.17)

AN/SRN-12 Omega Receiving Set Maintenance course.

Relevant objectives in training:

Receiving set operation procedures.

Lane count determination procedures.

Preventive maintenance procedures using test equipment.

Not relevant: troubleshooting inside covers of equipment.

Estimated training time for all practical work on equipment: 6 days.

Estimated training time for relevant practical work: 3 days.

ASSESS THE BENEFIT PATTERN (05.18)

AN/SRN-12 Omega Receiving Set Maintenance course.

Relevant training target time: 3 days.

Relevant equipment: AN/SRN-12 Omega Receiving Set

*Not cost-effective on this device.

EXHIBIT: RANGE-OF-EFFECT ANALYSIS (Continued)...

Training Benefits

a. Estimated reduction in attrition rate: 80% reduction in rate (from 7% to 1%). The dollars saved by the attrition reduction have been assigned an importance rating of 10 due to present funding pressure.

   Confidence range -- best case, 85% reduction -- worst case, 50% reduction.

b. Liability to reduction in attrition rate: Inappropriate emphasis on evaluating student on "theory of operation" content in course. Would not affect attrition rate on targeted objective, but on the course itself.

   NOTE: If the reduction in attrition had value other than in the dollars saved, then it would be assigned an importance level as other nonquantifiable variables are. This might be the case where the particular manpower pool is in short supply.

c. Reduction in aptitude requirements: Potential, but not quantified.

d. Increased flexibility in training program development.

   Importance (rating of 2).

<u>ON-THE-JOB BENEFITS</u> (05.25)

a. Estimate of normal OJT before acceptable performance: 4 weeks.

   Estimate of OJT with innovation: 1 week.

   The dollars saved by the OJT reduction, as with attrition dollars, have been assigned an importance rating of 10.

   Confidence range -- best case, .5 week with innovation -- worst case, 1.5 weeks.

   NOTE: As with attrition, if increased availability of time had a value independent of dollars, it would be treated as a separate variable.

b. Reduction in units of standby equipment? Estimated 30% reduction.

   Confidence range -- best case, 50% reduction -- worst case, 10% reduction.

   Importance (rating of 1).

TASK 6 - PERFORM COST-BENEFITS ANALYSIS. The analysis performed in Task 4 will be refined to use more precise cost data, to assess these costs over a broader and more exacting range-of-effect, and to include in the analysis some of the less tangible benefits previously identified.

EXHIBIT: COST-BENEFITS ANALYSIS

ASSEMBLE DATA (06.01)

Obtain Items From Prior Tasks

Decision tree from completion of Task 4.

List of courses and jobs from Task 5 to which innovation is expected to apply.

Benefits pattern to be applied to courses and jobs, including magnitude change (amount of training; i.e., course length and number of graduates to which the innovation is considered applicable, etc.) and confidence limits.

Project Descriptive Data and Project File from Tasks 1, 4, and 5.

Derive Expected Values of Variables

The expected values for the cost models and decision tree input variables should be calculated and tabulated in a form as follows:

| Relevant Variable | Importance | Most Likely | Pessimistic | Optimistic | Expected | Standard Deviation |
|---|---|---|---|---|---|---|
| Attrition and OJT Time Dollars | 10 | .014 | .035 | .01 | .017 | .004 |
| | | 1.0 wk | 1.5 wk | .5 wk | 1 wk | .167 |
| Trng. Prog. Dev. | 2 | Increase Flexib. | - | - | - | - |
| Standby Equip. | 1 | Reduced 30% | - | - | - | - |
| User Acceptance (w/o projects) | | .50 | .40 | .60 | .50 | .033 |
| User Acceptance (with projects) | | .90 | .85 | .95 | .90 | .017 |
| Implementation Success (w/o projects) | | .75 | .65 | .85 | .75 | .033 |
| Implementation Success (with projects) | | .85 | .70 | .80 | .85 | .017 |
| Project Success | | .95 | .90 | 1.00 | .95 | .017 |

EXHIBIT: COST-BENEFITS ANALYSIS (Continued)...

PREPARE COST MODEL CASES AND INPUT DATA (06.02)

Develop Outcome Scenarios

A - Attrition will be reduced from .07 to .01.

Instr./Stud. Position Ratio will go from .25 to .05.

Equipment Life will go from 5 years to 10 years.

Equipment Unit Cost will go from $4375 to $5625.

OJT time would be reduced from 4 weeks to 1 week.

All other cost data from the formerly planned program to the proposed program will remain the same.

B - Attrition could fail to reach .01 and will stay around .04.

Two years will be required to determine acceptance.

Recovery will be accomplished by reinstituting the baseline or existing plan on which the improvements in Outcome A were based.

Trainers will have no salvage value at end of two-year period.

No OJT time will be saved.

C - Approximately $700K in development costs will be incurred.

Approximately $300K will be required to expedite equipment procurement to revert to existing program plan.

No OJT time will be saved.

D - Neutral Outcome.

NOTE: These outcome scenarios are highly simplified and in actual practice would require considerably more analysis.

Prepare Cost Model Input Data Sheets

- A run of the existing program plan is made by preparing input data as shown in Figure V-4 and V-5 for the Training Cost Model.
- A run of the proposed program is made by preparing input data sheets as shown in Figure V-6 and V-7 for the Training Cost Model.

```
                                COURSE COST ANALYSIS
INPUT:
  COURSE NUMBER    - CTRL                              DISCOUNT RATE  - 10.0 PERCENT
  PLANNING PERIOD -  8                                 INFLATION RATE -  6.0 PERCENT

INPUT TECHNICAL FACTORS:
  PLNG YR    1      2      3      4      5      6      7      8      9     10
  GRADS-  10000  12000  14000  14000  13000   9000   8000   5000      0      0

  PLNG YR   11     12     13     14     15     16     17     18     19     20
  GRADS-      0      0      0      0      0      0      0      0      0      0

  ATTRITION RATE (PCT)       -  0.07    TIME STUD POS DOWN (PCT) -     .01
  TRAINING LENGTH (WKS)      -  2.0     PCT EXTRA STUD POSITIONS -     .0
  RECYCLE RATE (PCT)         -   .10    EQUIP/STUD POS RATIO     -    0.25
  AVE. RECYCLE TIME (WKS)-      1.0     LIFE OF EQUIPMENT        -    5
  WEEKS SCHOOL OPERATES      - 50.0     COURSE DEV HRS/COURSE HR -   25.0
  INSTR/STUD POS RATIO       -  0.25    PCT COURSE REQUIRING DEV.-    1.00
  ADMIN/STUD POS RATIO       -  .010    PCT INSTR MAT. MAINTAINED-     .20
  SQ FEET/STUDENT POS.       -  9.00    PCT INSTR MAT. RMNG VALUE-     .40
  SQ FEET/INSTR. POS.        -  5.00    SUPPLIES/STUDENT POSITION-    1.0
  SQ FEET/ADMIN POS.         -  3.00    SUPPLIES/STUDENT         -    1.0
  PURCHASE POLICY            -  2       MISC/STUDENT POSITION    -    1.0
  DEPRECIATION POLICY        -  2       MISC/STUDENT             -    1.0
```

FIGURE V-4. TRAINING COST MODEL TECHNICAL INPUT DATA - EXISTING PROGRAM

```
                              COURSE COST ANALYSIS
INPUT:
  COURSE NUMBER    - CTRL                          DISCOUNT RATE   - 10.0 PERCENT
  PLANNING PERIOD -  8                             INFLATION RATE  -  6.0 PERCENT

INPUT COST FACTORS:
  PLNG YR   1      2      3      4      5      6      7      8      9     10
  O&MN-   200.   200.   200.   200.   200.   200.   200.   200.     0.     0.

  PLNG YR  11     12     13     14     15     16     17     18     19     20
  O&MN-     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.

  STUDENT SALARY (ANNUAL)- 11141.00     COST/HR OF INSTR MAT DEV    -   6.00
  STUD TRAVEL TO/FROM    -   228.00     SUPPLIES COST               -  10.00
  STUD TRAVEL IN COURSE  -     0.0      MISCELLANEOUS COST          -   0.0
  INSTR SALARY (ANNUAL)  - 16240.00     PCT MAX EQUIP PURCHASED     -   0.90
  ADMIN SALARY (ANNUAL)  - 13500.00     FACILITY COST/SQ FOOT       -  25.00
  EQUIPMENT UNIT COST    -  4375.00
```

FIGURE V-5. TRAINING COST MODEL COST INPUT DATA - EXISTING PROGRAM

```
                        COURSE COST ANALYSIS
INPUT:
 COURSE NUMBER   - EXPM                        DISCOUNT RATE   - 10.0 PERCENT
 PLANNING PERIOD -  8                          INFLATION RATE  -  6.0 PERCENT

INPUT TECHNICAL FACTORS:
 PLNG YR    1       2       3       4       5       6       7       8       9      10
 GRADS-  10000   12000   14000   14000   13000    9000    8000    5000       0       0

 PLNG YR   11      12      13      14      15      16      17      18      19      20
 GRADS-      0       0       0       0       0       0       0       0       0       0

 ATTRITION RATE (PCT)      -   0.014    TIME STUD POS DOWN (PCT) -     .01
 TRAINING LENGTH (WKS)     -   2.0      PCT EXTRA STUD POSITIONS -     .05
 RECYCLE RATE (PCT)        -    .10     EQUIP/STUD POS RATIO     -    0.50
 AVE. RECYCLE TIME (WKS)-      1.0      LIFE OF EQUIPMENT        -   10
 WEEKS SCHOOL OPERATES     -  50.0      COURSE DEV HRS/COURSE HR -   25.0
 INSTR/STUD POS RATIO      -    0.05    PCT COURSE REQUIRING DEV.-    1.00
 ADMIN/STUD POS RATIO      -    .010    PCT INSTR MAT. MAINTAINED-     .20
 SQ FEET/STUDENT POS.      -   9.00     PCT INSTR MAT. RMNG VALUE-     .40
 SQ FEET/INSTR. POS.       -   5.00     SUPPLIES/STUDENT POSITION-    1.0
 SQ FEET/ADMIN POS.        -   3.00     SUPPLIES/STUDENT         -    1.0
 PURCHASE POLICY           -   2        MISC/STUDENT POSITION    -    1.0
 DEPRECIATION POLICY       -   1        MISC/STUDENT             -    1.0
```

FIGURE V-6. TRAINING COST MODEL TECHNICAL INPUT DATA - PROPOSED PROGRAM

```
                         COURSE COST ANALYSIS
INPUT:
  COURSE NUMBER    - EXPM                           DISCOUNT RATE   - 10.0 PERCENT
  PLANNING PERIOD -  8                              INFLATION RATE -  6.0 PERCENT

INPUT COST FACTORS:
  PLNG YR    1      2      3      4      5      6      7      8      9     10
  O&MN-    200.   200.   200.   200.   200.   200.   200.   200.     0.     0.

  PLNG YR   11     12     13     14     15     16     17     18     19     20
  O&MN-      0.     0.     0.     0.     0.     0.     0.     0.     0.     0.

  STUDENT SALARY (ANNUAL)- 11141.00     COST/HR OF INSTR MAT DEV    -   6.00
  STUD TRAVEL TO/FROM    -   228.00     SUPPLIES COST               -  10.00
  STUD TRAVEL IN COURSE  -     0.0      MISCELLANEOUS COST          -   0.0
  INSTR SALARY (ANNUAL)  - 16240.00     PCT MAX EQUIP PURCHASED     -   0.90
  ADMIN SALARY (ANNUAL)  - 13500.00     FACILITY COST/SQ FOOT       -  25.00
  EQUIPMENT UNIT COST    -  5625.00
```

FIGURE V-7. TRAINING COST MODEL COST INPUT DATA - PROPOSED PROGRAM

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EXHIBIT: COST-BENEFITS ANALYSIS (Continued)...

- Input to the Job Cost Model will be as follows:

  3 weeks OJT time saved.

  Annual Salary Cost is $11,441.

  Annual numbers of graduates used in the input to the Training Cost Model will be the basis for job incumbents.

- To derive costs for Outcome B, input data are prepared for a two-year run with data for the proposed program, and a six-year run with data for the existing program plan. Examples of input data sheets to accomplish this are shown in Figures V-8 through V-11.

  NOTE: The financial analysis of Task 7 will use costs and savings separated by R&D, Investment, or Recurring. To save possible reclassification later, this categorization of costs should be considered at this time.

Ensure True "Opportunity Costs" Have Been Used

All costs used are true "opportunity costs."

The basis for savings in job incumbent's time was straight salary, exclusive of retirement benefits, etc.

Input Factors

Time saved per incumbent: 3 weeks/year.

Number of incumbent equals annual graduates.

Salary cost: $11,141.

RUN APPROPRIATE COST MODELS (06.03)

Training Cost Model Outputs

The Training Cost Model cost output data for the existing and proposed programs are shown in Figure V-12 and V-13. The Discounted Constant Dollar value for each program is shown below, and the incremental value calculated:

OUTCOME A

| | | |
|---|---|---|
| Existing | $ 57,361,408 | Cost |
| Proposed | 47,778,656 | Cost |
| Outcome A Incr. Training | $ 9,582,752 | Savings |

337

```
                         COURSE COST ANALYSIS
INPUT:
  COURSE NUMBER     - RCVA                     DISCOUNT RATE  - 10.0 PERCENT
  PLANNING PERIOD -  2                         INFLATION RATE -  6.0 PERCENT

INPUT TECHNICAL FACTORS:
  PLNG YR    1      2      3      4      5      6      7      8      9     10
  GRADS- 10000  12000      0      0      0      0      0      0      0      0

  PLNG YR   11     12     13     14     15     16     17     18     19     20
  GRADS-     0      0      0      0      0      0      0      0      0      0

  ATTRITION RATE (PCT)      -   0.04    TIME STUD POS DOWN (PCT) -    .01
  TRAINING LENGTH (WKS)     -   2.0     PCT EXTRA STUD POSITIONS -    .05
  RECYCLE RATE (PCT)        -    .10    EQUIP/STUD POS RATIO     -   0.50
  AVE. RECYCLE TIME (WKS)-      1.0     LIFE OF EQUIPMENT        -  10
  WEEKS SCHOOL OPERATES     -  50.0     COURSE DEV HRS/COURSE HR -  25.0
  INSTR/STUD POS RATIO      -   0.05    PCT COURSE REQUIRING DEV.-   1.00
  ADMIN/STUD POS RATIO      -   .010    PCT INSTR MAT. MAINTAINED-    .20
  SQ FEET/STUDENT POS.      -   9.00    PCT INSTR MAT. RMNG VALUE-    .40
  SQ FEET/INSTR. POS.       -   5.00    SUPPLIES/STUDENT POSITION-   1.0
  SQ FEET/ADMIN POS.        -   3.00    SUPPLIES/STUDENT         -   1.0
  PURCHASE POLICY           -   2       MISC/STUDENT POSITION    -   1.0
  DEPRECIATION POLICY       -   3       MISC/STUDENT             -   1.0
```

FIGURE V-8. TRAINING COST MODEL TECHNICAL INPUT DATA - TWO YEARS WITH PROPOSED PROGRAM

```
                         COURSE COST ANALYSIS
INPUT:
  COURSE NUMBER    - RCVA                          DISCOUNT RATE   - 10.0 PERCENT
  PLANNING PERIOD -  2                             INFLATION RATE -   6.0 PERCENT

INPUT COST FACTORS:
  PLNG YR    1      2      3      4      5      6      7      8      9     10
  O&MN-    200.   200.    0.     0.     0.     0.     0.     0.     0.     0.

  PLNG YR   11     12     13     14     15     16     17     18     19     20
  O&MN-      0.     0.    0.     0.     0.     0.     0.     0.     0.     0.

  STUDENT SALARY (ANNUAL)- 11141.00     COST/HR OF INSTR MAT DEV    -   6.00
  STUD TRAVEL TO/FROM    -   228.00     SUPPLIES COST               -  10.00
  STUD TRAVEL IN COURSE  -     0.0      MISCELLANEOUS COST          -   0.0
  INSTR SALARY (ANNUAL)  - 16240.00     PCT MAX EQUIP PURCHASED     -   0.90
  ADMIN SALARY (ANNUAL)  - 13500.00     FACILITY COST/SQ FOOT       -  25.00
  EQUIPMENT UNIT COST    -  5625.00
```

FIGURE V-9. TRAINING COST MODEL COST INPUT DATA - TWO YEARS WITH PROPOSED PROGRAM

```
                          COURSE COST ANALYSIS
INPUT:
  COURSE NUMBER    - RCVB
  PLANNING PERIOD  -  8                     DISCOUNT RATE  - 10.0 PERCENT
                                             INFLATION RATE -  6.0 PERCENT

INPUT TECHNICAL FACTORS:
  PLNG YR   1      2      3      4      5      6      7      8      9     10
  GRADS-       0      0  14000  14000  13000   9000   8000   5000      0      0

  PLNG YR  11     12     13     14     15     16     17     18     19     20
  GRADS-       0      0      0      0      0      0      0      0      0      0

  ATTRITION RATE (PCT)     -   .07     TIME STUD POS DOWN (PCT) -   .01
  TRAINING LENGTH (WKS)    -  2.0      PCT EXTRA STUD POSITIONS -   .0
  RECYCLE RATE (PCT)       -   .10     EQUIP/STUD POS RATIO     -  0.25
  AVE. RECYCLE TIME (WKS)- 1.0         LIFE OF EQUIPMENT        -  5
  WEEKS SCHOOL OPERATES    - 50.0      COURSE DEV HRS/COURSE HR - 25.0
  INSTR/STUD POS RATIO     -   .250    PCT COURSE REQUIRING DEV.-  1.00
  ADMIN/STUD POS RATIO     -   .010    PCT INSTR MAT. MAINTAINED-   .20
  SQ FEET/STUDENT POS.     -  9.00     PCT INSTR MAT. RMNG VALUE-   .40
  SQ FEET/INSTR. POS.      -  5.00     SUPPLIES/STUDENT POSITION-  1.0
  SQ FEET/ADMIN POS.       -  3.00     SUPPLIES/STUDENT         -  1.0
  PURCHASE POLICY          -  2        MISC/STUDENT POSITION    -  1.0
  DEPRECIATION POLICY      -  2        MISC/STUDENT             -  1.0
```

FIGURE V-10. TRAINING COST MODEL TECHNICAL INPUT DATA - SIX YEARS WITH EXISTING PROGRAM

```
                         COURSE COST ANALYSIS
INPUT:
  COURSE NUMBER    - RCVB                       DISCOUNT RATE   - 10.0 PERCENT
  PLANNING PERIOD -  8                          INFLATION RATE  -  6.0 PERCENT

INPUT COST FACTORS:
  PLNG YR    1      2      3      4      5      6      7      8      9     10
  O&MN-    200.   200.   200.   200.   200.   200.   200.   200.     0.     0.

  PLNG YR   11     12     13     14     15     16     17     18     19     20
  O&MN-      0.     0.     0.     0.     0.     0.     0.     0.     0.     0.

  STUDENT SALARY (ANNUAL)- 11141.00     COST/HR OF INSTR MAT DEV    -    6.00
  STUD TRAVEL TO/FROM    -   228.00     SUPPLIES COST               -   10.00
  STUD TRAVEL IN COURSE  -     0.0      MISCELLANEOUS COST          -    0.0
  INSTR SALARY (ANNUAL)  - 16240.00     PCT MAX EQUIP PURCHASED     -     .90
  ADMIN SALARY (ANNUAL)  - 13500.00     FACILITY COST/SQ FOOT       -   25.00
  EQUIPMENT UNIT COST    -  4375.00
```

FIGURE V-11. TRAINING COST MODEL COST INPUT DATA - SIX YEARS WITH EXISTING PROGRAM

COURSE COST ANALYSIS

INPUT:
COURSE NUMBER - CTRL
PLANNING PERIOD - 8

DISCOUNT RATE - 10.0 PERCENT
INFLATION RATE - 6.0 PERCENT

| OUTPUT COST RESULTS: | NON-DISC CONSTANT $ | DISCOUNTED CONSTANT $ | NON-DISC CURRENT $ | DISCOUNTED CURRENT $ |
|---|---|---|---|---|
| STUDENT SALARIES | 39751344. | 28814160. | 49306016. | 34934912. |
| STUDENT TRAVEL | 20838672. | 15105119. | 25847472. | 18313776. |
| INSTRUCTOR SALARY | 15217819. | 11030770. | 18875568. | 13373961. |
| ADMINISTRATIVE SALARY | 506011. | 366786. | 627636. | 444700. |
| EQUIPMENT | 566900. | 645611. | 437360. | 611993. |
| FACILITIES | 963295. | 698253. | 1194832. | 846578. |
| INSTRUCTIONAL MATERIALS | 14400. | 11093. | 17018. | 12989. |
| SUPPLIES | 951460. | 689675. | 1180153. | 836177. |
| MISCELLANEOUS | 0. | 0. | 0. | 0. |
| TOTAL OPERATIONAL | 78809840. | 57361408. | 97486016. | 69375040. |
| COST PER GRADUATE | 927.17 | 674.84 | 1146.89 | 816.18 |
| COST PER STUDENT INPUT | 862.27 | 627.60 | 1066.61 | 759.05 |
| COST PER STUDENT POSITION | 21049.64 | 15320.89 | 26037.93 | 18529.66 |

FIGURE V-12. TRAINING COST MODEL COST OUTPUT DATA - EXISTING PROGRAM

COURSE COST ANALYSIS

INPUT:
COURSE NUMBER - EXPM
PLANNING PERIOD - 8

DISCOUNT RATE - 10.0 PERCENT
INFLATION RATE - 6.0 PERCENT

| OUTPUT COST RESULTS: | NON-DISC CONSTANT $ | DISCOUNTED CONSTANT $ | NON-DISC CURRENT $ | DISCOUNTED CURRENT $ |
|---|---|---|---|---|
| STUDENT SALARIES | 38527984. | 27927344. | 47788608. | 33859776. |
| STUDENT TRAVEL | 19655152. | 14247222. | 24379456. | 17273648. |
| INSTRUCTOR SALARY | 3097385. | 2245167. | 3841873. | 2722092. |
| ADMINISTRATIVE SALARY | 514959. | 373273. | 638735. | 452565. |
| EQUIPMENT | 1726300. | 1680617. | 1722088. | 1714579. |
| FACILITIES | 884968. | 641477. | 1097678. | 777741. |
| INSTRUCTIONAL MATERIALS | 14400. | 11093. | 17018. | 12989. |
| SUPPLIES | 900214. | 652528. | 1116589. | 791140. |
| MISCELLANEOUS | 0. | 0. | 0. | 0. |
| TOTAL OPERATIONAL | 65321296. | 47778656. | 80601984. | 57604480. |
| COST PER GRADUATE | 768.49 | 562.10 | 948.26 | 677.70 |
| COST PER STUDENT INPUT | 757.73 | 554.23 | 934.98 | 668.21 |
| COST PER STUDENT POSITION | 17140.20 | 12537.04 | 21149.82 | 15115.32 |

FIGURE V-13. TRAINING COST MODEL COST OUTPUT DATA - PROPOSED PROGRAM

EXHIBIT: COST-BENEFITS ANALYSIS (Continued)...

The cost output data for Outcome B are shown in Figure V-14 and V-15 and are totaled below.

OUTCOME B

| | | |
|---|---|---|
| Proposed (2 years) | $ 16,614,874 | Cost |
| Existing (6 years) | 38,992,672 | Cost |
| Outcome B Total Training | $ 55,607,546 | Cost |

The incremental value calculated between the existing program and the proposed program, considering Outcome B, is:

| | | |
|---|---|---|
| Existing | $ 57,361,408 | Cost |
| Outcome B Total | 55,607,546 | Cost |
| Outcome B Incr. Training | $ 1,753,862 | Savings |

OUTCOME C

| | | |
|---|---|---|
| Dev. Costs | $ 700,000 | Cost |
| Expedite Costs | 300,000 | Cost |
| Outcome C Incr. Training | $ 1,000,000 | Cost |

Job Cost Model Outputs

Only the results are shown, since no Job Cost Model was available.

OUTCOME A

4904 man-years and $37,086,976 savings.

All other outcomes are zero.

DETERMINE BENEFIT-LIABILITY VALUES (06.04)

Use Variable Data Assembled in 06.01

| Variable | Importance |
|---|---|
| Standby parts and equipment reduced in Fleet | 1 |
| Flexibility in program development | 2 |

Rank Outcome for Each Variable

The outcomes are ranked as shown in the first three columns of Figure V-16 and V-17. In both cases, Outcome D (To Reject the Innovation) is considered neutral.

COURSE COST ANALYSIS

INPUT:
COURSE NUMBER - RCVA
PLANNING PERIOD - 2

DISCOUNT RATE - 10.0 PERCENT
INFLATION RATE - 6.0 PERCENT

| OUTPUT COST RESULTS: | NON-DISC CONSTANT $ | DISCOUNTED CONSTANT $ | NON-DISC CURRENT $ | DISCOUNTED CURRENT $ |
|---|---|---|---|---|
| STUDENT SALARIES | 10114376. | 9175896. | 10749610. | 9738751. |
| STUDENT TRAVEL | 5224998. | 4740187. | 5553154. | 5030953. |
| INSTRUCTOR SALARY | 813126. | 737678. | 864194. | 782928. |
| ADMINISTRATIVE SALARY | 135187. | 122644. | 143678. | 130167. |
| EQUIPMENT | 1482150. | 1410510. | 1528354. | 1454226. |
| FACILITIES | 232322. | 210765. | 246912. | 223694. |
| INSTRUCTIONAL MATERIALS | 0. | 208. | -148. | 86. |
| SUPPLIES | 239180. | 216988. | 254202. | 230298. |
| MISCELLANEOUS | 0. | 0. | 0. | 0. |
| TOTAL OPERATIONAL | 18241328. | 16614874. | 19339904. | 17591088. |
| COST PER GRADUATE | 829.15 | 755.22 | 879.09 | 799.59 |
| COST PER STUDENT INPUT | 795.99 | 725.01 | 843.92 | 767.61 |
| COST PER STUDENT POSITION | 18223.10 | 16598.27 | 19320.58 | 17573.51 |

FIGURE V-14. TRAINING COST MODEL COST OUTPUT DATA - TWO YEARS WITH PROPOSED PROGRAM

## COURSE COST ANALYSIS

INPUT:
COURSE NUMBER - RCVB
PLANNING PERIOD - 8

DISCOUNT RATE - 10.0 PERCENT
INFLATION RATE - 6.0 PERCENT

| OUTPUT COST RESULTS: | NON-DISC CONSTANT $ | DISCOUNTED CONSTANT $ | NON-DISC CURRENT $ | DISCOUNTED CURRENT $ |
|---|---|---|---|---|
| STUDENT SALARIES | 29462768. | 19480208. | 38371264. | 25028416. |
| STUDENT TRAVEL | 15445156. | 10212023. | 20115184. | 13120553. |
| INSTRUCTOR SALARY | 11279089. | 7457503. | 14689476. | 9581508. |
| ADMINISTRATIVE SALARY | 375043. | 247971. | 488443. | 318597. |
| EQUIPMENT | 566900. | 645611. | 437360. | 611993. |
| FACILITIES | 713972. | 472064. | 929851. | 606514. |
| INSTRUCTIONAL MATERIALS | 14400. | 11093. | 17018. | 12989. |
| SUPPLIES | 705200. | 466264. | 918427. | 599063. |
| MISCELLANEOUS | 0. | 0. | 0. | 0. |
| TOTAL OPERATIONAL | 58562496. | 38992672. | 75966960. | 49879584. |
| COST PER GRADUATE | 929.56 | 618.93 | 1205.82 | 791.74 |
| COST PER STUDENT INPUT | 864.49 | 575.61 | 1121.42 | 736.32 |
| COST PER STUDENT POSITION | 21103.60 | 14051.41 | 27375.48 | 17974.62 |

FIGURE V-15. TRAINING COST MODEL COST OUTPUT DATA - SIX YEARS WITH EXISTING PROGRAM

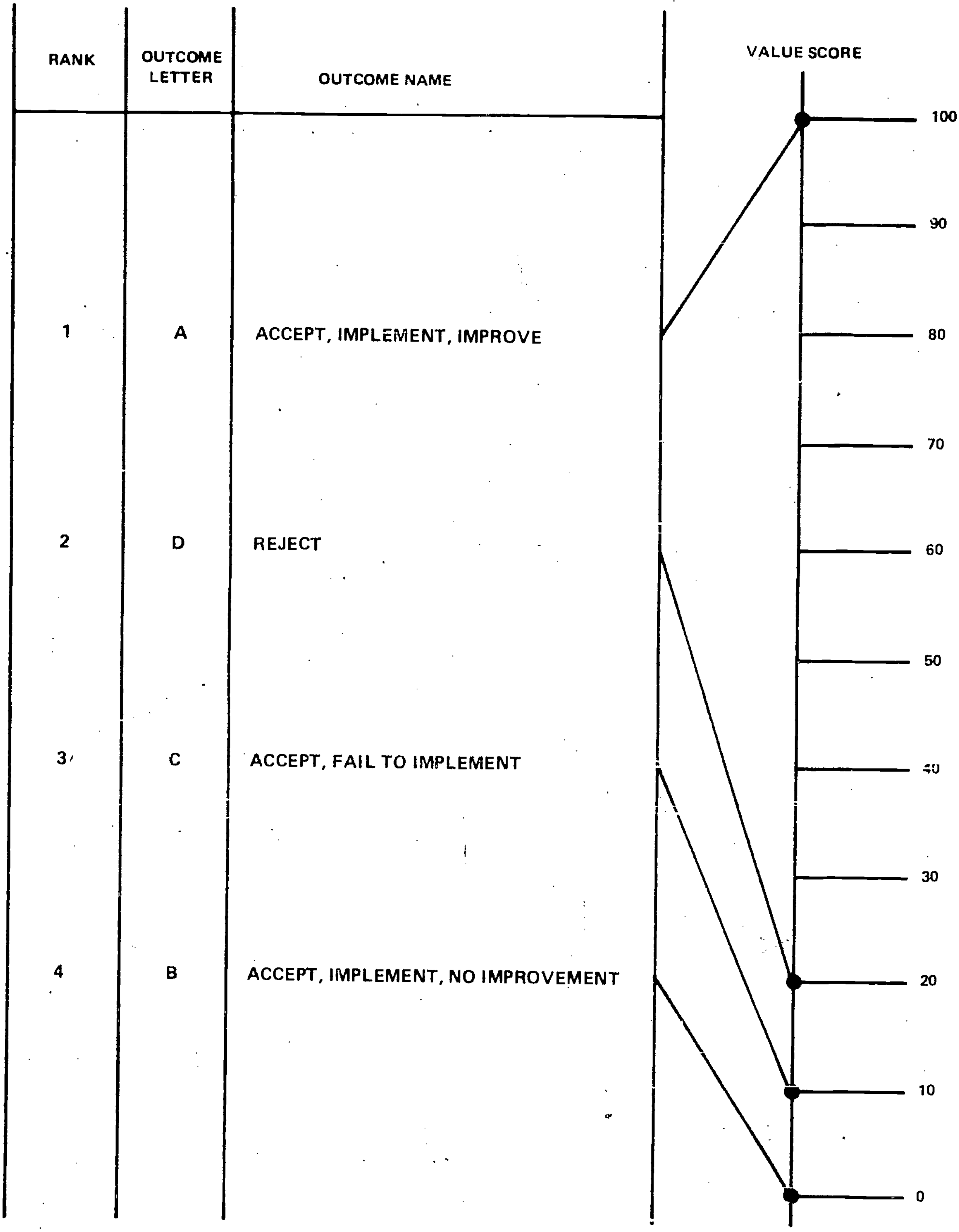



FIGURE V-16. BENEFIT RANKING AND EVALUATION: STANDBY PARTS AND EQUIPMENT REDUCED IN FLEET

| RANK | OUTCOME LETTER | OUTCOME NAME |
|---|---|---|
| 1 | A | ACCEPT, IMPLEMENT, IMPROVE |
| 2 | G | REJECT |
| 3 | B | ACCEPT, IMPLEMENT, NO IMPROVEMENT |
| 4 | C | ACCEPT, FAIL TO IMPLEMENT |

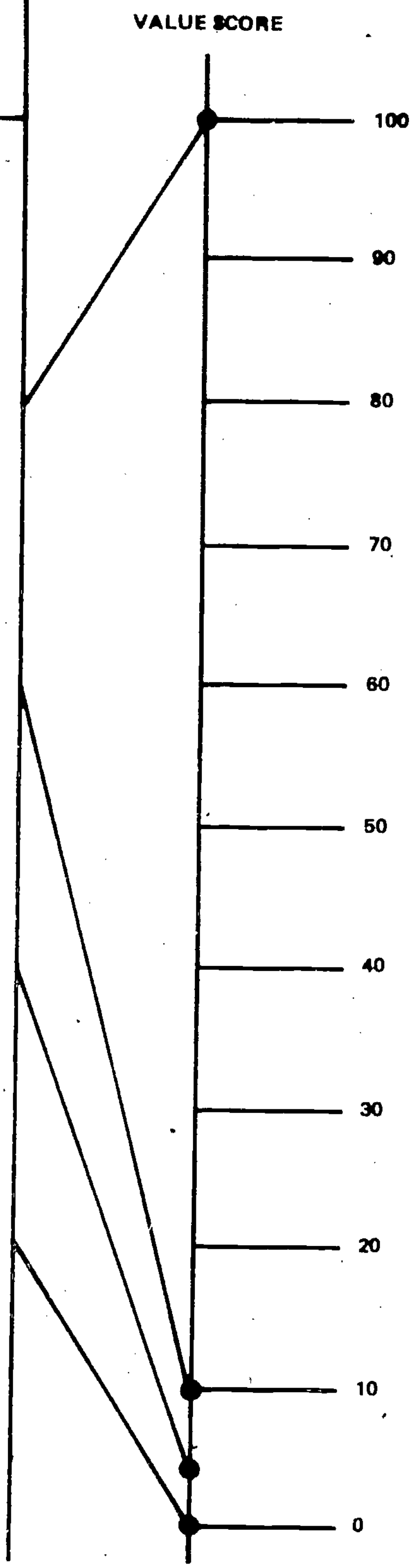



FIGURE V-17. BENEFIT RANKING AND EVALUATION: FLEXIBILITY IN TRAINING PROGRAM DEVELOPMENT

EXHIBIT: COST-BENEFITS ANALYSIS (Continued)...

Scale the Ranked Outcomes

The first and last ranked outcomes become 100 and 0, respectively, as shown in Figures V-16 and V-17.

Benefit: Standby parts and equipment reduced in Fleet

A = 100

B = 0

D is neutral

A is four times more favorable than B is unfavorable, therefore, the scale from A to D is four times the distance D to B.

D = 20

C is only half as unfavorable as B

C = 10

(See Figure V-16.)

Benefit: Flexibility in training program development

This follows the same logic as for the previous benefit analyzed. (See Figure V-17 for results.)

REFINE SUCCESS PROBABILITIES (06.05 - Use 04.02 and 04.04)

The reanalysis of the success probabilities shows no change from those estimated in Task 4 and assembled as input to Task 6 in 06.01.

User Acceptance (w/o projects) 50% (40% to 60%)

User Acceptance (with projects) 90% (85% ot 95%)

Implementation Success (w/o projects) 75% (65% to 85%)

Implementation Success (with projects) 85% (70% to 80%)

Project Success 95% (90% to 100%)

If projects fail, use user acceptance and implementation success w/o projects factors.

EXHIBIT: COST-BENEFITS ANALYSIS (Continued)...

DEVELOP DECISION TREE ASSESSMENT (06.06)

Data Requirements

Cost model incremental outputs from 06.03.

Benefits ranking and valuation data from 06.04.

Refined success probabilities from 06.05.

Develop Equivalent Dollars for Nonquantified Benefits

Standby equipment variable.

The importance ratio of 1:10 causes this benefit scale of 0-100 to be adjusted as shown in Figure V-18.

Flexibility in Training Program Development

(See results on Figure V-18.)

NOTE: The sum of the ATTRITION and OJT TIME benefits measured in actual dollars, was used as the basis for scaling the two nonquantified variables.

Display Range of Values for Each Outcome

Figure V-19 shows the relationship between the valuations for each benefit, adjusted for importance. The total value (in equivalent dollars) for each outcome is summarized at the bottom of the chart. These values are entered directly onto the decision tree for Outcomes A through D.

Complete Decision Tree Assessment Diagram

The values from Figure V-19 for each outcome are entered onto the decision tree, as are the values for the readjusted success probabilities from 06.05. Figure V-20 shows a completed decision tree diagram.

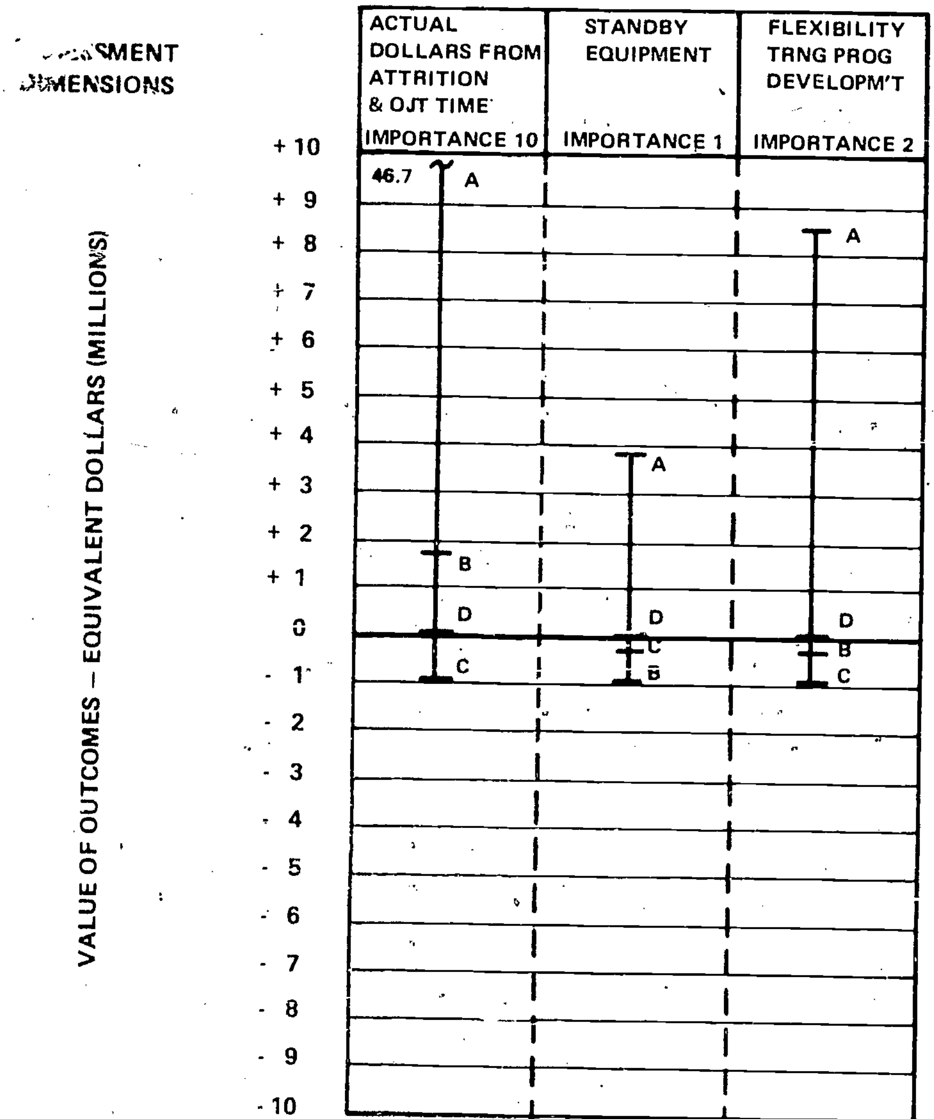
Foldback the Decision Tree

The folded back decision tree of Figure V-20 confirms more strongly, the indicated decision tree path established in Task 4, using the preliminary range-of-effect data. The calculated decision variable is 32.5, favoring acceptance and undertaking of the risk reduction projects.

| RELEVANT VARIABLE | RELATIVE IMPORTANCE | A | B | C | D | COMMENTS |
|---|---|---|---|---|---|---|
| ATTRITION | | 9.6 | 1.8 | -1.0 | 0.0 | TOTAL SINGLE VALUE IS 47.7 (46.7 + 1.0) AND WILL CARRY A WEIGHT OF 10. |
| OJT TIME | | 37.1 | 0.0 | 0.0 | 0.0 | |
| TOTAL | 10 | 46.7 | 1.8 | -1.0 | 0.0 | |
| STANDBY EQUIP | 1 | 100 | 0 | 10 | 20 | SCALE VALUES FROM FIGURE V-16. D IS THE NEUTRAL OUTCOME AND THE TOTAL SCALE WILL BE 1/10 OF 47.7 OR 4.8. |
| ADJUSTED | | 3.8 | -1.0 | -.5 | 0.0 | SCALE VALUES FROM FIGURE V-16. ADJUST CONSIDERING THE RELATIVE IMPORTANCE OF THIS BENEFIT COMPARED TO THE IMPORTANCE OF TOTAL REAL DOLLARS SAVED. |
| FLEXIBILITY IN TRAINING PROGRAM DEVELOPMENT | 2 | 100 | 4 | 0 | 10 | SCALE VALUES FROM FIGURE V-17. D IS THE NEUTRAL OUTCOME AND THE TOTAL SCALE WILL BE 2/10 OF 47.7 OR 9.5. |
| ADJUSTED | | 8.5 | -.4 | -1.0 | 0.0 | SCALE VALUES FROM FIGURE V-17. ADJUSTED CONSIDERING RELATIVE IMPORTANCE OF THIS BENEFIT COMPARED TO THE IMPORTANCE OF TOTAL REAL DOLLARS SAVED. |

FIGURE V-18. BENEFIT OUTCOME SUMMARY (3-D PROCEDURAL TRAINER)

## OUTCOME ANALYSIS – BENEFIT UTILITY ASSIGNMENT




OUTCOME SUMMARY

| | | | | TOTAL |
|---|---|---|---|---|
| A | 46.7 | 3.8 | 8.5 | 59.0 |
| B | 1.8 | - 1.0 | - .4 | .4 |
| C | - 1.0 | - .5 | - 1.0 | - 2.5 |
| D | 0.0 | 0.0 | 0.0 | 0.0 |

FIGURE V-19. BENEFIT OUTCOME SUMMARY
(3-D PROCEDURAL TRAINER ANALYZED OVER FULL RANGE-OF-EFFECT)

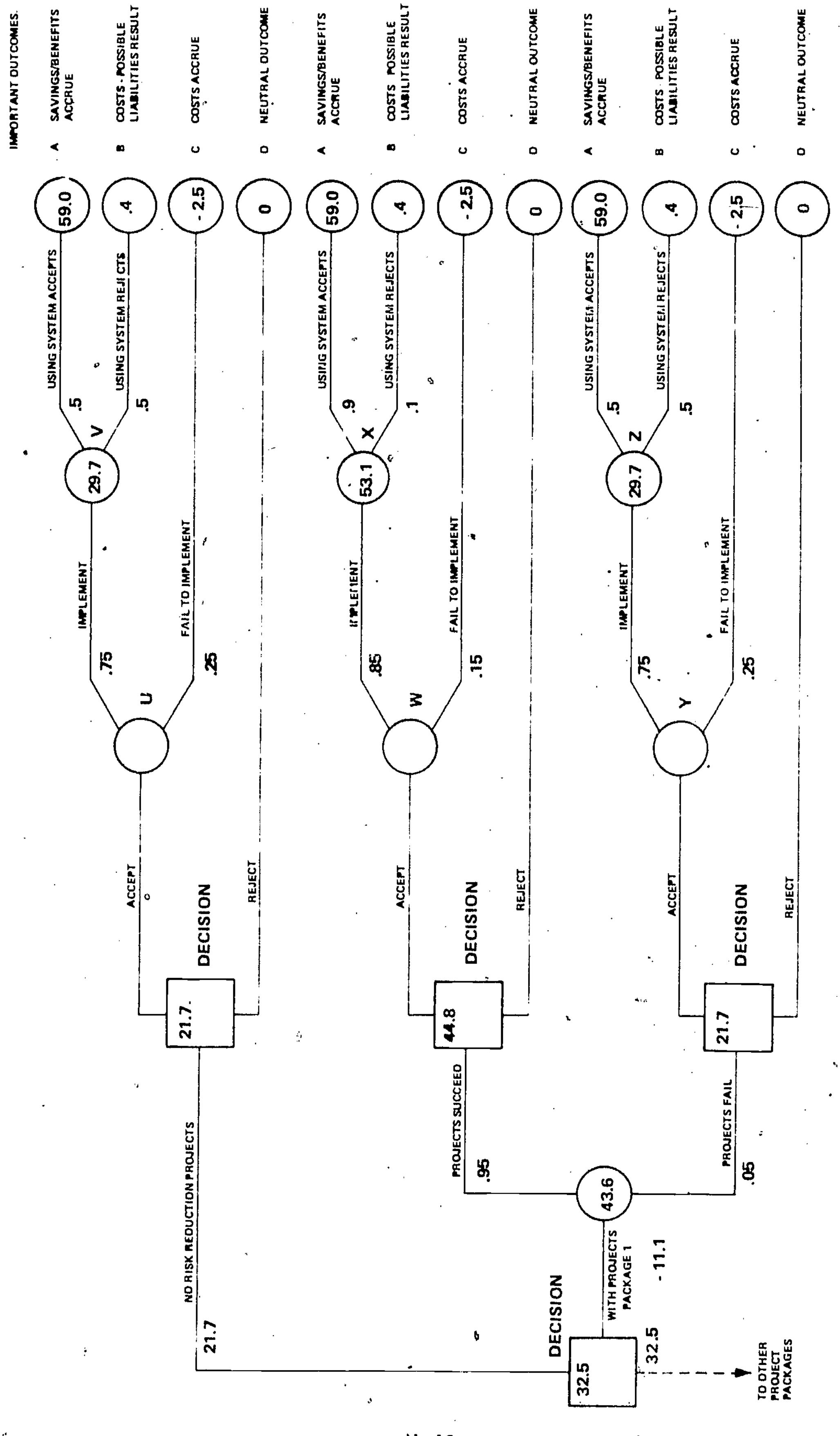



FIGURE V-20. DECISION TREE FOR ASSESSMENT OF TRAINING INNOVATION (3-D PROCEDURAL TRAINER ANALYZED OVER TOTAL RANGE-OF-EFFECT INCLUDING NONQUANTIFIED BENEFITS)

EXHIBIT: COST-BENEFITS ANALYSIS (Continued)...

PERFORM SENSITIVITY ANALYSIS (06.07)

Review Sensitivity Profile for Each Model

The characteristics of each cost model are reviewed to determine if any of the variables used in the preceding analysis might be sensitive enough to cause a change in the decision.

| Variable | Confidence Range |
|---|---|
| OJT Time | 1.5 to .5 weeks |
| Attrition | 3.5% to 1% |
| User Acceptance (w/o projects) | 40% to 60% |

(An output report as shown in the 06.07 procedures was not generated, since none of the variables caused a change in the decision across the confidence range -- scenario values were selected to avoid sensitivity calculations because of excessive manual computational requirements.)

TASK 7 - PERFORM FINANCIAL ANALYSIS. The cost-benefits analysis has indicated a decision in favor of accepting the innovation, including the performance of the risk reduction projects identified in Task 4. The techniques of financial analysis are fairly straightforward, therefore, only the results of basic comparison between the existing system, the proposed approach, and one alternative approach identified in Task 2 are presented here.

EXHIBIT: FINANCIAL ANALYSIS

ASSEMBLE DATA (07.01)

Cost Model Output Data From 06.03

Risk reduction project costs.

Training savings.

OJT time savings.

Alternative Approach to Meeting Objective From Task 2

DEVELOP COST/SAVINGS ANALYSIS (07.02)

Make Required Cost Model Runs

An additional model run was required to determine the cost of the alternative identified in Task 2. Figures V-21 through V-23 show the inputs and outputs for this run.

COURSE COST ANALYSIS

INPUT:

| | | | | |
|---|---|---|---|---|
| COURSE NUMBER | - ALT1 | | DISCOUNT RATE | - 10.0 PERCENT |
| PLANNING PERIOD | - 8 | | INFLATION RATE | - 6.0 PERCENT |

INPUT TECHNICAL FACTORS:

| PLNG YR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| GRADS- | 10000 | 12000 | 14000 | 14000 | 13000 | 9000 | 8000 | 5000 | 0 | 0 |

| PLNG YR | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| GRADS- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | |
|---|---|---|---|
| ATTRITION RATE (PCT) - | .05 | TIME STUD POS DOWN (PCT) - | .01 |
| TRAINING LENGTH (WKS) - | 2.0 | PCT EXTRA STUD POSITIONS - | .0 |
| RECYCLE RATE (PCT) - | .10 | EQUIP/STUD POS RATIO - | 0.20 |
| AVE. RECYCLE TIME (WKS)- | 1.0 | LIFE OF EQUIPMENT - | 5 |
| WEEKS SCHOOL OPERATES - | 50.0 | COURSE DEV HRS/COURSE HR - | 25.0 |
| INSTR/STUD POS RATIO - | .200 | PCT COURSE REQUIRING DEV.- | 1.00 |
| ADMIN/STUD POS RATIO - | .010 | PCT INSTR MAT. MAINTAINED- | .20 |
| SQ FEET/STUDENT POS. - | 9.00 | PCT INSTR MAT. RMNG VALUE- | .40 |
| SQ FEET/INSTR. POS. - | 5.00 | SUPPLIES/STUDENT POSITION- | 1.0 |
| SQ FEET/ADMIN POS. - | 3.00 | SUPPLIES/STUDENT - | 1.0 |
| PURCHASE POLICY - | 2 | MISC/STUDENT POSITION - | 1.0 |
| DEPRECIATION POLICY - | 2 | MISC/STUDENT - | 1.0 |

FIGURE V-21. TRAINING COST MODEL TECHNICAL INPUT DATA - ALTERNATIVE IDENTIFIED IN TASK 2

```
                              COURSE COST ANALYSIS
INPUT:
  COURSE NUMBER    - ALT1
  PLANNING PERIOD -   8                          DISCOUNT RATE   - 10.0 PERCENT
                                                 INFLATION RATE  -  6.0 PERCENT

INPUT COST FACTORS:
  PLNG YR    1       2       3       4       5       6       7       8       9      10
  O&MN-    200.    200.    200.    200.    200.    200.    200.    200.     0.      0.

  PLNG YR   11      12      13      14      15      16      17      18      19      20
  O&MN-      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.

  STUDENT SALARY (ANNUAL)- 11141.00       COST/HR OF INSTR MAT DEV     -   6.00
  STUD TRAVEL TO/FROM    -   228.00       SUPPLIES COST                -  10.00
  STUD TRAVEL IN COURSE  -     0.0        MISCELLANEOUS COST           -   0.0
  INSTR SALARY (ANNUAL)  - 16240.00       PCT MAX EQUIP PURCHASED      -    .90
  ADMIN SALARY (ANNUAL)  - 13500.00       FACILITY COST/SQ FOOT        -  25.00
  EQUIPMENT UNIT COST    -  5000.00
```

FIGURE V-22. TRAINING COST MODEL COST INPUT DATA - ALTERNATIVE IDENTIFIED IN TASK 2

COURSE COST ANALYSIS

INPUT:
COURSE NUMBER - ALT1
PLANNING PERIOD - 8

DISCOUNT RATE - 10.0 PERCENT
INFLATION RATE - 6.0 PERCENT

| OUTPUT COST RESULTS: | NON-DISC CONSTANT $ | DISCOUNTED CONSTANT $ | NON-DISC CURRENT $ | DISCOUNTED CURRENT $ |
|---|---|---|---|---|
| STUDENT SALARIES | 39297904. | 28485424. | 48743536. | 34536384. |
| STUDENT TRAVEL | 20399952. | 14787115. | 25303312. | 17928224. |
| INSTRUCTOR SALARY | 12035370. | 8723944. | 14928194. | 10577111. |
| ADMINISTRATIVE SALARY | 500239. | 362602. | 620476. | 439627. |
| EQUIPMENT | 489600. | 567772. | 365878. | 533536. |
| FACILITIES | 929147. | 673500. | 1152476. | 816567. |
| INSTRUCTIONAL MATERIALS | 14400. | 11093. | 17018. | 12989. |
| SUPPLIES | 931791. | 675417. | 1155756. | 818891. |
| MISCELLANEOUS | 0. | 0. | 0. | 0. |
| TOTAL OPERATIONAL | 74598336. | 54286800. | 92286592. | 65663280. |
| COST PER GRADUATE | 877.53 | 638.67 | 1085.72 | 772.51 |
| COST PER STUDENT INPUT | 833.75 | 606.74 | 1031.44 | 733.89 |
| COST PER STUDENT POSITION | 20156.26 | 14668.14 | 24935.58 | 17742.04 |

FIGURE V-23. TRAINING COST MODEL COST OUTPUT DATA - ALTERNATIVE IDENTIFIED IN TASK 2

EXHIBIT: FINANCIAL ANALYSIS (Continued)...

Generate Cost/Savings Reports

Each alternative is assessed for incremental effects against each other alternative, and up to three formats of Cost/Savings Report are generated for each case.

Cost/Savings Reports for the existing vs. the proposed system have been generated in two formats as shown in Figure V-24 and V-25. Similar reports in all formats would normally be generated for the existing vs. the alternative system and for the proposed vs. the alternative system.

DEVELOP ALTERNATIVES COMPARISON ANALYSIS (07.03)

Select Alternatives for Further Consideration

Each of the two alternatives (the proposed 3-D Procedural Trainer and the alternative from Task 2) has been selected for comparative financial analysis.

Organize Data

Since the data have been divided previously into R&D, Investment, and Recurring, processing can take place directly. The R&D costs, for economic analysis purposes, are treated as an investment, as are equipment purchases.

Generate Alternatives Analysis Report

Figure V-26 summarizes the data comparing the proposed 3-D Procedural Trainer with the existing (or presently planned) system, the alternative approach from Task 2 with the existing system, and the 3-D Trainer with the alternative.

Review Alternatives

The results portrayed in the Alternatives Analysis Report may be difficult to interpret because of the values used in this scenario. They can be summarized as follows:

- The proposed innovation provides about a 75% return on investment which is extremely high, and in the absence of excessive risks (already eliminated with the risk reduction projects), should be accepted.

- The alternative proposal, however, is even more lucrative since it requires a negative investment to produce savings. This is due to a lesser equipment cost and the fact that no R&D funds were identified to be expended. Thus, it would be favored for acceptance over the proposed 3-D Procedural Trainer.

COST/SAVINGS SOURCE REPORT

(EXISTING VS. PROPOSED SYSTEM)

INPUT:

DISPLAY FORMAT - COURSE/EQUIPMENT/JOB
PLANNING PERIOD - 08 YEARS

DISCOUNT RATE - 10 PERCENT
INFLATION RATE - 6 PERCENT

---

OUTPUT:

| CST(-)/SAV(+) SOURCE | TOTAL | YEAR 1 | YEAR 2 | YEAR 3 | YEAR 4 | YEAR 5 |
|---|---|---|---|---|---|---|
| PROJECTS | | | | | | |
| (LIST) | - 11,123.2 | | | | | |
| COURSES | | | | | | |
| (LIST) | 12,611.7 | | (ANNUAL INCREMENTAL VALUES NOT CALCULATED) | | | |
| JOBS | | | | | | |
| (LIST) | 54,635.5 | | | | | |
| NONDISCOUNTED TOTAL $ | 56,124.0 | | | | | |
| PRESENT VALUE-CONST $ | 35,727.0 | | | | | |
| INFLATED TOTAL $ | 69,424.0 | | | | | |
| PRESENT VALUE-CRNT $ | 49,615.8 | | | | | |

FIGURE V-24. COST/SAVINGS ANALYSIS OF EXISTING VS. PROPOSED SYSTEM BY COURSE/EQUIPMENT/JOB CATEGORY

COST/SAVINGS SOURCE REPORT

(EXISTING VS. PROPOSED SYSTEM)

INPUT:

DISPLAY FORMAT - COST CATEGORIES
PLANNING PERIOD - 08 YEARS

DISCOUNT RATE - 10 PERCENT
INFLATION RATE - 6 PERCENT

---

OUTPUT:

| CST(-)/SAV(+) SOURCE | TOTAL | YEAR 1 | YEAR 2 | YEAR 3 | YEAR 4 | YEAR 5 |
|---|---|---|---|---|---|---|
| R&D | | | | | | |
| (LIST) | -11,123.2 | | | | | |
| INVESTMENT | | | | | | |
| (LIST) | - 2,036.2 | | (ANNUAL INCREMENTAL VALUES NOT CALCULATED) | | | |
| RECURRING | | | | | | |
| (LIST) | 69,283.4 | | | | | |
| NONDISCOUNTED TOTAL $ | 56,124.0 | | | | | |
| PRESENT VALUE-CONST $ | 35,727.0 | | | | | |
| INFLATED TOTAL $ | 69,424.0 | | | | | |
| PRESENT VALUE-CRNT $ | 49,615.8 | | | | | |

FIGURE V-25. COST/SAVINGS ANALYSIS OF EXISTING VS. PROPOSED SYSTEM BY COST CATEGORY

ALTERNATIVES ANALYSIS REPORT

| SUMMARY OF RELEVANT FACTORS CONSIDERED IN THE ECONOMIC ANALYSES: | PROPOSED VS. EXISTING | ALTERNATIVE VS. EXISTING | PROPOSED VS. ALTERNATIVE |
|---|---|---|---|
| COMPARATIVE ECONOMIC LIFE OF ALTERNATIVES (YEARS) | 8 V S 8 | 8 V S 8 | 8 V S 8 |
| TOTAL NONDISC NET INVESTMENT | 13,159.4 - | 77.3 + | 13,236.7 - |
| TOTAL NONDISC RECURRING CST/SAV | 69,283.4 | 58,769.7 | 10,513.7 |
| PRESENT VALUE OF NEW INVESTMENT | 11,977.1 - | 77.8 + | 12,054.9 - |
| PLUS: PV EXISTING ASSETS USED | 0.0 | 0.0 | 0.0 |
| LESS: PV EXISTING ASSETS REPL | 0.0 | 0.0 | 0.0 |
| LESS: PV INVESTMENT END VALUE | 0.0 | 0.0 | 0.0 |
| TOTAL PV OF NEW INVESTMENT (-) | 11,977.1 - | 77.8 + | 12,054.9 - |
| PV NET RECURRING CST(-)/SAV(+) | 47,704.8 | 40,083.8 | 7,621.0 |
| PLUS: PV REFURB/MODIF SAVED | 0.0 | 0.0 | 0.0 |
| TOTAL PV OF CST(-)/SAV(+) | 35,727.7 | 40,167.6 | 4,433.9 |
| DISCOUNT RATE (PERCENT) | 10 | 10 | 10 |
| SAVINGS INVESTMENT RATIO | 3.98 | *** | NEG |
| RATE OF RETURN ON INVESTMENT | 75.0 | *** | NEG |
| UNIFORM ANNUAL CST(-)/SAV(+) | (NC) | (NC) | (NC) |

***Not Calculatable
NC - Not Calculated

**FIGURE V-26. ALTERNATIVES ANALYSIS REPORT (3-D PROCEDURAL TRAINER AND ALTERNATIVE FROM TASK 2)**

EXHIBIT: FINANCIAL ANALYSIS (Continued)...

- From the foregoing, it is seen that there is a negative incremental return on investment between the proposed 3-D Trainer and the alternative identified in Task 2.

- Since the alternative was not subjected to the analyses from Tasks 3, 4, 5, and 6, these should be performed to determine if it should be accepted without the investment of risk reduction project funds. If substantial risk reduction project funds are identified, the financial analysis may have to be redone.

PERFORM SENSITIVITY ANALYSIS (07.04)

Review Sensitivity Profile for Each Model

This is similar to the analysis in 06.07, however, it would be restricted to the tangible factors measurable in real dollars. The decision variable being tested in this analysis is the return on investment factor.

Identify Sensitive Variables to be Analyzed

| Variable | Confidence Range |
|---|---|
| OJT Time | 1.5 to .5 weeks |
| Attrition | 3.5% to 1% |

(An output report as shown in 06.07 procedures was not generated since none of the variables caused a change in the decision across the confidence range.)

TASK 8 - MAKE ACCEPT/REJECT/STUDY DECISION. The major outputs of this task will be left to the reader's interpretation, using the guidance outlined in Task 8. The presentation content, however, will include:

1. A statement of the problem.
2. Background data.
3. The objective.
4. The proposed approach for meeting the objective.
5. Supporting rationale.
    - Assumptions made.
    - Risks (including projects to bring them under control).
    - Benefits/liabilities (including savings and costs).

- Results of decision tree analysis.
- Results of financial analysis.
- Plan for accomplishment.

6. Summary conclusions and recommendations.

SCENARIO NUMBER TWO - COST ANALYSIS AND MEASUREMENTS SYSTEM

This scenario deals with a subset of the analytic and decision process and points out some the considerations in the treatment of variable estimates, costs, risk, financial return, and measurement statistics used by training management.

FINANCIAL ANALYSIS. An identified segment of training presently handles 10,000 Student Days (DE) per year, at a total cost of $1 million. The cost per SD is $100. The $1 million consists of $100,000 in fixed costs and $900,000 in variable costs. The total cost of training can, therefore, be expressed:

TOTAL COST - $100,000 + $90 X STUDENT DAYS

A highly innovative proposal is submitted which permits students to be trained at twice the existing rate; however, it will require an additional $200,000 in annual fixed costs. The proposed training system will have 5000 SD's. The two training systems can be described as such:

| | A (EXISTING) | B (PROPOSED) |
|---|---|---|
| ANNUAL STUDENT DEMAND | 500 | 500 |
| AVE COURSE LENGTH (DAYS) | 20 | 10 |
| NO. OF STUDENT DAYS (SD'S) | 10,000 | 5,000 |
| TOTAL FIXED COSTS ($) | $100,000 | $300,000 |
| TOTAL VARIABLE COSTS ($) | $900,000 | $450,000 |
| TOTAL COST/SD ($) | $ 100 | $ 150 |
| VARIABLE COST/SD ($) | $ 90 | $ 90 |
| COST/GRADUATE ($) | $ 2,000 | $ 1,500 |

The proposal obviously sounds enticing, therefore, the cost analysis should provide management with the appropriate decision-making structure with which to judge the proposal. The key questions are "What are the relevant costs?" and "How does the acceptance of the proposal affect the measurements which managers at all levels may be viewing?"

Before addressing these questions specifically, it might be well to look at an economic analysis of the proposal. Assume that the proposal is to be analyzed

over a period of five years and that annual student demand will be maintained at 500. An incremental analysis of the proposal gives the following results.

| YEAR | ANNUAL SAVINGS | - | ANNUAL COST | = NET | DISCOUNTED @ 10% |
|---|---|---|---|---|---|
| 1 | 450,000 | - | 200,000 | = 250,000 | 238,500 |
| 2 | 450,000 | - | 200,000 | = 250,000 | 216,750 |
| 3 | 450,000 | - | 200,000 | = 250,000 | 197,000 |
| 4 | 450,000 | - | 200,000 | = 250,000 | 179,250 |
| 5 | 450,000 | - | 200,000 | = 250,000 | 163,000 |
| | | | NET PRESENT VALUE | | 994,500 |

If the opportunity cost of capital were considered to be 10%, then one would pay nearly $1 million for such an innovation in training. Even in a situation where there is some risk that the annual demand will not be sustained, and it is decided to weight the outyears according to the risk potential, the analysis might look as follows.

| YEAR | PROJ DEMAND | | RISK ADJ DEMAND | SAVINGS | - | COST | = NET | DISCOUNTED @ 10% |
|---|---|---|---|---|---|---|---|---|
| 1 | 500 | X | .90 = 450 | 405,000 | - | 200,000 | = 205,000 | 195,570 |
| 2 | 500 | X | .80 = 400 | 360,000 | - | 200,000 | = 160,000 | 138,720 |
| 3 | 500 | X | .70 = 350 | 315,000 | - | 200,000 | = 115,000 | 90,620 |
| 4 | 500 | X | .60 = 300 | 270,000 | - | 200,000 | = 70,000 | 50,190 |
| 5 | 500 | X | .50 = 250 | 225,000 | - | 200,000 | = 25,000 | 16,300 |
| | | | | NET PRESENT VALUE | | | | 491,400 |

Here, with the risks as stated, one might pay nearly $500,000 for the innovation. Additional risk could be associated with the training length. For example, assume that the probabilities of achieving the projected training length reductions were as follows. (Remember the existing training length is 20 days while the proposed length, with the innovation, is 10 days.)

| NEW COURSE LENGTH | PROB. OF ACHIEVING | EFF REDUCTION | |
|---|---|---|---|
| 20 | 0 | 0 | |
| 19 | 0 | 0 | |
| 18 | 0 | 0 | Eff Course Length = 10.95 Days |
| 17 | 0 | 0 | |
| 16 | 0 | 0 | |
| 15 | 0 | 0 | |
| 14 | .05 | .70 | Savings in Course Length = 9.05 Days |
| 13 | .10 | 1.30 | |
| 12 | .15 | 1.80 | |

| NEW COURSE LENGTH | PROB. OF ACHIEVING | EFF REDUCTION | (Continued)... |
|---|---|---|---|
| 11 | .20 | 2.20 | |
| 10 | .45 | 4.50 | |
| 9 | .05 | .45 | |
| | | 10.95 | |

If this dimension of risk is added to the previous analysis, rather than the adjusted demand being multiplied by a 10-day savings per student, it will only be multiplied by 9.05. That analysis would give the following results.

| YR | ADJ DEMAND | X | DAYS SAVED | = | TOTAL DAYS SAVED | COST/ X SD | = SAVINGS | - COST | = NET | DISC @ 10% |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 450 | X | 9.05 | = | 4072.5 | X 90 | = 366,525 | - 200,000 | = 166,525 | 158,865 |
| 2 | 400 | X | 9.05 | = | 3620 | X 90 | = 325,800 | - 200,000 | = 125,800 | 109,069 |
| 3 | 350 | X | 9.05 | = | 3167.5 | X 90 | = 285,275 | - 200,000 | = 85,275 | 67,197 |
| 4 | 300 | X | 9.05 | = | 2715 | X 90 | = 244,350 | - 200,000 | = 44,350 | 31,799 |
| 5 | 250 | X | 9.05 | = | 2262.5 | X 90 | = 203,625 | - 200,000 | = 3,625 | 2,364 |
| | | | | | | | | | NET PRESENT VALUE | 369,294 |

The value of the proposal is down to $370K, however, it still appears attractive.

From the preceding examples, it can be seen that the relevant costs (or costs avoided) are:

1. The additional fixed cost ($200,000).

2. The variable costs saved ($90 per Student Day).

These costs were adjusted in several ways to account for risk, and the net savings were discounted at a 10% rate to account for the time value of money. An additional adjustment could have been made on the annual fixed cost if it were felt that some risk was attached to that value remaining at the specified level.

MEASUREMENTS ANALYSIS. An equivalent concern with adoption of a proposal such as this relates to the effects it might have on the values reported to management for measuring and controlling the training system. The use of ratios is quite common, such as cost/student hour, cost/student day, cost/graduate, etc. The introduction of the proposed innovation will affect certain ratios of these types, some favorably, others adversely. For example, the proposed innovation will cause a 50% increase in student day costs, while it will cause a 25% decrease in the cost per graduate. The following comparison shows how these changes result. Variables names have been shortened to facilitate mathematical handling.

| VARIABLE NAME | SYMBOL |
|---|---|
| Annual Student Demand | GRAD |
| Ave. Course Length (Days) | TLENGH |
| No. of Student Days | SD |
| Total Fixed Costs | CFX |
| Total Variable Costs | CVRB |
| Total Cost/SD | CSDT |
| Variable Cost/SD | CSDV |
| Cost/Graduate | CGRD |
| Total Cost | CTOT |

VARIABLE RELATIONSHIPS

CSDT = (CFX + CVRB)/SD

= (CFX + CSDV*TLENGH*GRAD)/(TLENGH*GRAD)

CGRD = (CFX + CVRB)/GRAD

For A (Existing):

$CSDT_A$= ($100,000. + $90. * 20 * 500)/(20 * 500)

= ($100,000 + $900,000)/10,000

= $1,000,000/10,000

= $100 (COST PER STUDENT DAY)

$CGRD_A$= ($100,000. + $900,000)/500

= $1,000,000/500

= $2,000 (COST PER GRADUATE)

For B (Proposed):

$CSDT_B$= ($300,000. + $90. * 10 * 500)/(10 * 500)

= $300,000. + $450,000.)/5000

= $750,000./5000

= $150. (COST PER STUDENT DAY)

$$CGRD_B = (\$300,000. + \$450,000.)/500$$

$$= \$750,000./500$$

$$= \underline{\underline{\$1500}}.\ \text{(COST PER GRADUATE)}$$

A failure to consider the economic justification as well as measurement impacts, may lead to future misinterpretations of the value of the innovation, once it has been implemented. A management measurement and control system which focused only on Cost per Student Day (CSDT) might be shocked at the 50% increase and may not give proper credit for adoption of an economically sound innovation.

Another important management consideration is with the sensitivity of various measurements to student loads under existing and proposed conditions. The two previously considered measurements, Cost per Student Day and Cost per Graduate, should be analyzed for their profiles of variance under the two training situations, (A) existing system and (B) proposed system.

In Figure V-27, Total Costs and Cost/SD are plotted for the two alternatives. It can be seen that under the proposed system (B), student day costs are higher for any number of student days, and they rise more rapidly as student days decrease. However, a more relevant consideration is the break-even point for Cost per Graduate as shown in Figure V-28. If the number of graduates drops from 500 to 222, then the cost of operation under the existing system and the proposed system is the same ($500,000); therefore, the Cost/Graduate is the same ($2222.). At the break-even point, however, the Cost/SD under the proposed system will be twice that of the existing system ($225. vs. $112.5). This is not a relevant concern. What is of concern is the higher operating cost below the break-even point of 222 graduates under the proposed system. This is due to the higher leverage provided by the increased level costs. A higher Cost/Graduate exists, also, under the proposed system, as the number of graduates falls below the break-even point.

There are several alternatives for maintaining the continuity of the previous measurements if the proposal is accepted. One is to use the Cost/SD (B) as a control value for all subsequent numbers of graduates. Even though it is higher, future cost problems can be detected from a higher Cost/SD than projected at the time of the analysis. Another alternative is to adjust all future student day costs by a ratio of the before-to-after costs at the time of the analysis. Since this value will vary depending on the number of graduates, it must be calculated for each level. The procedure would be as follows:

Let $CSDT_O$ be the Cost/SD measured and observed at some future date.

Let $CSDT_M$ be the Cost/SD adjusted to the preproposal base and the value that will be presented to management.

Then:

$$CSDT_M = CSDT_O \times \frac{CSDT_A}{CSDT_B}$$

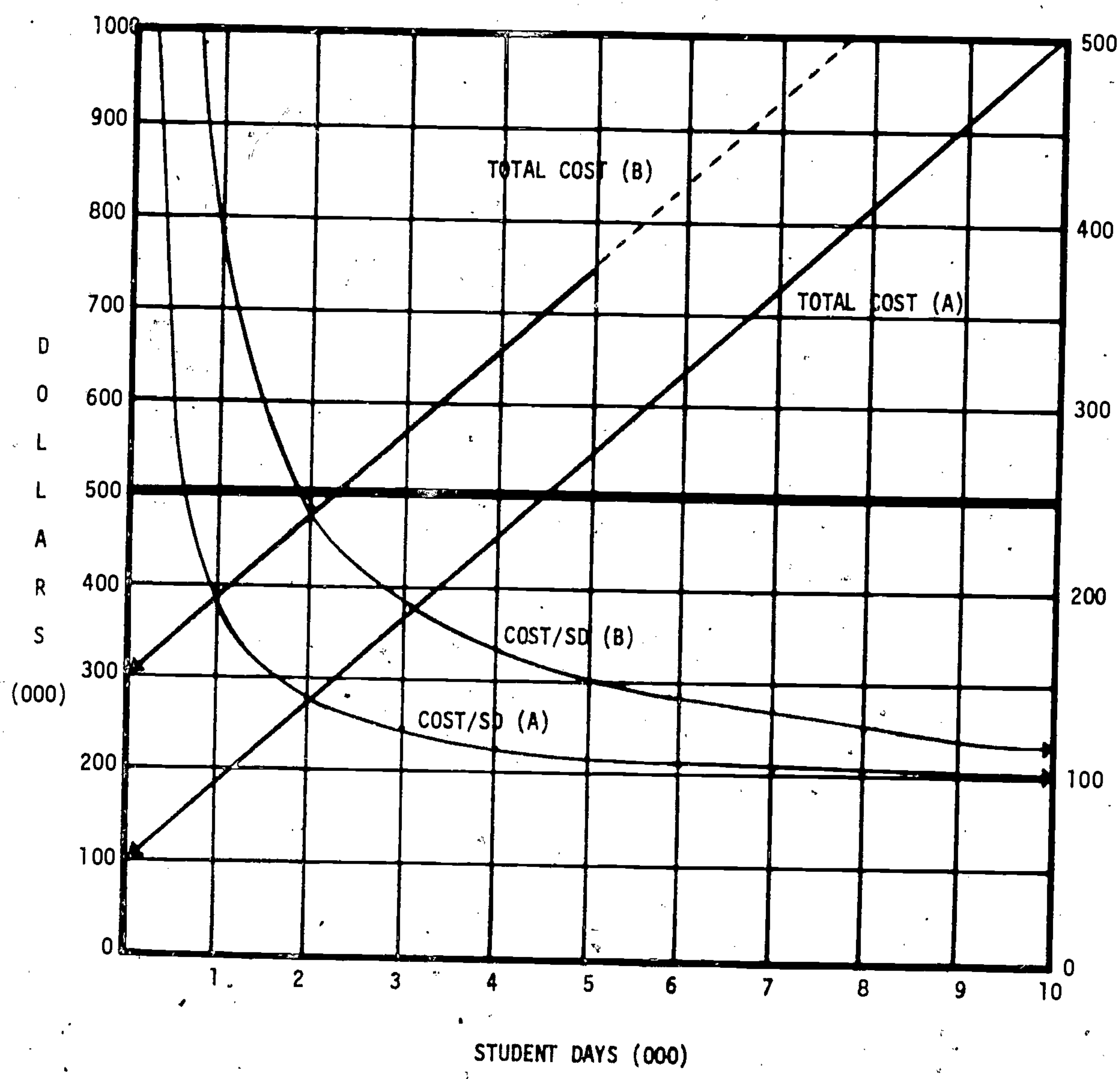



FIGURE V-27. TOTAL COST/COST PER STUDENT DAY BREAK-EVEN ANALYSIS

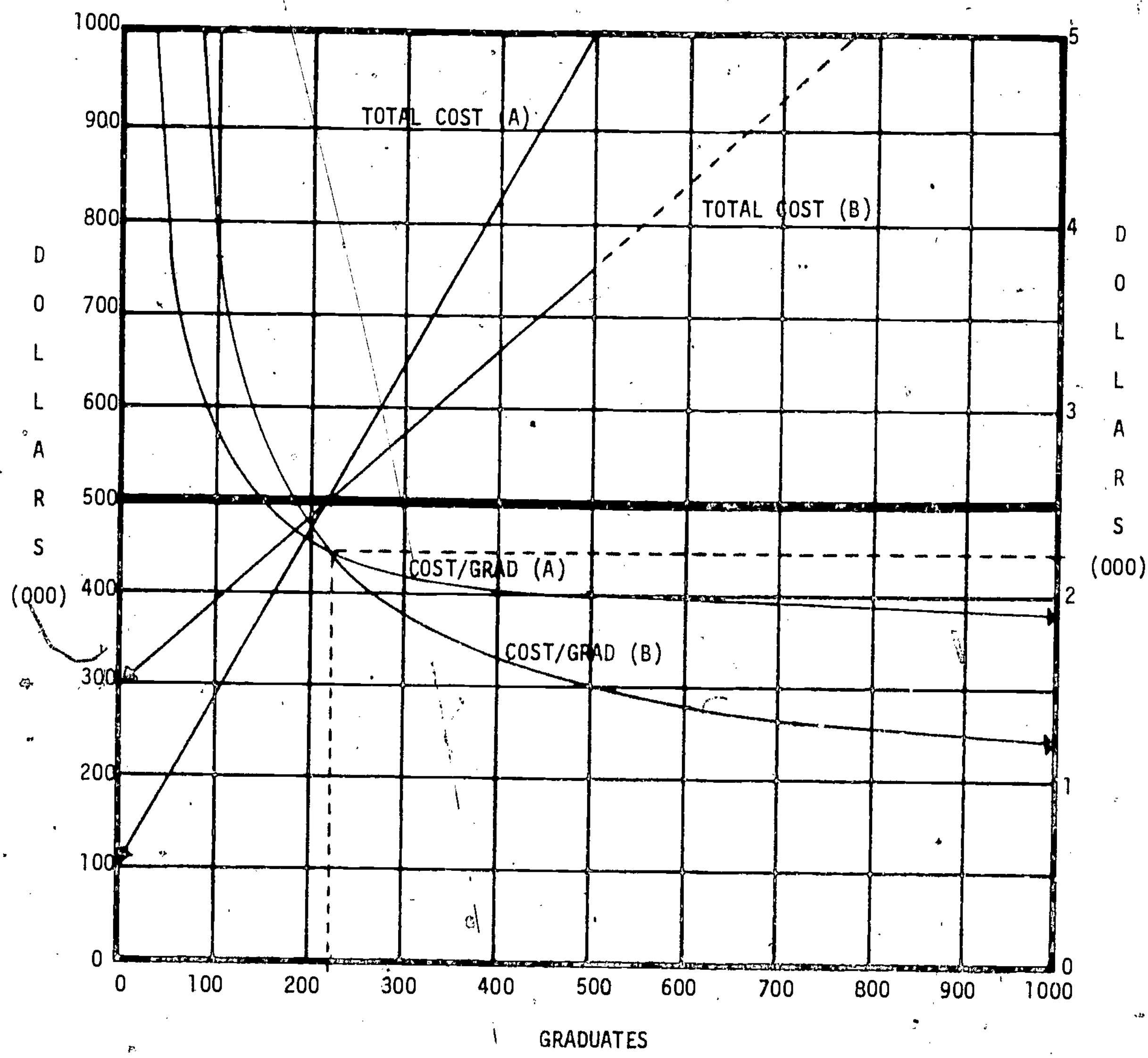



FIGURE V-28. TOTAL COST/COST PER-GRADUATE BREAK-EVEN ANALYSIS

Since $CSDT_A$ and $CSDT_B$ are calculable as a function of numbers of graduates (GRAD) at time of proposal analysis, the equation reduces to;

$$CSDT_M = CSDT_0 \times \frac{1000 + 18\ GRAD}{6000 + 18\ GRAD}$$

For example, assume

$CSDT_0$ = \$160

GRAD - 500

Then:

$$CSDT_M = \$160 \times \frac{1000 + 9000}{6000 + 9000}$$

$$= \$160 \times .67$$

$$= \$107.$$

Since at a level of 500 graduates prior to the proposal, management would have expected the Cost/SD to be \$100, the $CSDT_M$ = \$107, reflects a cost problem which should be investigated further.

SUMMARY. The purpose of this scenario has been to unfold several of the more important factors in evaluating an innovation proposal; namely, the identification of relevant variables, the economic justification process, and the effects upon the measurements and control system.

SCENARIO NUMBER THREE - SHIPBOARD TRAINING WITH MICROFICHE

The following is an example of the use of ETAM in assessing the potential of using microfiche as a medium with a simple M/F viewer for shipboard training of courses or course content now taught on shore-based installations.

In this scenario, it is understood that the assessment operations are to be applied principally to Tasks 1, 3, and 5 in ETAM. Cost data are not to be used and computed, but the general classes of cost information should be identified. The major point in this exercise, however, is the use of Task 5, Range-of-Effect, structure on this problem.

The writer, who served as analyst here, has limited background in the use of microfiche for training purposes. He was given several study reports into M/F use, some briefing by Dr. Braby of TAEG, and some literature on extensions of microimage technology into training, such as the Lincoln Lab technology. This was the analyst's background to the present assessment results.

Since an assessment must have, at least as a starting point, a fixed reference as to the entity being assessed, it was decided to use the standard microfiche and the simple, portable viewer as the "innovation." If instructional or other

functions were to be added to this "system" (such as the elaborate Lincoln system contains), these additions would and could be superimposed on the present pattern of benefits and costs as modifications or extensions.

Because this report is intended to have instructional value on ETAM as well as being a trial operation, the text is fairly extended. Many of the reasons for making the stipulations in the assessment that appear here have been reported, perhaps at more than necessary length. Issues have been raised and explored which, in the present problem, have led into a dead end. It is believed that a full exposition of this kind enables others, as contributors to the assessment, to work with the rationale for a conclusion, as well as with the conclusion itself. Thus, it would be surprising if there were not some strong disagreements with some of the opinions asserted as "assessments." Clarification can be progressive, however, when the participants to a controversy can sort out whether their disagreement is based on assumptions, stipulations, rationales, or inferences and judgments.

The preparation of this entire assessment, including more than 27 pages of text, has occupied between four to five days of time. The setting down of the actual assessment data in the report -- without the rationales, etc. -- with the information at hand, would have taken between one and two days, and closer to one than to two. These estimates are intended to suggest that it does not necessarily take forever to go through the range-of-effect structure. As a matter of fact, describing the innovation in Task 1 would have taken more than half of the time given to the assessment operation through Task 5.

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY FOR TRAINING

TASK 1 - FORMALIZE THE DESCRIPTION OF THE INNOVATION

MICROFICHE TECHNOLOGY

Objectives and Summary (01.01)

The general proposal is aimed at the substitution of a system for producing and using micro-images, such as microfiche, for paper as a medium for individualized instruction on shipboard. The microfiche type of card can be coupled with a viewing mechanism that enables student responses to be evaluated. The result of the evaluation can be the basis for the selection of what is next presented to the student. It is also feasible to develop techniques which simplify the creation and modification of instructional content by authors, using a computer to assist in formatting, indexing, sequencing, and retrieving instructional material. The general benefits made possible by this technology are:

1. Reduction of storage space for equivalent content on paper, from 50 to 1, with a potential of 200 to 1. About the same proportional reduction in weight for transport and distribution purposes.

2. Somewhat greater flexibility in the amount and range of content, and in content sequencing: this enables options in sequencing that increase instructional capability.

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

3. Substantial reductions in costs of updating and reproducing of images as compared with printing on paper. These reductions in cost can be increased by computerizing the means whereby sets of images are created; layouts are generated by the author; and indexing, retrieval, and collation of images is managed.

4. The technical feasibility for shifting a large burden of instruction from shore schools to individualized shipboard instruction in a substantial range of knowledge and in some skills.

Because of the substantial development and operating costs of the proposed technology, the payoff must come from a large scale of application. Furthermore, any implementation should enable extensions of other technologies, such as update by satellite communication, or conversational interaction between the student at a microimage terminal with a central computer, to be readily integrated to existing facilities.

Delivery System and Training Vehicle (01.02)

Microimages are contained on transparent cards. One of the standard sizes is 4" x 6". Between 60 to several hundred images are on a card. Greater reductions are possible. The card is inserted into an optical viewer which enlarges the image to readable size. Substantial advances have been made in the quality of viewers, and in compactness of the device. The desired image is located manually; movement from one image to the next is manual. There are various forms of indexing assistance for locating an image and mechanical devices for advancing image frames. Manual advance seems, until now, as effective as mechanical aids. The cost of automatic sequencers would greatly increase the cost of the device and increase failure rate and maintenance costs.

The proposal does not include a firm specification for the properties of the viewing device. A reference base, however, for further cost-benefit analysis and comparison is the simple, portable viewer which projects the equivalent of an 8-1/2" x 11" display with a resolution of 150 lines to the inch. The microfiche card is manually inserted and images are manually selected and advanced.

At present, it is assumed that the formal testing of what the student learns at the level of specific course objectives would be made on another medium and device, perhaps served by a human instructor.

Jobs and Tasks Applicable (01.03)

Preliminary examination suggests that anything that can be learned from print on paper can be learned by microimage. This applies to the large body of knowledge material called "Knowledge Factors" in occupational standards. To the extent that a knowledge factor is necessary to the performance of a skill (or "Practical Factor"), this medium is applicable. Most procedural tasks require a knowledge substrate.

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

On this premise, practically all jobs and job advancement opportunities would be candidates for this facility.

Relevant Student Attributes (01.04)

The requirement is a reading ability at the level of programmed instruction for the given instructional topic and training objective.

The student may require somewhat higher levels of self-discipline than would be needed in formal school where time is structured and study activities are more or less supervised. Another complication could be the fact that on shipboard, the student might feel his primary responsibility was his job -- and properly so -- but this motivation could lead to rationalizations that the effort required for self-instruction could be postponed. For many students, some externally applied incentive might need to be applied on a daily or weekly basis.

The lack of the stress of schedules whereby schools must operate classes, however, would enable slower students to spend more time in mastering subject matter. The consequence could be a lower washout rate, at least on the basis of applied ability level.

Empirical Data on Benefits and Savings (01.05)

Samples of data, both on the potential liabilities and benefits in learning with the microfiche system and its costs, are in process of being collected.

At least indirect evidence shows that microfiche is at least as good as paper manuals, texts, and programmed instruction.

The physical density of storage of content on microfiche makes it feasible to make a large variety of instructional material available to the learner. This enables him to satisfy his curiosity, and may enable additional learning through redundancy: the same idea or pattern of ideas may become not only better learned and understood (paraphrased in various contexts) but better remembered and potentially better applied to appropriate occasions.

The negative possibility is that most students will tend to learn material only to a minimum level of grasp if they are left to set their own criterion. This means rapid forgetting, even if the test is passed. An external means of controlling amount of practice and criterion level reduces this liability. However, this liability exists in printed materials.

Practical Importance of the Training Product (01.06)

A large majority of skills has a substantial knowledge component, either as background for acquiring the skill, or as operational and

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

reference information for exercising the skill. To the extent that opportunity and incentive can be created on shipboard for acquiring these knowledges, a double savings can be effected. One is the reduction in classes and class time in shore installations. A second is the reduction in the proportion of enlistment time during which the incumbent is not in operational status -- at least following his first enlistment's period of schooling.

If this innovation can be realized, the achievement of its goals have substantial practical importance.

Resource Requirements for Further Study and Implementation (01.07)

A program has not yet been prepared.

Although the right hardware may not be available, no break-through in technology is required for microfiche. The anticipated use of holographics which could extend the instructional possibilities perhaps substantially would require some technological break-throughs both in cost and in miniaturization of components.

It appears that considerably more effort may need to be spent in determining ways of using the medium and its possibilities for instruction. Some useful principles have been invented and applied, but with limited empirical data.

Although the unit cost of the microfiche viewer is relatively small, it is not trivial. But the development of a coordinated system for generating and administering large scale curricula would require a multi-million dollar effort.

A somewhat higher level of average talent is likely to be needed to develop effective microfiche instructional content than is characteristic of classroom instructors and of programmed instruction designers. The latter have the instructional machine as a surrogate human instructor to keep the student going through to the end of an instructional segment. The student with book or microfiche can more readily turn off without a sense of noncompletion of a responsibility.

TASK 2 - DEVELOP/EXAMINE ALTERNATIVES TO THE INNOVATION. Instructional material on paper is the primary alternative. The microimage may be cost-justified over paper, quite independent of other benefits.

There may be technical alternatives to microfiche and the simple microfiche viewer. It is unlikely that they will be lower cost per frame of displayed information, but they may turn out to be lower overall cost per unit of learned product such as a knowledge objective or a skill objective, and across a wider range of subject matter and learning levels.

Those comparisons are not a part of the present evaluation, except insofar as this evaluation provides a reference for comparisons.

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

TASK 3 - PRELIMINARY FEASIBILITY PROFILE

Importance of the Innovation to the Projected Navy Mission (03.01)

Shipboard training is an alternative to shore training, and therefore cannot be considered crucial. In the event of an extended military emergency and full-scale mobilization, the ability to upgrade the capabilities of every person, wherever he may be, and to do so rapidly, could be crucial. But this is not the case, nor is it a present planning consideration.

Secondly, the training of knowledges is subordinate to training in actual job skills as such where, in most cases, the learning and application of the knowledge is likely to be most effective and efficient.

Taking both of these arguments into account, the estimate would have to read:

> Shipboard training with microfiche and what can be learned from microfiche technology would have an effect of moderate importance.

But taking into account that relatively few pounds of microimages as training material and as job aids (technical manuals) can displace tons of paper containing equivalent information, the picture changes rather radically:

> The effect can be substantial and important.

Organizational Compatability (03.02)

Shipboard training, as contrasted with shore-based training, is irrelevant to Navy command and career structure, or supportive of career structure. Since the policies of the Navy are to support the fullest possible growth potential of all of its personnel, shipboard training is indeed supportive and relevant.

Goals/Policy Compatability Within Training and Personnel Organizations (03.03)

To the extent that an organization prefers to maintain complete control of both the process and the product it is charged with producing, it is understandable that the training institutions would prefer full-time students studying in the training establishment itself. The student within this jurisdiction has direct accountability only to the training officers and management, and thus the training management has the authority to discharge its responsibility for producing trained men.

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

On the other hand, training management can perceive its objective as achieving training at lowest cost and penalty to the Navy as an operational enterprise. In this latter light, shipboard training is an extension of the training enterprise with a concern for cost as well as the benefit of the product.

A realistic assessment would be that some minor conflicts of a temporary nature would arise within the training establishment, not on the microfiche program as such, but against shipboard training on a wide and formalized scale.

Estimate of State-of-the-Art Applicable to the Innovation (03.04)

With respect to the technical effectiveness of instruction with more or less existing microfiche technology, it seems realistic to expect a high probability of success with at least a moderate R&D effort. This effort would be most profitably spent in the techniques of successful instruction with this medium, and in techniques of generating or organizing such instruction.

Estimate Further R&D Funding (03.05)

Programs for R&D in this enterprise have not been formulated. But a full-scale implementation across a wide variety of courses, job skills and knowledges, and students would require a moderate level of funding somewhat above the level of present planned and integrated programs.

It would be possible to demonstrate feasibility on a relatively restricted scale with relatively modest funds. Such a demonstration would lack, however, any basis for assessment of the economic benefit and the instructional range and flexibility of a full-scale development which included computerized techniques for preparing and disseminating training content.

Required Technical Support (03.06)

The kinds of talent that would be needed for developing these training materials, and for administering this entire instructional program, might be unusual but not rare. Adequate talent could be made available.

Attitudinal Acceptance (03.07)

In the case of shipboard training, the key requirement for attitudinal acceptance will be that of the commanding officer of the ship. Very reasonably, he feels his primary mission and responsibility is the effective operation of the ship. He is unlikely to feel that the training of personnel on his ship is a legitimate competitor to the operational mission. If shipboard inadequacies are traced to this "excuse", the commander is likely to downgrade the training mission.

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

This set of values will quickly be transmitted to trainees. Since self-instruction requires considerable incentive, the loss of the drive in this incentive will impair motivation to take the training seriously. Thus, both opportunity and incentive can be largely destroyed.

It is unrealistic to expect that commanders brought up in traditional Navy doctrine will accept a tradeoff criterion between any threat to shipboard effectiveness and training objectives that do not point directly to an increase or at least maintenance of shipboard effectiveness. The acquisition of new knowledge and skills for promotion to another grade does not point directly to such an increase in the capability of the ongoing mission of the ship.

This is a major impediment, not to microfiche as such, but to the instructional environment of its intended use.

The assessment must be: The community in which the innovation is to be introduced will respond with sustained hostility.

Many potential students on ship may, even with the encouragement of the commander for training, be ambivalent about time and effort spent in training that is away from their duties and comrades, or from relaxation.

TASK 5 - DETERMINE RANGE-OF-EFFECT. Some preliminary comments are in order before plunging into the procedural operations of Task 5. Clearly, one proposed advantage of microfiche is in its various economies over its equivalent in paper on shipboard -- plus perhaps shore-based training and operations. One could, without going further into the specifics of range-of-effect, make dollar comparisons of the M/F and paper alternatives for existing shipboard materials. Substituting M/F for much of the present shipboard paper might be justified on this basis alone.

The second problem is the justification for using M/F for shipboard training. Here, the major question -- assuming acceptance of shipboard training by the command levels -- is what can be taught and learned with the M/F medium? The most comprehensive answer here is "knowledge content." So before making further analysis, a good tactic would be:

1. Identify knowledge courses now in the Navy training curriculum that could be candidates for shipboard training.

2. Assuming at least equal -- and probably superior -- training benefits from M/F as from paper, determine the cost advantages of shipboard as contrasted with shore-based training on knowledge material.

This relatively simple analysis could in itself lead to a justification for M/F and shipboard training. Clearly, this would not constitute a full "range-of-effect" analysis, but this may be unnecessary for reaching a decision to use it rather than alternatives.

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

If, however, the decision makers demand, as a basis for their decision, some range of training in task-skills to be specified in addition to knowledge training, then the following steps will have to be performed.

These steps might also be performed if the objective were not merely that of accept or reject M/F as a medium on the least amount of information that would enable such a decision, but to make a research type inquiry into the possibilities of M/F for the fullest range of potential applicability. Such information would be useful and perhaps essential as a basis for a <u>system</u> design structure that used M/F or a similar medium, for instructional purposes. It should be noted that although ETAM is intended to serve this kind of purpose -- as demonstrated on the following pages of analysis -- the performance of this purpose will entail more labor than the minimum that might be required for producing "accept-reject-study further" kinds of decisions.

The exercise of assessment will assume that one or both of the objectives cited in the two preceding paragraphs applies to the problem.

(The point should be underlined, however, that because ETAM is comprehensive, its application is <u>necessarily</u> extensive, no matter what the problem of assessment may be.)

<u>Choose Major Routes for Range-of-Effect</u> (05.01)

It is expected that part of the justification for microfiche technology can be developed from displaceable costs in the printed paper: costs of paper, printing, distribution, storage, updating and obsolescence. So one prong of inquiry will be that of <u>Instructional Vehicles</u>.

It is also important to determine the range of instructional applicability of the microfiche system. The objective is to determine the teaching/learning hours of shore-based training in classrooms across all applicable course materials that can be displaced by shipboard training that can be achieved through microfiche. The analysis will, therefore, attempt to identify the types or classes of knowledge and skill that can be acquired, in whole or in some specified part, through microfiche usage. The specification of what instructional objectives are applicable to microfiche will then be applied to existing courses in order to quantify the potential range of applicability of M/F on shipboard.

At a later time, when plans have been completed for computer-assisted development, distribution and management of training, and job aid development with M/F technology, a third route of assessment will be through the Development and Administrative Management of Training route in ETAM. The M/F program has not developed to a point where this analysis would now be profitable. It is expected that the following categories in the D&A route would be applicable:

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

- Developing training requirements from skill requirements descriptions.
- Selection or devising of training modules and modularities.
- Designing the content of instruction.

Although microfiche as an instructional vehicle does not have properties directly applicable to these D&A issues, a semi-computerized subsystem which produced and selected microimages can be devised that would enable this medium to be more attractive than paper equivalents.

Comment

The present assessment will extend to the use of M/F as a substitute for paper job aids such as technical manuals on shipboard. The assessment will assume operational feasibility for the substitution of M/F displays for paper, supplemented with printer-copiers of M/F images where paper copies are essential at a given time. The operational justification for this assumption will not enter into the present assessment, which will, therefore, be limited to the economic opportunity in substituting M/F for paper.

Vehicle Type That Fits the Innovation (05.03)

The microfiche and its viewer are applicable to the full-range of static graphics used in instruction. It can, thus, display any content shown on paper, foil, slides, or static images on a display tube. Fiche images can be used to project enlarged images for group discussion or classroom presentation, thus displacing slides and foils.

Note that an economic assessment could be made at this point:

a. Determine present costs of all shipboard training, demonstration and briefing materials contained on paper, slides, charts, etc.

b. Determine costs for microfiche equivalents. Assume a reasonable requirement of paper duplication -- say 10% of the total. In both cases, costs should include generating and editing the content, updating it, distributing it, storing it, and accessing it selectively.

c. Compare the two sets of costs. A preliminary justification for M/F may appear and be more than marginal. In any event, a cost ratio between M/F and other media with equivalent function will be generated.

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

Type of Training Objective (05.04)

In general terms, microfiche can be used for the learning of:

a. Reference knowledge.

b. Knowledge that is task-specific and enabling -- to the extent that the knowledge can be acquired, retained, and applied as a verbalized, cognitive content.

c. Some task-skill formats at preliminary stages of competence.

d. Some skills that are primarily symbolic transactional, such as filling out a requisition or a duty roster. These may be treated as "task formats", however.

The foregoing identifications mean that specifics will be sought in the assessment routes leading to Reference Knowledge, Enabling Knowledge, and Task Formats.

Select Vehicle Properties (05.05)

At this point we become concerned with displaceable costs in the present inventory and usage of M/F alternatives in current training courses.

Since the "Instructional Functions" in 05.05 are roughly equivalent between the M/F technology and the alternatives it is displacing (paper, slides, etc.), these functions are not pertinent to this assessment and can be disregarded.

The "Utilization Functions" that do apply for comparison purposes consist of:

Programmability of instructional content.
Portability and storage.
Multiple usage.
Maintenance.
Combining instructional capabilities distributed among several media/devices.
Modularization of training content for more general applicability.

Cost advantages and liabilities may arise in each of these categories of cost assessment. It should be recognized that raw dollar estimates of saving may present an incomplete picture of value. For example, it is common practice to assess the cost of building space on a per square foot basis. But on shipboard, construction costs per square foot of floor space will be an incomplete evaluation of savings. The dramatic example is cubic foot space in a submarine. The assessor

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

may, therefore, want to get the help of appropriate operations people to develop a "functional multiplier" for the unit of objective cost. Thus, on a given type of ship, the construction cost per square foot may have a multiplying factor of 3 for space saving. But because of considerable idle time of shipboard electronics maintenance men, the normal "maintenance cost" for simple instructional devices might well be .5. Obviously, when a multiplier of this kind is used, both the multiplier (and its rationale) and the cost factor as objectively determined should be presented to the decision maker.

The portability of a compact, lightweight M/F viewer, plus the instructional and reference context in a few square inches of M/F cards, can be assessed in two ways. One is in the readiness with which a relatively small stock of viewers can be borrowed, used, and returned by a number of trainees. There is, thus, high opportunity for much usage per instructional entity or unit. The second point of view is that the combination of compactness and low cost makes it possible for all learners to have a copy of the device and instructional materials in their private living quarters where it is continuously accessible to the spare moments of the learner, as well as for more extended periods of study time.

(Incidentally, books may be printed in M/F, and these may include reading for entertainment as well as study materials. This may add to M/F justification.)

Specifications for Searching the Instructional Vehicle Inventory (05.06)

In this example, the search specification is simple: it consists of "static graphics" as defined in the ETAM context.

In this case, however, it is simple to become more specific in identifying the names of the relevant media. These are:

All printed materials used for instructional purposes except student evaluation tests.

All slides, foils, and other single image transparencies for projection purposes.

All charts, diagrams, tables, pictures.

Manuals of operating instructions -- if they are used for teaching purposes. If these manuals will be used on the job in M/F form, there is a clear cost advantage for using them in M/F training. If this is not the case, a separate assessment should be made that compares a redundant M/F version for training with paper manuals used both for training and on the job. It should be recognized that the shift from M/F to paper will call for some adjustment by the incumbent, but this may be transitory, especially if there is a common indexing structure to the two versions.

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

Identification of Relevant Inventory of Training "Vehicles" (05.07)

The listing of types of static image representations culled out of the total inventory list will identify the contexts of application and use. Of the total list, a number of items may be judged inapplicable for M/F treatment. For example, a class schedule which directs where and when a student will take what classes should obviously be on paper that the student can carry with him. Some condensed "pocket guides" of definitions, general structures of relationships (such as the schematic of a procedure or a device) should be on paper carried by the student for rapid reference either at odd moments or in connection with study.

After making a number of detailed examinations of items in the list, the assessor may decide, on the basis of the sample he has examined, that a reasonable estimate is that 95% of all the applicable types of a given medium (say, paper print) is subject to M/F application and apply this formula to the remainder of the relevant items. The potential error in the final assessment contributed by such estimates will probably fall into the cracks of estimating unreliability.

Identify Benefit Pattern for Instructional Vehicles (05.08)

Separate comparison breakdowns of unit costs would be prepared for instructional materials on paper, on slides, foils, charts, and for M/F for similar materials.

Cost data would be obtained from samples typical of each medium according to the following:

Preparation of the image content to a process-ready state.

Image reproduction, singly and in groups representative of a collected unit -- such as a booklet, or training element.

Cost of raw materials; spoilage and wastage factors.

Distribution costs.

Update (with typical examples) costs to process, distribute and enter into user image files.

Inventory maintenance costs: storage, handling, obsolescence.

Medium holding and handling materials: book binding, slide mounts and holders, etc.

Associated display device costs per unit of use; e.g., M/F viewer or slide projector.

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

To these cost comparisons will be added benefits data from Task Training analysis.

Identification of the Learning Objective (05.10).

Those listed in the Task 1 Description of the Microfiche Technology will be sustained and repeated here. In general, they are:

Reference knowledge.
Enabling knowledge.
Some task formats to limited stages of learning.
Some transactional procedures to limited stages of learning.

Further specifications of objectives will be made in the respective topics cited above in later sections of this analysis.

Preliminary Evaluation of Importance of Benefits (05.11)

Further examination of the potential benefits of the technology as applied to shipboard training has sustained the evaluations of importance made earlier.

1. The training objectives, if feasible in this environment, are at least of moderate importance and could become, if sufficiently widespread, of very substantial importance.

2. The magnitude of the benefit, if microfiche became a key factor in the practicality of widespread shipboard training in job knowledges and formats, could assume very substantial importance to the Navy. This is on the assumption that some x percentage (to be estimated) of all shore-based training could be shifted to shipboard training.

Application of Microfiche to Skill or Knowledge Training (05.12)

Assessment will be made both in the knowledge branch and the skills branch of the analytic procedure.

Task Structure Elements in Skills Relevant to M/F Instruction (05.13)

The assumption is that the M/F device or viewer is advanced manually frame by frame. Advance may be relatively random with respect to frames on a given M/F card. The content of the frames on a card may be designed so that the center row across the card contains the primary level of instruction sequence. If the student requires more procedural information at a given frame in the primary row, he moves to the frame a row above or below the primary frame. Each row contains a standard category of information to supplement the primary row. A given row may contain workbook information, or test questions for the primary frame in its column. Depending on his needs, the student can obtain

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

supplemental instruction at any point, and test himself. (These procedures have been described in an R&D report, and demonstrated to be effective.)

The question in this topic is what skills or components of skills can be learned merely from static displays, without timing constraints, and where the student expresses his response output symbolically and must himself determine, from displayed information, whether his response was adequate or inadequate. (Separate analysis will be given to knowledge and task format objectives.)

Goal-Image. These can be learned to the extent that the goal-image can be displayed realistically in the form of text, diagram, or picture. The image represents the appearance of a state of affairs when the task is properly performed as contrasted with outcomes when the task is improperly performed. The student learns to make the discriminations. In the process of instruction, he may be given analytic guidance for making these judgments, but ultimately he may have to recognize all-at-once whether the picture is correct or incorrect, and specify what should have been done, or what should now be done to correct the goal-picture.

Some examples of goal-images learnable by M/F are:

Correctly filled-in questionnaires of a given kind, or other transactional documents; dietary menus.

Sighting pictures.

Wave shapes shown on test instruments.

Diagrammatic and verbal descriptions of battle plans.

Except for the first item, all of these are examples of learning that call for Identifications and, in some cases, Interpretations. The first example in the list, although legitimate to Goal-Image, may be equally legitimate as an instructional factor in "decision-making" and "constructing" formats. The fact that examples for Goal-Image teachable by M/F can dissipate into other more inclusive categories of learning operations suggests that we abandon this as a search descriptor, and expect little loss in the range-of-effect picture.

Scan-Detect. Only the scanning-detecting in static images will be applicable and this element should, therefore, probably be included as members of a set extending to Identify. The types of task content for this category applicable to M/F clearly are maps, charts, blueprints, semi-symbolic representations such as radar displays, and materials used in photo-reconnaissance interpretation. Knowing the applicability of these examples of content should help the investigator judge whether to accept or reject the hits made by the Scan-Detect-Identify search on job tasks or on training course descriptions.

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

The large number of training and test examples that can be put into small physical space on M/F for individual use make this an excellent medium. This value is augmented by the student's ready access to supplementary guidance for each problem presented. Useful skill levels in scan-detect-identify are acquired only when there is the speed and reliability of performance that can be attained only by many hundreds of practice examples. This is not a trivial training function where it is applicable.

Identify. Part of this task function's applicability has been treated in the Scan-Detect topic. What is additionally applicable to the learning of task information consists of:

> Nomenclature: naming and identifying work objects, processes and characteristics; specifying or recognizing their location and physical relationships to other work objects.

The learning of task nomenclature is often not a trivial operation and can be a useful substrate to learning the procedures that apply to the work objects denoted by the nomenclature. M/F and a manually operated device may not be ideal for learning this kind of content, but it can serve adequately, especially if supported with effective student testing operations.

Interpret. Unless the task is time-driven, the capacity for M/F to deliver hierarchically organized and accessible information should make it useful for training up to at least intermediate competence in the "interpreting" demands of many tasks. A situation may be displayed, and the student is required to interpret its significance either as to the circumstances that caused the pattern of conditions to appear, or in the judgmental aspects of selecting a useful task response. It is perhaps more useful for the student to be exposed to a large number and wide variety of situations requiring interpretations, than to engage him in profound analysis of a limited number of examples. A substantial aspect of his training and performance is in his ability to hold in mind the context of information upon which the interpretation is based.

Examples that would apply to M/F instruction are:

> A pattern of symptoms in a device, where its interpretation could result in determining (a) the cause of the symptoms and/or (b) what capabilities the device still retained for operational performance.

> A pattern of enemy actions is described from which the enemy's intent and objective is to be inferred.

> A pattern of behavior data from an incumbent from which his capabilities and motivations are to be inferred.

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

A pattern of signals is apprehended through a noisy channel from which the entire message is to be reconstructed.

A pattern of symbols is displayed on a map, or other type of diagram is presented from which the actual physical characteristics of the objects symbolized are to be interpreted so that they would be recognizable if present.

The foregoing would be guides for identifying training objectives and their contexts that might be identified under "Interpretation" but require additional judgmental criteria for selection as candidates for training with M/F, at least to intermediate stages of competence in the task element.

Interpret. Where the meaning or significance of a pattern of cues must be translated into an inference about a probable state of affairs, and there is little interaction allowed in the task itself for specific inquiry for further data, M/F can provide useful instruction. But in the contexts of relevance to M/F capabilities, the content of such instruction can more usefully be characterized as "task-enabling knowledge."

What will be excluded from consideration for M/F training will be such meanings of interpret as: interpret from one language to another, and Morse code interpreting. Although it is possible to use a static medium for learning many aspects of a language translating skill, and perhaps especially if it is coupled to an audio input function to the student, the M/F medium is apt to be highly inefficient. (If there are empirical demonstrations to the contrary, the data should have primacy in guidance.)

The interpreting function draws upon task-enabling knowledge, so we can expect overlap of instructional content that is drawn from a task requirement using a term like "interpret" or deduce or figure out or similar expression with content that is drawn from descriptions of job and task knowledge, especially where the criterion of "enabling" has been used as a filter of content.

Note: The brevity of treatment of a topic, such as the present one, should not be misinterpreted to mean that little or unimportant instructional material will be derived from it. In this case, it is the contrary. In a fair number of tasks there can be substantial instructional content derived that is applicable to "interpret."

Procedures Performance. Microfiche technology -- with the simple viewing mechanism postulated for this assessment -- can train in any procedures which have been amenable to conventional Programmed Instruction. Thus, any PI on a paper medium could be readily translated into the M/F medium with somewhat greater flexibility in sequencing and material than is practical (in terms of the student) with paper.

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

Note that "formats" for procedures will be treated in a later section. In this section, the concern is about instruction in skill learning.

M/F lends itself to instruction in procedures that are restricted to symbolic materials and symbolic operations. It would be somewhat less efficient than, say, a computerized capability of answer analysis and branching to specifically suitable remediation. (One can be overly preoccupied with this kind of efficiency and neglect comparing the real benefits with the very real costs!) Examples of symbolic materials and operations are:

Learning and applying calculational rules.

Navigational calculations with various kinds of input data as given.

Performing statistical analyses and interpretations.

Filing procedures; setting up files.

Most clerical transactional procedures (see the analytic definition of "transaction" in the Appendix A section called Task Formats as a guide for applicable task structures here.)

Decide. At least preliminary training (at the decision format level) can be given in classes of decision that are well-structured (all variables relevant to the decision class readily prepresented), where the apprehending of the problem information is not dependent on absolute time values, and where the decision itself is not time dependent. Furthermore, because of the limitations of the medium and device, the problem information must be presented in a form where the variables have already been symbolized (the learner does not have to identify the variable and the value in a complex perceptual environment) and usually the learner has only to select from a restricted set of response alternatives.

Static display media, while able to give limited practice to the judgmental aspects of linking a problem situation to a decision response, may give extensive "task-reference knowledge" by giving the learner the implications of selecting various choices in a given kind of situation. Acquiring information that enables judgment in decision making is often difficult in real life because the incumbent frequently does not see the outcome of his choice, or if he does, so much time separates his making the decision from learning the outcome, that learning is inefficient and unreliable. Thus, although the learner may, with this medium, acquire only limited levels of skill in actual decision making, he can acquire verbal and conceptual information that will assist in that skill. In summary of this point, he can be given practice enabling him to anticipate outcome

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probabilities from selecting a given choice, as well as in the learning of the variety of options he may have available from which to choose. These might be called "task-enabling knowledges" for decision making.

Some decision-making task formats may be learned with the M/F meduim and the simple display device.

A qualification should be made here. The development of instructional content that will generate useful practice and learning even in the preliminary aspects of decision making (coping with uncertainty in problem situations varying in their degree of explicit structure), requires a high level of teaching art and insight into human decision processes. This level of talent is likely to be rare. A practical decision in assessment might well be to forego "decision making" as a task element for which M/F and the simple display device is a fruitful application.

Construct. The same arguments developed for Decide apply here, except that the limitations of the medium and the dependence on the art of the instructional content designer is even greater. "Construct" is not a promising candidate except for perhaps very rare tasks. The learning of task-reference knowledge to support skills in a given kind of constructing can probably be done with M/F, although not with ideal efficiency.

Microfiche and simple viewers hold little or no promise for instruction in the following task elements: Tracking, Motor Performance, Interpersonal Interaction, Recall of Task Cycle Information, or Recall of Enabling Information. The last two task elements are processes subsumed under other rubrics: M/F does not offer as a medium any special properties for either type of recall that are not shared or utilized by competing media.

In summary, we have the following descriptors that, with some qualifications in all cases, can be used to search the data base description of courses that include skill (or "practical factors") training.

Goal-Image: heavily restricted to tasks dealing with verbal formats and content, some perceptual skills in differentiation, and diagrammatic representations of task content.

Scan-Detect-Identify: cognitive content in maps, charts, blueprints, semi-symbolic representations such as radar displays, and photo-reconnaissance.

Identify: nomenclature, identifications and locations of work objects. (This item will be repeated in "Enabling

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

Knowledge".) Also the identification of <u>patterns</u> of elements that in combination become an identifiable entity.

Interpret: enabling knowledges that enable the operator to determine the meanings implied by patterns of task cues. (Note a distinction between identifying a pattern and interpreting what the pattern means).

Procedure Performance: in skill learning, restricted to early and preliminary levels of symbolic tasks and materials: calculations, navigational calculations and logic; clerical transactions -- as examples.

Decide: at least preliminary skill training beyond the level of decision formats, but in tasks where the actual problem information is presented symbolically as cognitive content and not time-dependent such as the decision to abort a landing on a carrier, or where the context of problem and resource is so complex that it cannot usefully be presented in static displays. Best bets are clerical transactions which demand "judgment" in the face of some indeterminacy and uncertainty.

Construct: only task-enabling formats for constructing a class of entity.

No additional task elements seem appropriate to the M/F medium except as they have been already treated in other task elements or in the enabling knowledge.

<u>Identify Relevant Jobs and Tasks</u> (05.14)

In the present assessment, this step will be skipped. The reason is that the major targets for M/F will be "knowledge" courses, and the "knowledge" component in practical skills courses.

If, however, a job-task data base were to be learned, the task element names selected in 05.13 would be applied with the following restrictive specification:

<u>Equipment and objects used in the task</u>: "symbolic".

<u>Reference information used in performing the task</u>: "symbolic; AND/OR static perceptual."

<u>Relevant Stage of Learning</u> (05.15)

Different classes of learning objectives applicable for microfiche as a medium -- and the simple viewer -- can be learned to somewhat different stages from the point of view of their contribution to task

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

performance level. Refer to the objectives selected in Subtask 05.10.

Reference Knowledge: although these can be learned to reliable levels as knowledge, practice in the context of the task itself is required for their effective integration into performance. Thus, with regard to a task performance criterion, reference knowledge will be learned "to the verbal level".

Enabling Knowledge: the same applies here as for Reference Knowledge. Stage of learning will be to the verbal level, except in the case of Transactional Procedures, treated below.

Task Formats: with respect to symbolic or perceptual tasks, the M/F training could take the student to "Performing Task Components with Guidance."

Transactional Procedures: the qualifications made in 05.13 should be recalled here. The tasks that fit the qualifications can probably be learned to the level of "Doing the Entire Task/Job Procedurally: Barely Acceptable Mastery." The student's reaching this level will depend, among other things, on the degree to which the practice content has adequately sampled the range of problem situations in the real job environment.

All Procedural Operations: although the initial objectives for M/F usage did not identify refresher training, M/F could be given on jobs currently being held by the incumbent-student and especially over knowledges and procedures that may be rarely used. Refresher training may also be given to students who have completed courses of training but who have not been assigned to jobs in which they can exercise that training. The present assessment will not include refresher training in the analysis because its inclusion could cloud the main issue of M/F as primary training. But its shipboard use for refresher training could be a strategy for widening its usage to primary training, and thus gain acceptance progressively.

Refresher training would be applicable to all incumbents in their present job positions. It would also apply to all incumbents who had training in duties into which they had not yet been assigned.

Identify Relevant Courses (05.16)

Some labor saving strategies may be used in determining courses and course content applicable to M/F instruction. Some of the following repeats advice offered in the introduction to Task 5

1. Courses that are primarily knowledge and theory background for practical skills training. Except for testing and student evaluation, virtually all instructional functions

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

provided by lecture and paper can be taken over by M/F. Whether the motivational functions of the classroom environment (such as they are) can be replaced in the self-teaching environment would require empirical inquiry. The equivalent in classroom course hours (which normally does not include self-study hours) in M/F study hours might need to be determined empirically in any benefits evaluation, although student time of shipboard given to study may have a different cost and value than student time in shore-based training.

2. Skills courses potentially applicable to shipboard training.

Training Units Within Courses (05.17)

Within skill courses, the following training units or objectives will be applicable to M/F instruction.

1. Any type of knowledge as identified in Subtask 05.19.

2. Procedural and transaction formats as defined in Subtask 05.23.

3. Nomenclature and identifications specific to task and environment.

4. Task structure elements as summarized at the end of the writeup for Subtask 05.13 in this assessment report.

Procedural Comment. A short-cut for making estimations can be based on sampling procedure. Subdivide all skills courses considered eligible for shipboard training into groups that deal with (a) operational skills with equipment; (b) maintenance jobs; (c) service and miscellaneous jobs, including clerical; and (d) command jobs. Within each group, choose at random half a dozen course descriptions at the most detailed level available. Make an analysis, objective by objective, of each item of training in the course description that fits the applicability to M/F according to the search criteria established in Task 5. Make an estimate of the ratio of the training hours of M/F material to the total course hours. Thus for one course in a group, the M/F applicable content may be 25% of the total hours; for a second course it may be 22%; for a third 28%. If there is relatively little practical variation among the samples of these ratios for the group of course, choose the representative value among the sample ratios and extrapolate to the ratio value for the entire set of courses in that type of course. If the sample values fall within a 10% range for 90% of the sample members, it would seem safe to choose a mean or median of the sample values as representative of that class of courses.

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

In some job and training specifications, the Navy has already made a division between knowledge content and practical skills content. Thus, in the Personnel Qualification Standards, the 100 series and the 200 series are directly applicable to knowledge training, hence to M/F.

In the format used for the Navy's "Occupational Standards Workshop Worksheets," the knowledge factors are separated from the Practical Factors (skills).

Where job specifications of these kinds are reflected in the specifications of training objectives, the identification of M/F applicable training is tedious rather than complicated.

As a course applicable both to shipboard training and to the M/F medium is identified, the projected numbers of students for that course is noted. These numbers will be used to put scale into the magnitude of the potential M/F application.

Assessing the Benefit Pattern (05.18)

The two innovations that are jointly to be assessed consist of the substitution of M/F medium, plus simple viewer, for paper in instructional materials -- with the unassessed by-product in M/F substitution for many Navy technical manuals now on paper -- and the substitution of shipboard training for a large proportion of shore-based training. In both of these factors, the major benefit to be expected is a savings in costs. In part at least, the ability to reduce the bulk of training material from that of paper to that of M/F, makes it practical as a "necessary" condition for shipboard training. The range of training (in terms of courses and jobs affected) and the importance of what can be learned with it makes shipboard training feasible.

But shipboard training will be shown to be practical (assuming that conflict with operational exigencies has been adequately managed) if cost factors for shipboard training compare favorably with costs for shore-based training. Making this comparison requires invoking the cost model for shore training and an equivalent cost model applicable to shipboard training.

A factor not previously examined about shipboard training is that of supplemental devices, including samples of operational equipment, for training in actual skills (the practical factors) for which knowledge and format learning is merely a precursor. Either such skills-training equipment is on the ship, or the student must acquire the practical skills in shore-based schools, or the "skills" factor will be satisfied (for advancement purposes) by verbal learning, including descriptions of procedures.

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

The most realistic assumption is that only those skills courses will be taught on a ship for which there are copies of operational equipment on which students can learn skilled performance. But this assumption in practice has costs, possibly including operational costs and risks, which complicate the shipboard training picture, beginning with acceptability to the commander of the ship.

Let us assume that cost comparisons have been performed and qualified by judgments of probability of achieving the cost-benefits of M/F. Let's now make a pass at the questions in 05.18.

1. Reduction in training time. None expected. If M/F increases training time as compared with shore-based training, the costs are not relevant to any budget.

2. Reductions in attrition rate. There are somewhat different factors that, a priori, seem to work for and against attrition rates in shore-based conventional training and shipboard training. Shipboard, the trainee works at his own rate, and there is little or no penalty if he takes twice as many study hours to complete an objective to criterion mastery as some other student. On the other hand, he may have less direct association with instructors on shipboard who could help him past a learning obstacle, or to motivate him individually to keep on trying. All together, one set of factors seems to cancel out the other.

3. Reductions in student aptitude. Because there is little expense (as compared with shore-based training) in committing a student to shipboard training, it is feasible to lower the aptitude levels for shipboard training and take a greater chance on the student's success in completing the course on the assumptions that (a) aptitude tests have substantial standard errors of prediction and (b) the student can take more time to complete the course requirements. This policy ignores the possibility that there is a relationship between an aptitude score and the ultimate level of the incumbent's skill no matter how much training he was given. Any estimate that student aptitude could, in general, be somewhat reduced because of the M/F shipboard capability, would have to be close to zero benefit.

   There is this proviso, however. It has been said that in many cases the difficulty of the cognitive (knowledge) materials in training such as, for example, "Theory of Operation," is one major basis for many student's attrition. If success in such knowledges has a low correlation with eventual success on the job, then any training procedures which help the student get past his formal knowledge

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOBY (Continued)...

requirements will increase his opportunities for getting into practical training and, thus, to the job. If this argument is justified, then the flexibility offered by individualized paths through M/F would lower the aptitude requirement, perhaps by substantial amounts.

4. Supplemental benefits. Shipboard training may have highly useful side-benefits to the ship as well as to the man. There is at least indirect psychological justification for the belief that "learning activities" and "job activities" should not be separate blocks of activity, but that the learning process and the motivation to learn should be continuous in a person's lifetime. The intellectual struggle to learn something new during prescribed hours of the day may well reflect in greater alertness and inquiry in the hours spent on the job, even though the content of what is being learned differs widely from the content of the job. Opinions of this kind remain to be empirically validated across wider populations than merely the professionals where, in industry, this assumption is being applied. People take courses as a part of their work-day, and presumably some of the stimulation rubs off into their work.

Like many really important values and "benefits", this "stimulus to learn" is not susceptible to quantitative assessment. In degree, it would be applicable to all job incumbents who were also students, and apply to all jobs and tasks. It would have at least a moderate importance to the quality of performance of the Navy mission, the morale of the crew, and presumably of the reenlistment rate of desirable personnel.

This factor should probably be stated as a qualitative plus to the decision maker rather than in a quantitative format.

Types of knowledge (05.19, 05.20 and 05.21)

Microfiche as a medium and the simple viewer as the device, supplemented by periodic performance testing with other means, can be applicable to the learning of any type of knowledge for which the student is motivated to learn. For some types of knowledge learning, there may be other interactive arrangements that can be more efficient. But the skill with which the instructional content is designed, displayed, and sequenced may be more important than any combination of other factors for efficiency in learning and effectiveness in retention and application.

All classes of Reference Knowledge (05.20) and Enabling Knowledge (05.21) are applicable. The more significant classes of knowledge under these rubrics are:

EXHIBIT: ETAM EVALUATION OF MICROIMAGE TECHNOLOGY (Continued)...

System purposes.

Contexts of operation.

Theory of operation.

Enabling facts and prescriptive rules.

Concepts and principles.

Nomenclature, identification and locations of work objects.

Procedure descriptions.

Types of Task Formats (05.23)

The following types of format are susceptible to learning from the M/F medium and the simple viewer. This combination is somewhat more flexible for branching purposes than is paper, but far less so than a computer-driven display terminal. The branching requirement is essential for enabling the student to try out various alternatives, and to determine the implications of various alternatives, as well as to present to him contingencies that may be associated with a "standard" situation.

Procedural Formats: the general sequence of actions whereby something gets done.

Transaction Formats: preskill and skill learning in performing more or less routinized, well-structured transactions (often of a clerical type) that involve filling out of forms, or translating information from input forms into output forms with some processing judgment.

Decision Formats: learning the variables of problem and resource to keep in mind and optimize in choice-making activities. Extent to which the student's management of "branching" operations in M/F enables skill development in use of the format on task samples will probably depend on the specifics of the decision-making task and information content. Decisions of the clerical type associated with transaction formats, identified above, can almost certainly be done with M/F because the task usually presents limited alternatives.

Conclusion to the Assessment Exercise

In many ways, the problem of M/F and shipboard training is an example that is not representative of the primary objective of ETAM which is rather consistently pointed towards practical skill training. But perhaps this is why it may be a useful test of the procedure.

An attempt has been made to express not merely assessment outcomes -- which could be done in a very few pages -- but the lines of thinking, with the format of ETAM as a guide, to the conclusions made. It should also be noted that the conclusions reached had the benefit of almost no empirical data given in the Task 1 statement, as to the capabilities of M/F, other than that it could serve as a medium at least as good as paper (and other static presentation media) for whatever could be taught and learned with paper.

One intent for ETAM was that assessors would be led to think constructively about many things which might otherwise be ignored. Even though the ETAM formats and rationales were created over a number of months and with the help of a number of problem scenarios, it was found that the present format was a significant probe and stimulus. It is hoped that the reader of the exercise will vicariously share this observation.

An attempt has also been made to show examples of by-passing procedural steps when common sense or invention justified the by-passing. Although the ETAM procedures emphasize that the assessors make analytic short-cuts when their objectives are clear and limited, examples may be more forceful in communicating this procedural flexibility. Analysis should not, in principle, be more extensive than is required to make the decision which is the objective of that analysis. It is possible, of course, for the analysis to reveal what the nature of the decision should be.

Another major value in this form of assessment is that, by being structured and its response made in writing, it can be reviewed by others who may be better informed or who have additional insights. These may contribute to effective modifications leading to better decisions about acceptance, rejections, or "more study." But perhaps just as important, the added qualifications and insights may lead to the superior use of an "innovation," or better safeguards against its misuse. Thus, the assessment process itself makes contributions to the technology of education and training under conditions favorable to the direct application of that technology: the actual practices of instruction and of learning.

# SECTION VI

## ETAM VALIDITY AND UTILITY

The validation of a procedure can be split into several parts. One is the extent of flexibility and adaptability of the procedure to a variety of conditions and objectives. A second is whether the procedures can be followed, and with what difficulties, uncertainties and pitfalls. The third aspect of validation is the evaluation of how good the results of following the procedures can be.

### FLEXIBILITY

It is unnecessary to crank an assessment through the entire ETAM procedures in order to present data to the decision process. The description of the innovation, as structured in Task 1, may be passed directly to Tasks 3 and 4 where they can be formatted for presentation to the decision maker. Wherever the pattern of the benefits projected from a proposed innovation sufficiently outweighs the costs and liabilities, the combined patterns may bypass the remainder of the data collecting and analysis steps, and be presented to the decision maker.

Task 5 assists the assessor to probe into the fullest potential range of effect of the innovation in terms of extent and boundary limits. But if at any stage of inquiry, a sufficient range of effect has been determined to justify a benefits-to-cost decision, further analysis can be halted and the case can be presented to the decision maker. If gross, overall estimates of a benefit are justified, (say for all of a given type of course) it is unnecessary to undertake analytic work for each individual course and sum the totals. If, however, a decision is made to accept the innovation and at the same time specify a program for implementing the decision in practice, the full-scale analysis in Task 5 should be made for that purpose.

Task 3 in ETAM poses a number of key questions to be addressed to the proposed innovation. Even one crucial negative answer can justify terminating further assessment because the innovation has failed to meet a necessary condition to acceptance: so why continue further?

The assessor is invited in Task 8 to anticipate the kind of data presentation and analysis that the decision makers will want. Some will prefer emphasis on the financial analysis developed in Task 7, others will consider the output of the benefit-cost analysis in Task 6 as the more important input to the decision process. Furthermore, the decision maker may prefer to ignore the outputs of the analytic models and prefer to base his decision on the picture of the raw benefits, costs, liabilities and probability data developed in Tasks 1, 3 and 5; as well as on several alternatives which may have been developed in Task 2.

This flexibility in ETAM procedures, while increasing its versatility and responsiveness to the needs of the occasion, also increases the difficulty in "evaluating" those procedures according to fixed criteria on quality of outcome. By definition, a rigid entity is more easily evaluated than a flexible entity.

It is possible that in the future some policy makers will deplore the existing options for bypassing large segments of formal analysis in ETAM. The existing exits can be blocked off readily enough--but the choice should lie with the using agency.

## VALIDATION OF THE LOGICAL STRUCTURE OF ETAM

Formal presentations of the procedural structure of ETAM Tasks 1 through 8 have been given to representatives of the sponsor and to associated Navy agencies. Although constructive comments were made that led to changes in procedure and nomenclature, no fundamental flaws were revealed in the course of these reviews. This is supportive rather than conclusive evidence that flaws do not exist, but they do not seem evident to inspection by experts in training systems and in decision systems.

## SCENARIO APPLICATIONS OF THE PROCEDURE

ETAM procedures were conceived and formalized around a number of hypothetical "scenarios." Several of these exist in preliminary working papers, and were one major basis for communications with the project consultant, Dr. Gagné.

Section V of this report contains a full-dress evaluation scenario of a hypothetical innovation that was carried through all tasks up to and including the presentation of decision-making content. This example is the most comprehensive "validation" of the ETAM procedure to this date. Each step could be readily performed. Where the assessor was uncertain about expected outcomes, this uncertainty, and its approximate level, could be expressed formally. In this sense, a major objective of ETAM to get as much information as possible that was available to the assessing team, including the expression of tentativity, was clearly realized. One does not need to get stuck and be unable to proceed in the procedures because one lacks absolute data at any given point. Ignorance and undertainty, by being expressed, become legitimate evaluation data.

A second scenario treats only a portion of the ETAM procedures, focusing more on the selection of relevant variables and on the effects of decision-making upon the management and measurements systems. It was not so much a validation of the usability of the procedures as much as a vehicle for developing an awareness by decision makers of the potential implications of their decisions.

A third major scenario run-through was made on a problem assigned by a representative of TAEG: shipboard training using micro-image in the form of microfiche and standard viewer. The primary objective in this exercise was to test the usability of procedural Tasks 1, 3 and especially 5. The results of that exercise are also reported in Section V of this report. The scenario may be useful in showing the adapatability of the framework to short cuts, key issues, and especially to the classificatory structure for determining limits to the range of applicability of the stipulated proposal. If functions are added to the stipulated innovation, the benefits conferred by these functions in terms of extended range of training effect can be readily identified.

A cost and business assessment was not required of the microfiche assessment exercise, although the data leading to that phase of assessment were pointed to.

Since in all three of these scenarious the assessors were by necessity also the developers of the procedures, their representativeness of future ETAM users may be questioned. But no claim is made that assessment based on limited information applied to a wide range of semi-knowns will be simple or automatic. The written assessments should be evidence, however, that the procedure can be made to work. The results of the microfiche assessment and the "Three-D Procedure Trainer" assessment revealed that the structure of the procedure fostered both creative and analytic thought, and offered a clear pathway through a potential jungle of possibilities.

ETAM should be validated further by consultant level persons and decision makers within the naval training function all of whom have accepted the stipulations of training in ETAM concepts and procedures, but who were not part of the development team.

This should lead to the determination of the levels of decision-making sophistication that are practical to use for the officials responsible to make them. But because ETAM is not tied exclusively to any one format of presentation to the decision maker, he can elect to use what is congenial to him.

EVALUATIONS OF THE PROJECT CONSULTANT, DR. R. M. GAGNÉ

Dr. Gagné is an international authority on education and training technologies both as a researcher and as an application development consultant. He has shared a continuing interest in pragmatic taxonomies especially in educational content and process. He has been intimately exposed to the conceptual anatomy of ETAM during all stages of its development. His counsel has been an invaluable contribution.

He concluded his detailed and exhaustive review of the content of the Preliminary ETAM report with the following overview comments in his letter of June 11, 1975.

On Section V (scenario examples):

"Seeing the procedure followed in its entirety is highly illuminating."

On the procedures and report overall:

"My thoughts about the analysis and procedure are these:

"1. It seems to me that the system proposed is definitely a feasible one. Innovations and other proposed changes can be evaluated in this way.

"2. The procedure described is highly comprehensive and thorough. It takes into account what seems to be the full range of factors which might influence a decision, and which might contribute to such a decision. It encompasses a very great range of materials, hardware and procedures that might be proposed for the purpose of accomplishing improvements in the cost-effectiveness ratio applicable to training operations. It considers the entire range of Navy jobs or job functions for which training might be given or proposed to be given.

"3. As a consequence of this comprehensiveness, it is a procedure which might be described as elaborate. I assume that a thorough procedure is what the Navy wishes to have. However, it needs to be said that simpler procedures, involving fewer steps, can readily be conceived. What any of these would do would be to "cut corners," that is, to make assumptions which are based upon informed judgment, rather than upon detailed consideration of all the sources of "hard" data that can be made available. Of course, cutting corners also means approaching more closely the procedures that already currently exist.

"4. Surely one of the most valuable contributions of the proposed system is its approach to the task of estimating range of effect. It would appear that there has been no truly systematic way to do this up to now, among Navy procedures. The ideas of deriving decisions from (a) the categories of training outcome, (b) the levels of training, and (c) the effects on job performance represent techniques of great originality and also of practicality. Existing procedures tend to neglect these factors, so that they do not enter into the estimates of effects of innovations in systematic ways. As a result, inadequate estimations of the effectiveness portion of the cost-effectiveness equation are likely to be made. The inclusion of range of effect estimation procedures makes possible the elimination of this potential inadequacy.

"5. The additional value of range-of-effect procedures should also be mentioned. An introductory statement in this report speaks of this procedure as follows (p. I-3): "a descriptive and analytic terminology that can be applied to data base descriptions of instructional vehicles and their relevant properties, job tasks and their relevant properties and training courses and content within training courses." The broad applicability of such a planning tool reaches far beyond the single activity of estimating cost-effectiveness of an innovation.

"6. The procedure seems no less thorough in its identification and estimation of cost factors. Although this part of the cost-effectiveness has always seemed relatively the easier (because of the assumed existence of "hard" data), it is notable that the sources of costs in this system appear to be fully covered, whether they seem initially large or small. This aspect of the system also contributes in no small measure to its precision.

"7. On the whole, I consider the proposed system, to which I have contributed only as a critic and evaluator, a very substantial accomplishment, of outstanding conceptual soundness."

This ends the quotations from Dr. Gagné's evaluations. His point number 3, directed at the preliminary version of ETAM, has resulted in changes in the final version which emphasize and underscore opportunities for "short-cuts" and procedural simplifications where the data available and the nature of the decision justify short-cuts.

Dr. Gagné, commenting on recommendations in the report for further ETAM effort, endorsed the studies proposed, and made the following assertion relevant to evaluation of ETAM:

"Developing a computerized assessment model ... would indeed be a challenging task. It would seem that ETAM in its fully conceived form could only be evaluated in this way. It would be good to see it done."

## COMMENTS ON THE DECISION MODELS

The primary validation emphasis was on the use of the decision tree framework outlined in Tasks 3, 4 and 6. One validation question was concerned with the structure of the decision tree itself. A second dealt with the approach used in handling utility functions with multiple attributes.

As a result of the concern that the original decision tree did not permit variations in the way risk reduction projects were packaged (and thus did not permit combinations that might perhaps be more cost-beneficial), the decision tree was redesigned to allow the decision variable to be calculated for more than one project grouping. Also, the new tree incorporated a project success probability not available in the original tree. The new format resulted from a review of the decision tree framework by Dr. William Giauque of the Naval Postgraduate School, Monterey, California.

A second key question concerned the use of the additive (rather than the multiplicative) model for multi-attributed utilities. Dr. Giauque was again consulted. A number of cautionary notes were inserted into the procedures based upon his recommendations, however, it appeared from formulating several analytic possibilities that the additive form would be valid for the high majority of proposals with which ETAM would be concerned.

It is recognized that the scaling methodology for the "importance" factor needs further study and refinement. An ETAM predevelopment study has been recommended in Section I of this report.

## CONCLUDING REMARKS

The logical structure of ETAM as a conceptual model of assessment parameters that are comprehensive and relevant has not been challenged. These include the taxonomic parameters which lead to (a) identification of key rejection factors in assessing an innovation (Task 3); (b) potential range of effect analysis (Task 5); (c) presentation of assessment data to the decision-making process (Tasks 4, 6, 7 and 8).

The center of concern has been the implied amount of labor and level of skill for responding to the apparently large number of steps and alternatives (as offered by the cost and benefit taxonomies) contained in the procedures. Figure VI-1 shows rough estimates of time to apply ETAM to a range of innovations. The bulk of the voluminous report itself is intimidating. The question is asked: "Is the outcome of an assessment worth all this trouble?" This is a cost-effectiveness question, and can be answered only by reference to the costs and effectiveness measures of existing or alternative practices in reaching decisions about acceptance or rejection of innovations or other structural changes in the Navy's education and training picture. A clear-cut "decision point" often cannot be ascertained in traditional practices but rather what appears is a network of localized pressure points, and unshared rationales and objectives. Neither the costs, nor the benefits, liabilities, and risks can be determined from such processes.

Revisions in the ETAM statements of procedure in the preliminary version have emphasized where and how short-cuts can be taken. In this respect, at least opportunities for "simplification" have been offered and justified.

But this still leaves the large bulk of pages making up the procedural "map" of ETAM, a formidable tome comparable to the size of an operating and maintenance manual for a piece of radar gear. It is proposed that ETAM be implemented on a conversationally interactive display terminal. This facility will simplify the procedure in several ways. One, it suppresses procedural information that is not pertinent to the analytic route--and stage in that route--which is of significance to the assessor. The user retrieves selectively both type of content and level of content. Two, it relieves the user from the labors of computation. Three, not only are appropriate data formats presented for the entering of data values, but these data values are automatically transcribed to output formats in whatever variety have been established. The computerized implementation would enable a "human factors" validation, as contrasted with the "logical validation" of the ETAM procedures.

The reduction of clerical paper shuffling and arithmetic will not, however, eliminate "complexity" from the task of making predictive assessments. This complexity is inherent in coping with uncertainty and incomplete information in the problem to be solved. Finally, human judgments of "relative importance" and "probability of given outcomes" will have to be made, however simplified the format structures for making these judgments. In general, the more important and far-reaching the outcome, the greater the range of uncertainty because of the incompleteness of "hard data." It would be dishonest and dysfunctional to disguise real dependencies on informed human judgment or the effort and cost involved by the exercise of that judgment. The act of creating useful information where it does not exist is not simple even though it has been "simplified."

Because ETAM was explicitly designed as a tool to serve human users, its validation cannot be independent of the skills and diligence of the user in the role of assessor and in the role of decision maker.

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| | TYPE OF INNOVATION | | |
|---|---|---|---|
| | SIMPLE | AVERAGE | COMPLEX |
| Task 1 | 1 Hr. | 4 Hrs. | 8 Hrs. |
| Task 2 | (Not Included) | (Not Included) | (Not Included) |
| Task 3 | 1 | 2 | 3 |
| Task 4 | 16 | 40 | 160 |
| Task 5 | 8 | 24 | 40 |
| Task 6 | 12 | 16 | 24 |
| Task 7 | 4 | 8 | 12 |
| Task 8 | 8 | 16 | 40 |
| | 50 Hrs. | 106 Hrs. | 287 Hrs. |
| | 1.25 Wks | 2.65 Wks | 7.175 Wks. |
| | .29 Mos. | .61 Mos. | 1.65 Mos. |

Figure VI-1. ESTIMATES OF TIME TO PERFORM ASSESSMENT USING ETAM PROCEDURES (ASSUMES AVAILABILITY OF AUTOMATED PROCEDURES)

This level of validation awaits the future, and would be meaningful not so much in the formal exercise as in the nature and scale of adoption. ETAM represents systematic rationality on a broad scale, and in many environments now, would be a cultural as well as a technical innovation. Cultural acceptance is relatively independent of technical validity, if indeed the two forms of acceptance are distinct from each other. It should be conceded that introducing ETAM into adoption may require inventions for cultural acceptance at least as substantial as the technical inventions required for its creation.

Many of the recommendations for follow-on efforts are directed towards cultural acceptance in the milieu of its intended use. Because it is completely explicit as a decision-making tool, its inadequacies can be identified and remedied with usage. As a structure for retaining archival data, it also enables the quality of decisions to be assessed and thus potentially improved. Because of its scope, decisions in training and education can become coordinated rather than competitive. This would be an ultimate validation.

# APPENDIX A

## SUPPLEMENTARY DESCRIPTIONS OF TASK FORMATS AND TASK ELEMENTS

CONTENTS PAGE



This appendix includes extended descriptions of the task structure elements and their training and learning implications. It is intended to complement the material in Task 5 of the ETAM Procedures (Section III).

# TASK FORMATS IN HUMAN PERFORMANCE

## Introduction

Travelers from the United States to the United Kingdom, who overcome their initial fears, may be pleasantly surprised to discover how quickly they can "reverse" many of their driving habits. The British gearshift is operated by the left hand rather than by the right hand, the driver sits on the right side of the car rather than the left, looks to the left for the rear view mirror rather than to his right, and drives on the left side of the road rather than the right. Many of these reversals have to be performed simultaneously such as when making turns at intersections. The need to reverse scanning patterns for traffic liabilities still further complicates the adaptation. Yet in a relatively few hours, depending on survival during the first few minutes, the driver begins to be comfortable and can even divert his attention to viewing the countryside. The adaptation is made in perhaps a thousandth of one percent of the time required to learn the original driving skill. There is, of course, large individual variation in such adaptability, but this variation may be largely compounded of attitudes towards making the change rather than "information-processing" capabilities.

If we think of the driver's skill only as a set of required fixed linkages between what he sees and what his hands and feet do, it is impossible to account for this rapid adaptation, although it does help account for some of the errors he will tend to make. In addition to, and partly independent of, these eye-hand linkages he has acquired a model or "format" for receiving and processing classes of information that relate (a) his purpose of the moment, (b) his projection of the track of the vehicle into the roadway "corridor" ahead, and (c) the control variables of direction (steering), velocity (accelerator and brake) and power ratio (gearshift positions). The input <u>variables</u> and the output <u>variables</u> in driving remain the same, although the data content is very different. It is this processing format which, when established by learning a task, can mediate substantial shifts of learned patterns of behavior from one context to another.

When a brilliant marketing executive is hired away from a soap company to organize a marketing operation for a clothing firm, his knowledge about soap and soap markets had better be left behind; what will be useful will be his conceptual models and formats about market development strategy that are at least partly independent of the product. The ability of the experienced programmer to learn new programming languages quickly is at least partly mediated by the constants in program language structure and entities.

The design of training and the design of task tools and supports can be enhanced by a workable awareness of how formatting occurs in the learning process, and the various adaptive functions it supports in the economics of behavior.

## Definition

A distinction should be made between the <u>description</u> of a task format and the <u>embodiment</u> of a task format in task activities. The embodiment of a task format in human performance consists of situational variables and the response variables that recur when the task is performed many times. The value assumed

by each variable may change on each occasion the task is performed. Thus, in driving the car, the picture of the projected track or corridor for the automobile through traffic and the transient states of velocity and direction are never twice the same. But the operational variables as variables, are constantly present each time the task is performed.

The format of filling out a purchase requisition is explicit in terms of the information variables printed on the form. The requester of the service -- making the purchase requested by the requisition -- is given the standardized data names that will yield the information essential to providing the service. The printed form is a cultural invention which acknowledges a "task format" in the sense described here. Despite complaints, the printed form is one of the more powerful labor-saving devices for handling transactions among organizations that request and supply services.

The human is capable of learning a large variety of tasks having a variety of structures: perceptual, interpretive, decision-making, constructing, perceptual-motor. The variety of tasks is somewhat paralleled by variety in task formats: we shall be able to see similarities among tasks that superficially appear to differ, and these similarities will help account for the human operator, having learned one of these tasks, to learn quickly the other members in the task group. It would indeed be useful to know if, perhaps a few dozen task format "archetypes" might account for sixty percent to eighty percent of work tasks in our culture.

The reader is again reminded that a task format can be thought about with either of two different references in mind. From one point of view, the reference is to an <u>external</u> structure -- such as a printed transactional form -- while from the second point of view, a task format is part of the behavioral pattern that is learned by an operator in the acquisition of a skill or ability. Both meanings of task format have utility for the intelligent design of task supports and training, and for expectations of transfer of training by the operator from one set of work requirements to another. But unless qualified, the expression "task format" in this paper will refer to a learned pattern of organization in behavior rather than an external representation of a format.

## The Learning of Task Formats

When regularities are repeated in human experience, they become identified and anticipated. This process whereby general patterns are abstracted from the mass of variations occurring on repeated occasions takes place spontaneously in learning the task. Thus, as an individual user of a computer terminal I have learned that the following things have to happen when I use the facility:

The device must be turned on.
I must identify myself with an acceptable code.
I may have to respond to an authorization request.
I must identify the program context I plan to use.
I may have to cope with the system denying me service because it is too busy.
I must request, by suitable identification, work that I have stored in the system on previous occasions, or state that I am engaging in new work.

In some applications several of these operations may be procedurally merged, but I am aware that the variables nevertheless exist. If I am to learn to sign on and use a new application, or a new terminal-computer configuration, I spontaneously ask for the specifics of procedure on each of these variables. This format not only structures my getting information about a modified task "content:, it also helps me remember it and apply what I have learned. The model may also help me interpret why something goes wrong when it does. Even in a new set of circumstances, I can generate a set of "diagnostics" for probing into a difficulty on the basis of this conceptual structure of variables in this class of activities. Within limits, this format enables me more or less readily to substitute one response mode for another: pointing at menu selections with a light pen or entering the data from a keyboard, or calling it over a telephone.

The greater the regularities in the presence of the same variables from one task occasion to the next, the more rapidly will implicit format develop. Regularities consist in: the same set of variables; the same sequence in time; the same arrangement in spatial location. If the sequence in which the operator must cope with a set of task variables changes from one occasion to the next -- that is, the sequence is variable or random -- the task format will be learned and be a part of performance somewhat more slowly. That is, more repetition of learning trials will be necessary. The same will be true of spatial position of the task variables in the field of regard or in the work environment. Where there is standardization both of sequence in the operator's coping with given task variables, and in their absolute or relative spatial location, the redundancy increases the rate at which the task format becomes learned as a factor in performance proficiency. It is a fundamental principle of learning that, up to some point of diminishing returns, redundancy of task cues increases the rate of learning and favors retention and reinstatement of the skill over periods of disuse. The principle is significant, even though in highly practiced performance the operator gradually tends to disregard redundant cues by selecting (through spontaneous processes) a cue element that is sufficient for selecting a task response.

To the extent that, in early learning of a task, the learner engages in activities during practice that are irrelevant or extraneous to the processing format to be developed, the format will be learned slowly. For example, troubleshooting electronic equipment can be divided into two major classes of activity: (1) the procedures of setting up test equipment, applying probes, taking measurements, comparing test results with norm readings, searching in manuals of instruction and (2) the application of strategy in the selection of that next test to make that will yield the largest amount of diagnostic information, and the logical operations of deducing the significance of a given test finding as to what sections of the system may be excluded from further suspicion. Where practice exercises in early stages of learning mix these classes of activities, the formation of strategic and logical skills may be very slow because of the confounding and attenuating information required for the procedural operations. Obviously, the <u>exercise</u> of the strategy in the real job demands integration of the activities, but the <u>formation</u> of the format structure may require at least temporary separation during training of these two sets of activity. The analysis of the psychological functions of task formats in a later section will reveal the justification for this separation. (It is possible that a task format can

be so overlearned in artificial conditions, that it may not adapt to combining with other formats which may need to be exercised and integrated with the first: stage of learning is an important dimension for the design of efficient training schedules.)

The "Description of Formats" and "Behavioral Formats"

It is possible to memorize the bidding rules of the game of bridge as a set of verbal instructions. If they can be recalled, these verbalized rules may assist in making appropriate bids, but in themselves they are insufficient for excellence in bidding -- even if the psychology of bidding were to be set aside. When the rules are embedded in the skill of sizing up a hand, the bidder can cope with exceptions to the formal rules, making tradeoffs and treating the elements in his hand as a pattern. He may add to the mere bid count in his hand an imaginary playing out of his hand against his opponents, and add the imagined outcome to his assessment of the bid value. The verbalized description of card value count making up a bid serves as an external guide that should help him to learn the format as a skill component. In the sense that it is a guide to behavior, it is of course a format by definition.

Take the example of an expense account form. The variables on the form specify the kinds of information that ordinarily are necessary and sufficient for submitting a statement of trip expenses according to the requirements for accounting and reimbursement. It is the external format for generating a statement of trip expenses. It may be contrasted with submitting a statement in the form of an essay. The printed format usually helps the person learn comparatively quickly a psychological or behavioral format for selecting data from perhaps a random assortment of notes on expenses, and to quickly translate them into entries on the paper. The implicit format for expense accounting in the employee's head will also tend to guide him during his trip as to what expenses he makes notations of, collects receipts for, remembers and qualifies. The accounting format, when in his head, guides his spending -- or at least his attention while spending. The format becomes operationally meaningful beyond its printed embodiment.

The point here is that it is naive to assume that because a learner has been told or shown a format structure, it will thenceforth serve as an effective component in his skill. Formats become learned and effective in skilled performance as one learns to ride a bicycle: by repeated practice.

The Behavioral Value of Learned Formats

Recall that, in general terms, a task format is a framework of those factors and variables in information and response that tend to be constant in many repeated cycles of the task. When a format becomes learned as a component structure in a task skill, it serves as a behavior organizer in the following ways.

1. Directing attention. The task format embodies selective attention. The operator learns what variables or properties of the work environment are task-relevant, and those that are irrelevant to any task action. When the operator

has learned what specifically to look for as essential work cues, and can disregard the non-essential and irrelevant, the burden on his attention and information processing filters is substantially reduced. It may again be emphasized that the format directs attention to categories of task cues, "stimulus variables" or "task parameters" -- where each of these expressions is intended to mean about the same thing. The effect of the format is, therefore, both that of a selective filter and that of a scanner for what have been learned as "essential" categories of task data. When attention becomes automatically directed and selective, the further processing of task data can become simplified.

Efficiency is, however, bought at a price and the price usually is some degree of rigidity. The task format can be practiced by repetitive experience to the point that the operator disregards -- fails to notice -- what should be qualifying conditions, or out-of-the-ordinary demands. His perceptions can become stereotyped so that he operates on the minimum standard format. His performance now becomes vulnerable to a demand for behavior that requires accepting and processing information that is outside his format structure.

The determination of what are the "essential" cue variables in a task does not arise by magic from some abstract specification of ideal task performance. It arises from the psychological operations by which input states, goal concepts and output actions are linked to consequences as perceived by the learner over a substantial number of learning and performance trials. (All performance has some learning effect.) By the general principle of least effort, continued practice will result in the processing of the least amount of information that is sufficient to produce results that are adequate or "satisfy" the performer -- or do not interfere with his satisfactions, which is perhaps a different picture. Understanding this principle should help in the programming of learning experiences.

There is irony in the development of perceptual rigidity. As the learner acquires perceptual formats, the demands on his attention dealing with standard task data tend to become less, so that in effect he can disperse attention over a larger field of situational content. He, therefore, is acquiring the capacity for more flexible perception, both in range and detail, but he must be induced to exercise this channel capacity. If he must learn to perform several streams of task activities more or less concurrently, this is in part how this added channel capacity is acquired.

It is possible for the enlightened learner to continue to impose on himself continuously more rigorous criteria of attention to nuances in input information after he has mastered the ability to process the minimum required data in a task -- that is, he uses the task format as a performance tool rather than being used by it as a tyrannical constraint and limit. This assertion assumes some cognitive freedom of choice rather than the notion that learning must be acquired only through external "shaping" of behavior at the time of skill acquisition. There are, no doubt, large individual differences, perhaps arising from many causes, in this self-instructing phenomenon.

In conclusion, the learning of a task format has a powerful effect in restricting the range of what the operator pays attention to and notices in the total stimulus environment of the task. This restriction and focusing of attention is one factor in the improvement of qualitative and quantitative factors in task performance. The greater the standardization of information categories, and the temporal and spatial presentation of given categories of task information, the more quickly will the format be learned as manifest in selective attention. If the task demands sampling for periodic changes in value of given task input variables, the standardization of spatial location of the indicator for the variable assumes special significance when the operator is highly loaded or stressed.

2. Organizing short term memory. Short term memory -- or "working memory" -- is the retention of variable information peculiar to a given cycle of task performance. It ranges from keeping in mind one's "place" in a procedural sequence, or perhaps briefing instructions for a particular set of job operations, to the many factors of demand and resource and sequence in formulating the solution to a complex logistics problem. For practical purposes, the complexity of the problem which the human can solve is limited by the amount of information he can effectively hold and use in his short term memory. Short term memory can, of course, be assisted by job aids which, like a displayed map, may refresh the content in short term memory but cannot serve as its equivalent.

At any given moment in a work cycle short term memory tends to hold representations of task conditions and status, momentary purpose, and perhaps a symbolic key to the invoking of a class of response operations to be performed on the data. Where the operator's experience has encountered a high degree of regularity in time, space and data content of task stimulus and task response, the content of short term memory tends to become reduced to merely that situational data sufficient to evoke the next response of execution. To the extent that a stimulus sequence is invariant, the response sequence may be invoked and executed without attention to the elements within the stimulus sequence, but as an automatic train of response.

Since performance is limited by the ability of short term memory to cope with task information, both the design of the task and training for the task should be directed towards the structuring of short term memory content. This structure is based upon the task variables which make up the situational context to which task responses are made.

With practice on a task, the learning processes seem to sort out the recurring task variables so that short term memory develops the equivalent of a matrix or template for the reception and implicit "labeling" of classes of task data. A limited (and partially misleading) analogy is that of setting up a set of standard pigeon-hole locations for task data variables. The analogy breaks down because there is interaction among the contents of pigeon-holes: pattern as well as elements may be perceived by the operator -- the content may operate dynamically rather than passively like impulses written into the register positions of a computer. Thus, the driver of the car may implicitly note his own speed and direction and the speed and direction of another car, and more

or less continuously compute the projections of the data samples with respect to collision probabilities. Or the symptoms reported by the patient to the diagnostician may continuously summate in the physician's mind into a pattern which he recognizes as a disease entity.

The value to performance of this parameterizing of task data is clearly enormous. That task data which demands differential task response is sorted out from that which is either irrelevant to the moment, or calls for a standardized subroutine or pre-established responses. The psychological categorization of data enables it to be apprehended and stored both as data elements in the matrix, and as a pattern to be completed. In an operational sense, short term memory has become "organized." Increased practice on the task increases the stability of this organization of input data structuring. The result is an effective or functional increase in the capacity of short term memory. That is, to the extent that existing data patterns are well-structured in short term memory, additional data can be stored in it. The driver with increasing competence can note and remember additional data in the driving environment; the diagnostician can hold in mind a larger set of data specific to this patient and his ailment; the architect designer can optimize a larger set of design parameters and constraints in the course of design.

A major function for task performance served by short term memory is the capacity to separate stimulus information temporally from response execution. Thus, the accomplished typist apprehends a group of letters and words as a clump which is stored in short term memory which is later executed as a clump by her fingers on the keyboard. A contrasting organization of work would consist of looking at an input character in the source document and keying that character, then looking at the next character and keying it. The temporal separation of input from output enables the operator to prepare adjustments to momentary complexities of response demand without a disturbance to the pace of the output. Variations both in the complexity in the input and complexity in output response tend to be smoothed out by some separation of rate in the reception of stimulus input and execution of output. A pattern of input is apprehended and briefly stored and matched to a pattern of output. All of these factors together reduce fatigue in the performance of the task, and delay the onset of "blocks" -- a period of time when within the operator, presumably from fatigue, there is a psychological block between input processing and output processing. These are also occasions for errors.

To the extent that the rate of apprehending stimulus input is faster than the rate of response execution, the operator can attend, at least intermittently, to other streams of information. For example, he may monitor the outcomes of executed responses.

Short term memory mechanisms can be viewed, therefore, as information buffers that enable temporal flexibility between the presentation of a task stimulus and its action in eliciting a task response. This flexibility exists as a capacity. How this capacity becomes an operational ability depends largely on the conditions and extent of task practice from which no skill can be independent. The operator learns what he does. What he does may be modified both by external circumstances and by what he tries to do by voluntary processes.

The buffer in short term memory may be thought of as consisting of a set of registers. Each register position has become specialized to receive the data value of a given task variable. When the registers in the buffer are filled, the content as a pattern is dumped into an action converter. This mechanistic description is intended only as a highly oversimplified analogy and should in no way be treated literally. The point to be understood is the potential for increased processing efficiency when processes of this kind result in the organization of short term memory content.

3. Task closure and reset. The learned structures that operate in short term memory may also yield the phenomenon of the sense of task completion. This source of completion may be accompanied by the erasure of much of the variable content in short term memory. Thus, one looks up a telephone number, and perhaps keeps it in mind until the digits have been dialed. On the completion of the dialing, the number may tend to be forgotten at once. The "space" in short term memory is now available for other semi-transient data. And the human has an accompanying sense of completion: the task or sub-task is "closed".

What constitutes a task closure depends on how the task is learned. When a telephone operator mediates between a caller and the station or person being called, her task is ordinarily not completed until she verifies the calling number. She will, therefore, tend to retain the calling number in mind (assuming it hasn't been written down) until it has been verified. When it has, then and not until then, will she have closure and the unbuffering of the transient content. The understanding of this phenomenon should help in the design of task training. Thus, if a pilot or a maintenance mechanic has extensively practiced and learned his primary tasks as being completed without filling in a debriefing report, he learns closure before filing the resport of what happened during the task. If now he must file the report, his memory of task data may be unreliable and incomplete. But if filing a terminal report is learned as a normal portion of a work cycle, his closure will be delayed until completion of the report.

These comments must be qualified. Closure, as we know from everyday experience, is not all-or-none. Insofar as forgetting is concerned, it is a matter of degree. Since tasks are composed of subtasks and also of higher order tasks, closures are also hierarchic. Furthermore, there are relationships between short term memory and long term memory whereby some content in the former becomes content in the latter. But mechanisms of relationship between short term memory and long term memory are outside the scope of this paper. Task formats are retained in long term memory from which they are accessed and enter operationally into short term memory under cues that initiate a given task activity. A person is "set" for a task or a task cycle when the task format has entered short term memory from long term memory.

A final practical comment. The learning and performance situation of the learner can be such as to foster the sense of closure when he has completed some terminating task response. If so, he will tend not to search for evidence of outcome adequacy of his performance, nor to link efficiently (in the psychological sense) such outcomes with the elements of task situation and task response. This pattern of behavior will tend to preclude the progressive improvement of his own performance with respect to given criteria except by externally imposed instruction. The most effective context for learning occurs when the information of the task cycle is still in mind and the resulting outcome is presented while

that information is still "live" in present memory, which must be preliminary to closure as described above. This observation suggests not merely a temporal connection between performance of task and presentation of outcome: it also points to what the operator has learned as the completion status of a task cycle. These factors suggest why so much academic study aimed at "finishing the test" is not only inefficient but poorly structured for enabling the student to become an effective self-teacher.

4. Transfer of skill. The task format, like a template for inserting the values of variables in a more or less standard equation, enables large variations in the values of the situation variables to be processed effectively by the operator. The format may thus play a major role in enabling rather substantial changes in task content and task setting to be learned quickly, relative to a control condition where the new task was learned without benefit of existing format.

Perhaps it should be underscored that a highly routinized task that is always performed in an invariant way to an invariant sequence of readily identified stimulus elements may, when practiced many times, be performed purely as a rote sequency with a minimum development of a transferable format or abstract or implicit model of the task. Formats develop to cope with variability within the task and from one task occasion to the next. In other words, where the task "variables" assume only a single value, and little or no information is carried over from previous steps to later steps in a sequence of actions, the procedure will tend to become automatized. Little transfer is to be expected, unless the operator learns a variety of tasks having the same structure. In this case, the conditions of variability are met, and a task format will tend to develop. The result will aid progressively in still more new tasks having similarities in structure. For example, a shop man learns and practices for years taking the same kind of bicycle apart and putting it together. He will be inept in learning to disassemble and assemble mechanical objects different from that bicycle -- say, a gasoline engine. But a person who has taken apart and put together a variety of objects learns a general pattern, including some strategies, for this class of work. He can, with comparatively little guidance, disassemble and assemble devices quite strange to him. He has acquired a general format for disassembling and assembling devices.

There are, of course, factors other than task formats which can be responsible for transfer of training: a common base of nomenclature and reference information between the old and new task are examples.

## Types of Task Format

Task formats are as numerous as there are classes of tasks. This writer, in several reports (1969, 1973), has analyzed several dozen that might be regarded as widely distributed in the domain of cognitive and perceptual-motor work. There are a few which may be regarded as archetypical.

Verbalized self-instructions and external formats. Task performance can be structured by verbal instructions given to oneself or given by a manual or an instructor. The information in the verbalized instruction may contain information necessary for actual performance, but not sufficient. There must be a

capability for translating the verbal instruction into perceptual actions and muscular or other output actions. The self-instruction is an external format for performing the task: it guides behavior without in itself being that behavior.

A printed form to be followed in a transaction is another example of an external format. It specifies the classes (variables) of information necessary to obtain in order that a given action can be taken. The printed form not only facilitates the performance of the task of getting and setting down the essential data, it also simplifies the learning of that task as contrasted with a situation in which such a guide is absent. It enables the operator to restrict his operations in getting the data content: he does not have to think about what kinds of data to provide. (Obviously, efficiency here has its tradeoff in flexibility and adaptiveness, but we cannot address all issues at once!)

There may be procedure formats. An example may be that of formulating a search specification into a data base system. The operator may have the task of searching a large data base of electric motors and parts by attributes and functions associated with given parts. This requires him to name attributes and the associated attribute value as well as to indicate logical connectors such as AND, OR or NOT between elements of the search request. A graphic display may show him boxes and box names to fill in -- a standard format for creating the specification of his inquiry; he may or may not have to follow a prescribed sequence for entering the data. This is an external task format. He may have to learn the format -- as contrasted to using a "free form" of inquiry specification -- but once the format is learned, he will tend spontaneously to think of his request in this format. The format becomes internalized. When it is, it will take less of his channel capacity (and probably produce fewer unintentional errors) than if he were to continue in "free form". But even allowing him free form mode would, with repetitive experiences, result in his developing (eventually) his internal format which standardizes the operation for him. Repeated human experiences lead to regularities in behavior which is, of course, a major characterization of what happens in learning a task.

Procedural sequentialities. If an individual is placed in a variety of situations all of which have a general pattern, he will tend to learn and anticipate the elements in the pattern. Thus, the operation of a mechanical vehicle generally requires getting into it, turning it on, engaging power to the wheels, releasing a braking mechanism and proceding. Most of these operations apply equally to an automobile, aircraft or boat. Depending perhaps partly on intelligence, but more on the variety of experiences, this pattern of sequentiality can be adapted to novel situations.

Operations with a weapon have the general sequence of preparation for use, loading, aiming and firing. It is not necessary that the individual be able to verbalize the format in order to have it expressed in his behavior. The format is expressed in behavior by the relative rate at which he can learn the task as compared with a control subject who lacks the experiences for having developed the format. Clearly, a format in behavior may have many individual levels of specificity and generality. No sets of habits are alike in any two individuals, and an internal format is a learned entity that, in psychological jargon, is a habit.

Transactional formats. The general structure of a transactional format consists of the following constituents: (a) a set of more or less standardized input variables to a processing function; (b) a set of variables of reference information that supports the input data for the processing function; (c) a set of more or less standardized output variables from the processing function; and (d) the processing function itself. Some transaction structures may include a comparator of the processing output with an idealized or criterion output and if the actual output is out of prescribed tolerance, a feedback arrangement leading to a recycle of the input with the benefit of the added corrective data. In the case of interest to us here, the processor is a person.

An illustration will help to translate this definition into a clearer picture. A dispatcher takes trouble calls and selects what repairmen will take what calls and in what order. His inquiry about the trouble will tend to consist (in this particular task) of a pattern of the same variables: name and address of the caller and geographical location of the trouble, the urgency of the trouble and the nature of the trouble. He has learned to extract those essential classes of data that help him decide (a) the priority to assign to the service if he has a queue of requests; (b) whom to send; (c) what supplies and tools to send; (d) whether to send only one or more than one man. These are the output variables in his decision-making. His reference information may consist of the following: (a) the implications of any in a given set of reported troubles to the customer; (b) the implications of a given class of trouble for the company; (c) the relative importance of a given customer; (d) the abilities of each of his service crew; (e) the availability of members of his service crew with special skills who could respond to the trouble call. He attempts a best match between the variables in the demand for service and the properties of the resources available for responding to the demand. His mental processes leading to the decision may include various strategies and tradeoff values.

This describes decision structure. (It also is a specification for a procedure to develop data base content and structure for the support of human decision-making tasks.) These variables, more or less, apply to any dispatching and scheduling task. The task format that is learned by this dispatcher may be transferred, with various degrees of savings in learning, to a wide variety of contexts from telephone repair to the handling of contingencies on the shop floor. (The greater the overlap of reference knowledge variables between the old and new tasks, the greater the additional savings in training.) Obviously, the extent to which the new task to be learned has explicit parallels in its structure of variables to the old task, the more rapidly will the learner adapt.

This transaction structure is also applicable to the understanding of task formats dealing with multiple-variable tracking tasks such as operating vehicles. This form of analysis is, of course, precisely the approach that the engineer and computer programmer must take when they try to automate a manual activity: isolate and identify the input variables and the control variables essential to the task.

Some external arrangements of the task make implicit formats easier to learn and reinstate, and generally offer more flexibility in performance. For example, if the entire set of task variables comprising the format is displayed to the operator at one time, like a map, the pattern of variables will more

quickly be learned. The example is that of the printed expense account form, or the engineering change form. The alternative arrangement, fostered by limitations in computer display technology, is to display only one variable at a time until the operator responds to it -- the remainder of the transaction is hidden from his view. The same principle of showing the entire structure all at once, rather than a fragment at a time, is probably desirable for training, perhaps even where the operational environment may present only one or a few variables at a time.

Obviously the visual layout of the external format should parallel the sequence in which information is received, and is grouped and organized for reaching decisions. If reference information is externally provided (that is, external to the operator's head such as a display screen) its layout in terms of data names and attributes of entities should be consistent with the implied demands of input variables, output variables and processing strategy in the decision-making operation.

Even though a learned task format can mediate transfer of training across substantial variations in task setting and task content, the larger the number of identities between stimulus layout and response selection, the more rapidly can the operator learn the second task.

Psycholinguistic Formats

In no existing field of behavioral inquiry has the construct of "task format" been so widely investigated as in the psychology of grammar and psycholiguistics: the study of structure in verbal expression. It is indeed a fact that the "rules" of grammatical constructions become embedded in our verbal behavior, although the rules may be manifest in well-nigh infinite variation of content. The structure of "format" of the sentence as a "unit of thought" seems fundamental, as are the sentence structure variables of subject, predicate and object, and the association of qualifiers (modifiers) with each of these parts.

It is outside the scope of this paper and the competence of the writer to discourse on this topic. It is cited as a widely examined example of the fact that humans develop and use organizing structures of variables, and relations among variables, in behavior that operates with wide varieties of content.

In this context, another point can be made about the difference between an external format and an internal format. The external format of sentences is expressed by written rules about grammatical "correctness". It should be obvious that individuals do not literally incorporate these rules in the form of these verbal expressions in the formulation of their sentences. The verbal expressions of rules may guide the selection and implicit editing of sentences expressing cognitive content, and thus assist in learning to criterion performance. But the implicit formats for the "grammatical" construction of a sentence come to operate at behavioral levels where the structure of a verbal rule, such as "one should not split infinitives", is as irrelevant and misleading as to say that the mechanical design of a switch contains the "rule" whereby it will open or shut. If this kind of analogy is used (and some of us do use it), the context should be clear.

One learns to operate with behavioral models not by verbal descriptions of the models -- except at very preliminary stages -- but by the exercise of the model in behavior. It is not clear that a large body of educational and training practice recognizes the difference -- as well as the relationships -- between external task formats and implicit embodiments in behavior.

For the time being, let us leave psycholinguistic models with the scholars. They have given us, however, an example of the notion of task format in a respectable field of inquiry. Their findings about the processes whereby implicit cognitive formats develop and operate may help us better understand these phenomena in other than linguistic behavior.

"Understanding" a Task

Except where the manager must serve the role of teacher, it is generally recognized that "management" of workers does not require the ability to perform their various tasks at acceptable skill levels. The unsettled question then becomes "What should a manager know about the job-tasks he manages in order to assign, coordinate and evaluate?" A reasonable proposal is that he should be able to identify and describe the formats of the tasks of the people who report to him -- where these descriptions take the structures that have been discussed in previous pages. This is the structure of the task variables in input problem situation, output response and reference entities and attributes. The details of the processing rules and operations that translate input problem to output solution, although obviously essential to <u>performing</u> the task (and to teaching it) are secondary to a useful understanding of it for management purposes.

If a working knowledge is to be extended beyond format structure, however, the most useful information about the processing function consists of the strategic tradeoffs in the task criterion. In other words, what is the task operator trying to optimize (or should optimize)? The dispatcher was trying to optimize the matching of a resource skill with a resource demand but with some minimum of delay in time-to-repair multiplied by the severity of the problem. Even if objectively measurable, these sets of parameters are not linear nor entirely independent of each other, so that "optimization" may, under heavy load, have to be substituted by a satisficing criterion.

If the manager has an operational awareness of (a) the task format; (b) criteria of effective as contrasted with ineffective levels of performance and (c) the strategic tradeoff variables to be optimized or satisficed in performing the task, he will often have more explicit knowledge of the task than the incumbent on the job.

This kind of understanding can be functionally useful to professional persons whose work interfaces with other expertise. It should also be useful to those engaged in cross-training of personnel for career guidance and in the structuring of performance tests. Its significance to those engaged in the design of tasks and task supports has been mentioned.

This kind of information about tasks may be contrasted with job-task descriptions consisting of a list of work "functions" or of detailed procedural statements.

Conclusion

Learning that is directed towards performance criteria is a process of increasing order and organization from states of disorder and uncertainty. The expression of disorder is contained in the statement, "What am I suppoed to do and how do I do it?" The level of a competence or skill is tested by the operator's coping with circumstances that he has not precisely encountered before: the imposition of order on uncertainty and variability.

Depending on the nature of the task, the conditions of training and performance -- and perhaps on the cognitive capabilities of the operator -- learning and performance may occur at more than one apparent level. To the extent that there is variation in conditions between one cycle of performing the task and another, the operator learns not merely a one-for-one stimulus-response relationship. He acquires a format of processing variables. A mathematical equation is an extremely crude and unsophisticated analogy: the value of variable x added to the value of variable y yields the value of variable z: that is, "Add the rate of the rower downstream to the rate of the current of the stream to determine the rate at which the boat is moving downstream." The process of learning -- at least under some conditions -- enables subjective "formulas" to be developed. The requirement is some pattern of regularity in the variables of the problem presented to the learner, but variability in the values that the variable take. The clod does learn the physics of operating a wheelbarrow over rough terrain in the sense that he incorporates it in his behavior with the wheelbarrow.

A conceptual construct has been required to account for the everyday knowledge that people adapt the literal content of their experiences (i.e., what they have learned) to variations in problem situations not literally equivalent to previously experienced patterns. The notion of implicit task formats seems to help account for these adaptations. The notion also accounts for some of the phenomena of improvement in task skills that are recognized on a subjective basis but not readily fitted into traditional cognitive schema.

In psychological terms, one should not think of a task format as a mechanism, or produced by a specialized "format generator" in the nervous system. Rather it should be regarded as a phenomenon having, like any other product of learning, variety in kind and in effect. It is to be hoped that the label "format" is not taken too literally or mechanistically. It is a logical construct, like the constructs of attitude and motivation, which are tested not for truth as perceivable entities, but for utility in generating hypotheses about practical as well as theoretical matters.

In the practical community where objects and procedures are designed for human use, and where training is designed for programming these procedures into human operators, the notion of task standardization may acquire a broader base. Some designers are guided by the philosophy of giving the operator a completely unstructured work environment with the intent of giving him freedom and flexibility. But with repeated practice, the operator will develop spontaneously a structure for coping with constants in variable situations in a constant way. The risks in freedom are slowness in reaching criterion levels of task efficiency and the probability that a spontaneously developed task format may usually be poorer than one that has been deliberately designed with the full range of task purpose, task environments and the properties of human behavior in mind. On the other hand, a few gifted individuals may spontaneously develop

implicit formats of their own which, at least for them, are superior to their use of explicit formats designed by others. The risk in designing an explicit, external format for a task is that the structure may be inappropriate, or that it will unduly tyrannize and stereotype a task which should be performed with judgment and flexibility. But these are the well-known tradeoffs that apply to any form of standardization whether in tasks or in automobile mufflers. Only to the timid or uninformed need a tradeoff be a standoff. Any finite solution should be aimed at a statistical expression of success, not an absolute one.

In any event, the clear recognition that human operators can and do generate behavior that abstracts and copes not only with data, but data variables in procedural and conceptual tasks, as well as in tracking tasks such as aiming and driving a vehicle, offers design and training concepts that can facilitate order in human task learning and performance with less than a straitjacket.

## GOAL PROJECTION

A specification or characterization of a desired or satisfying state of affairs which a system seeks to acquire or maintain as shown by the alternatives it selects (or avoids) in its choice-making behavior, and towards which it is energized in its drive levels.

The goal projection or image is the reference information with which a system compares a present or planned state of affairs. If on comparison a difference is found, behavior is modified accordingly in direction and/or magnitude.

In an automatic system, goal image or purpose is implicit in the cybernetic control mechanisms. In human systems, or systems that include a human operator, purpose and goal state concepts may be both implicit and explicit, and may be partly independent of control mechanisms.

An inanimate system may seek an equilibrium level and direction of activity that comprises its operating program with changing state of the environment. An animate system may have a striving component for moving by means of task actions from a given status to an approximation of a reference goal state. The internal "reference" for the human operator is a goal image. Thus, a goal image serves as the embodiment of a criterion for terminating a task or segment of work or mission, and terminating it with an experience of some degree of success or failure.

Different goal images may apply to different levels of activity; e.g., task, duty segment, work cycle, mission.

### Examples

- The recruit with a clear picture of what a clean rifle should look like, who continues cleaning it until, from all suitable points of regard, its appearance meets this criterion.
- The workman who fabricates a part to within his idea of what the inspection tolerances should be.
- The mechanic who services an engine until it looks, sounds, and operates well according to all its performance variables as he knows them.
- The pilot flying "straight and level" on instruments in a straight and level maneuver.

### Functions of Goal Image

The goal image serves as both a steering and a power reference for moving from a present or projected state of affairs into a projected route of action. Goal information is operationally meaningful insofar as the behavior of the system is not completely and rigidly programmed or proceduralized; i.e., where the system has options for activity in kind and amount.

Where the system operates on a performance criterion rather than on a fixed-cycle time criterion, the goal data indicate a point of work completion. Thus, the goal image tends to determine the subjective condition of "closure" and reset.

Forms of Goal Image

- With some kinds of subject matter, the image may be a mental pictorial picture of an idealized or satisfactory terminal state. The image may be clear or vague; and it may be clearer in terms of some variables than others.

- The goal image may consist of criterion or dependent variables within some wanted ranges of values.

- The goal picture may consist of indications of "progress" from a present position on one or a group of criterion variables, rather than terminal values.

Behavior Tendencies

Disregard of goal image. The student and novice operator often try to start training by learning procedures and manipulations rather than goals and goal variables. In many cases, the instructor must insist on the student learning to distinguish good from poor goal models before allowing the trainee to get into the mechanics of the task.

Deteriorating goal image. Goal images may become tentative and changeable. Change is often in the direction of deterioration. This decay may occur in the course of task and job learning when the effort and expertise demanded for a high level goal confront a low energy budget and low student ability. Social influences are well-known modifiers of goal levels or levels of aspiration. The goal image may vary markedly within and between work cycles, under the influence of physiological states, stress, work context, and other factors. These changes may be adaptive and functional in some cases. Goals that are "spontaneously" degraded are not likely to be the best operating adaptations, however, so that training may be necessary to guide the operator in priorities.

Disappearance of goal image. Routinization tends to blunt the clarity and dominance of the goal image, so that it may disappear into automatic procedural behavior. This may be adaptive in the sense of requiring reduced information processing activity if the automatic performance is at least acceptable and the environment is highly stable from one work cycle to another. Such conditions tend to be rare.

Training and Performance Strategies

The strategies set forth below reflect not only the operational factors involved, but also some philosophical and psychological biases of the author. One is that if the operator does not continuously strive to do a "better" job --

according to his own lights, as well as those of others -- his performance will tend to degrade, and he will oscillate just above and below externally acceptable levels of performance and, in a clutch situation, he will fail. Another bias is the belief that a job or task can remain interesting after acceptable mastery has been achieved only if the level of aspiration for the performance of the task always goes somewhat higher than the actual achievement level. Even intrinsically dull tasks can remain bearable if the operator continues to try to beat his own record. Obviously, the operator's work environment should not penalize the achievement of higher levels of performance; at worst, the work environment should be indifferent to such achievement.

Clear goal variables. Training should emphasize (and test) the student's early acquisition of goal variables. Where possible, emphasis should be placed on concrete pictures of good goal states that embody the desirable values among the entire pattern of goal variables associated with the task. The goal images that are presented should be realistic, not idealized ones that can be achieved only under idealized conditions that never occur. If goal images presented are not realistic -- realistic in terms of a skilled operator in representative conditions -- the student will become disillusioned and cynical of the instruction. The student should be taught to identify the variables that comprise a goal state.

Tolerance ranges. The student should learn the range of values that would be operationally acceptable on each criterion variable. If this is done, the student should be able to distinguish values on each variable that are barely acceptable and those that are unacceptable; he should also be able to distinguish limits in terms of the composite goal picture as well. If there are operational tradeoffs between goal variables (e.g., speed versus accuracy), the acceptable range within which these tradeoffs can be made should be clarified.

Reliably clear pictures of goal states, goal variables and their tolerance ranges should precede training on the performance of the work. This is sound training strategy because it enables the student to serve largely as his own feedback mechanism, a psychologically good arrangement in that it centers initiative in the student rather than leaving it entirely in the instructional mechanism. The strategy also induces achievement motivation in the student who may maintain it after he terminates formal instruction. (Contrast this with the student who continues improving only under the direct guidance of an instructor.) Application of this strategy makes learning purposeful -- in terms of objectives -- rather than mechanical.

Priorities and contexts. Goal aspirations may have to be compromised by operational exigencies. The operator should, therefore, know which criterion variables have the highest priority for sustained integrity and which may, when necessary, be degraded with least operational penalty, for given kinds of missions. Such knowledge enables one kind of rational judgment to be exercised. It may also enable a mission to be completed which otherwise would remain undone; if there seems to be no choice for the operator to go

ahead even in a degraded mode, he may flounder or cease to do anything at all. It is better, for example, to demolish a car than to kill or maim a pedestrian - a choice which apparently some motorists have not been trained to make correctly.

A concept of operational (and ethical) priorities among a collection of goal criteria is essential to the higher levels of work performance. In fact, strategic "rules" for selecting goal priorities make a large number of the strategies described in this handbook as procedural, seem almost trivial by contrast. In simple terms, the issue is what is more important, and what is less important to achieve in a task or mission. By being relatively specific on such matters, the operator himself becomes an active strategic element in the enterprise by being able to maintain a control initiative. In actual practice, how often does any worker get consistent instruction in goal priorities?

Rational control over impulse. To the extent that the operator has a clear picture of goal states, and is guided and driven by them, he has a basis for rational control over emotional impulse and the tendency for expedience at the moment -- in other words, he has a basis for "localized optimization". When the operator is under strong pressure from an internal or external source, any device for the control of emotional impulse, and/or proper direction of impulse as a source of energy, will have operational payoff. Obviously, such devices have the highest payoff frequency where the stresses are greatest and most frequent. (Note that even boredom is a stress!) Indoctrination and refurbishing of the subjective goal image, therefore, has a continuing strategic value for operator performance.

Comment

These "strategic principles" for training and performance are indeed self-evident and are probably known in one form or another by the layman. It is unfortunate, however, that such knowledge seems so rarely to be put into systematic practice, even by specialists in the training and educational arts and by managers.

## SCAN - DETECT

Is something there?

> Procedures and mechanisms for sensing the presence of a cue or condition requiring that some form of action be taken by the system. The action may consist of getting more information about the condition detected.

Detection requires discrimination of an action-stimulating cue from some background. What is detected may be occurring in the environment or within the system itself.

Detection is ordinarily a positive, consummatory response to the activity of scanning. "Scan" and "detect" should, therefore, be linked activities and they are treated as such here. Since effective detection is largely a function of effective scanning, major parts of the discussion in this section deal with scanning conditions and strategies. Scanning is defined as the moving exposure of a sensing device to a field of possible signals. The pattern of exposure may be systematic or random, periodic or aperiodic.

The terms scan, detect, search, identify, and interpret tend to overlap functionally; distinctions among them are somewhat artificial. Subtle differences between search and scanning/detection, as well as between detection and identification, are suggested by the following example. The operator may be looking for a needle in a haystack, but he can identify the needle when he sees it, even though he engages in scanning and detects the glint of the needle before he identifies it as the object he seeks. In performing a search function, the operator has a particular objective in mind. Detection is the sensing of an irregularity; in a stimulus context ordinarily, detection calls for attention which leads to getting more information that enables identification. An automobile driver, for instance, may detect an irregularity in the "texture" of the roadway ahead and begin an evasive maneuver before he has identified the irregularity as a pothole, an old tire tread, or merely a shadow.

Examples

Scanning and detection occur in a large variety of contexts.

- The indicator in an enclosed environment such as a cockpit.
- An open field in a natural environment, such as an aircraft in the open sky.
- A bounded field in an artificial representation of an environment, such as a radar scope.
- An open field with a complex ground in which a figure is to be detected, such as an enemy sniper concealed in part by foliage and other terrain features.

- A relatively closed field in which some property or attribute of one or more objects should be discriminated; e.g., a blackened wire in an electronic assembly.

- A collection of symbols; e.g., text which is being proofed for errors, a wiring diagram which is scanned for an uncompleted connection.

- In urban traffic, a faint whining sound that grows louder and is identified as a police or ambulance siren.

- A slight change of odor in a house which is identified (once attention is focused upon it) as gas from a leaking stove, or as a burning roast.

- An open body of water in which buoys must be detected that indicate shoals, hazards, and the channel.

## Operational Variables and Principles

- The lag or cycle time of the scan and detect function/device must be less than the cycle time required for the stimulus to be detected.

- The greater the contrast between the stimulus to be detected and its background, the greater the reliability of detection.

- Some scan patterns and frequencies are better than others for detecting given kinds of signal patterns.

- What the human operator detects is related to "set" or pre-established response tendencies. More simply, we tend to notice what we expect to see, what we are looking for, or what we are attending to.

## Discussion

In scanning, both the motivational stimulus and the ongoing stimulation for what to do next are of internal origin to the operator, and are sustained by internal stimulation. During much scanning time, there is no response from the environment that serves as a cue for specific adjustmental action. Unless the operator has been aroused by an emergency state -- such as pain, hunger, fear, an alert for some incipient threat -- the human mechanism tends to avoid scanning. Consequently, we should expect powerful behavioral tendencies resulting in perfunctory scanning. During periods that the operator interprets as "steady state" conditions between himself and the environment, the scan function will tend to be aborted. Strong motivations to reach a conceptualized or perceived goal reduce the quantitative and qualitative scope of scanning.

These phenomena are normal selective conditions of human attention which are generally adaptive, but may at times be maladaptive.

Scanning, as a form of information processing that must be supported almost entirely by internal activities, is perhaps more vulnerable to degradation and poor performance than any other dimension in task requirements. In scanning, the behavioral principle of progressive minimization of information handled per activity has the fewest off-setting factors in the task environment on which we can depend for rearousal of the degraded function.

## Behavior Tendencies

The following tendencies occur with extended experience over a number of task cycles, and also with experience within a given task cycle. In many respects, the tendencies are adaptive -- generally leading to reduced processing activity by the operator during task performance. In other respects, the behavior tendencies cited may be maladaptive, tending to reduce or delay the perception of potential crisis conditions.

Sampling becomes standardized. With extended experience, the operator tends to standardize: what he pays attention to and when; the sequencing of what is scanned; and the classes of cue which are sampled during scanning activity. Often, the operator standardizes what is not looked for -- and the cue may escape detection, regardless of its magnitude. Cues which initiate scan maneuvers may also become standardized.

Many scanning sequences, which are deliberately invoked early in task learning, become habitual and virtually involuntary with repeated experience. This tendency is adaptive if scanning habits continue to be adequate to the work conditions, and if alerting signals are detected as such. Since scan and detect must be a sampling activity, it is not likely to be successful in each and every environment. Failure probabilities in changed conditions and environments, and the cost of failure consequences, may rise to unacceptable operational levels. In such a situation, "redesign" of the scan and detect function becomes essential. Scanning appropriate to one class of situation may be quite inadequate in other types of situations. For example, the kind of situational sampling that is appropriate to high speed turnpike driving is mostly inadequate for driving in dense urban traffic, and vice versa.

Sampling scope and range become standardized. Habit tends to establish not only what is sampled, but also the range from which cues are sampled. Some drivers seem to fix attention a standard distance ahead, and only upon their intended path; some sample only from the speedometer, and generally ignore the other instruments (fuel gauge, tachometer, etc.). Even though early training may induce more or less appropriate scanning behavior, scanning tends to degenerate and unless scanning motivation and habits are reinforced, the function remains inadequate. Scanning habits (determining what is sampled and the scope of sampling as well) become firmly entrenched and inadequacies only rarely are subject to adverse feedback; appropriate scanning habits may quickly degenerate even after a period of determined improvement by the operator.

In certain operations, scanning habits may be measured and corrected. A lookout on a ship must continually scan a prescribed sector and report all objects sighted. If the officer on the bridge sights an object or vessel that the lookout fails to report, corrective action is taken to correct/improve scanning habits.

Progressive standardization of figure-ground sampling. An experienced jungle fighter who has learned to scan the brush for evidence of an enemy may, thereby, become vulnerable to enemies in towns and villages where a different pattern of figure-ground relations must be sampled in order to detect danger. The motorist who has driven mainly on well-paved superhighways, fails to scan for potholes in urban areas on city streets; he would reliably detect an object the size of a pothole if it were on the open highway, but not in the city. This tendency differs from the preceding one only in emphasizing that humans acquire sampling habits specific to given environments of figure-ground relationships and variables.

Reduced response to partial cues. Detection may be the summation of a number of cue samples obtained during a scanning sequence. No one of the cues in itself may be adequate to signal the need for overt action, or even to justify further inquiry. A bored sentry, for example, may hear the sound of a crushed twig and become alert for a few moments, but return to a demi-doze. Several minutes later, the swish of dry leaves and the cessation of bird chirpings may arouse him again. None of these cues by itself is likely to be sufficient to justify arousal and investigation or alarm. Together, they should indicate the approach of a body. Habitual absence of perceived threat reduces the tendency to link threshold cues that, put together in short-term memory, would sum into an awareness of a condition requiring full attention and action.

Projection of expectations. Under conditions of strong expectations, spurious or random cues in the environment may trigger incorrect detections and identifications. The more complex the ground and the greater the difficulty in differentiating figure from ground, and the stronger the anticipation, the greater the liability of spurious detections. This tendency is a case of the interpretive process interacting with the detection process. Thus, under strong anticipation of an enemy attack, many sounds and sights will be detected as cues that would otherwise fail to be detected. Circumstances of this sort can also lead to over-response. When a military unit is engaged in an assault on an enemy position, a tense soldier may detect movement out of the corner of his eye and turn and fire in that direction. Only instantaneous positive identification prevents him from shooting a buddy. Similar conditions occur in driving. When a driver anticipates an engine breakdown, he will detect as unusual, sounds and car behaviors which are quite normal for the car and to which he would pay no attention when he is not apprehensive.

Scanning and rate of change. This tendency is an important subset of standardized sampling. Scanning patterns and sampling rates tend to become associated with some prevailing rate of change. Scanning rates appropriate for driving at forty miles per hour are inadequate at a speed of seventy or more miles per hour. The driver who has spent several hours on a winding two-lane road at a relatively slow speed is at a disadvantage when suddenly accelerating to limited access freeway speeds. He is, in fact, in danger on his approach to the freeway, for this reason and others. The same difficulty appears in the shift in scanning activity required in the area of small local airfield compared to that necessary in approaching a large metropolitan area airport which services jet traffic.

Tunnel perception. In tunnel perception, the field of scan is markedly reduced, and tends to be limited to the intended goal path. Tunnel perception is an extension of the normal conditions of attention which restrict what one attends to in terms of a goal, or to the execution of a highly practiced chain of responses. It is an extreme form of preoccupation. A variety of conditions tend to create tunnel perception: fatigue; anxiety; extremely high motivation toward a goal; preoccupation with other than the task at hand; extreme routinization; and repetition of a series of standard stimulus-response sequences. Physiological depressants (including alcohol), no doubt, also affect tunnel perception.

Decreases in effective scanning and detection behavior may be one of the most sensitive means of identifying the impairment of an operator or of his skills. (Impairment in short-term memory capacity is another.) Because scan and detect functions are generally tested by relatively rare events, this impairment in scan-detect behavior may not be observable in the operations of the individual operator, but may appear only in statistical ensembles of task samples.

## Performance and Training Strategies

The way to train an operator for alertness and assure that alertness will persist indefinitely after formal training is not clear. In Infantry training, a soldier with his rifle loaded walks down a trail in a forest. He must instantaneously respond to targets that appear suddenly. He must identify these as friend or enemy and if enemy, fire immediately.

In nature, animals deficient in scan and detect mechanisms (commensurate with the speed and power of their fight or flight capabilities) tend to have a brief life. In human societies, such selective procedures are less ruthless. More compensatory mechanisms tend to keep the occasional bobble that is due to inattention from becoming a catastrophe.

It is clear that the learning of effective scanning behavior requires active and continuing cooperation of the student and continuing initiatives of the student/operator. He must not only acquire effective scanning and detection habits, but also recognize various conditions that lead to deterioration of these habits so that he can compensate for them.

The following are some training implications based on the liabilities cited above.

Cognitive models of threat. In operating any vehicle, there is a zone of threat involved. Safe driving consists, in part, of keeping as large a perimeter of safety against potential threat as practicable. This perimeter is not symmetrical; it is greater to the front than on the other three sides. The higher the speed, the greater the boundary of the safety zone. If one must stop quickly, the rear presents a hazard. The skilled operator, perhaps by sampling every few seconds, is aware of the location of other cars including oncoming traffic. In case there is a need for a rapid emergency response, his

awareness of the location of "competitors for his space" provides him with the greatest number of options for maneuver, and the information for choosing instantaneously. By continuous sampling from the entire region of his task operations, he is aware not only of the potential threats, but of his actual response options. This might well be thought of as an operational model of the "lifespace" of his task environment. The greater the driver's skill, of course, the better he can cope with constricted lifespace -- down to some limit.

Highly versatile, programmable simulators may be developed which can generate realistic situations that enable the operator to achieve effective sampling rates for various configurations in the environment. The relative frequency of hazards posed by the simulator would have to be far greater than what the operator can expect in real life. But he would be learning to cope with non-representative situations -- to anticipate through scanning and detection and perhaps to avoid threatening/hazardous situations.

A cognitive model of threat is a representation of the dynamic factors in a task that need to be sampled at some frequency and range in order for probable survival. Sampling that enables prediction of an event(s) generates the largest range of options for coping with the event if and when it does materialize.

A model of opportunities, the converse of a model of threat, is a "map" of the factors to be sampled by the operator in order to increase chances for a successful outcome. The map must include representation of events in real task time to enable the student to acquire habits of scanning and detection, rather than merely ideas about them.

Scan redundancy. If time permits, before committing himself to a response in a dangerous/serious situation, the operator should scan his environment several times for obstacles, or for competitors of the path he is choosing, and for a potential escape route if his maneuver fails. Scan redundancy permits the operator to evaluate the relative motion of his and other vehicles. The scan redundancy performance strategy is especially significant when moving from one field or rate of action to another. Critical information, missed in one scan (sample), may be caught or summated in a second or third sample. "Look before you leap," should perhaps be amplified: "Look twice before you take a long leap over a deep chasm."

Scan redundancy may be especially important if the operator is in an impaired state; e.g., fatigued, anxious, strongly goal-driven, affected by severe stress, or emerging from preoccupation with a particular matter.

Counteracting blind habit. Since routine habitual activities tend to elicit tunnel perception, the operator must generate and maintain initiatives for scanning; he must scan the environmental field for liabilities which may not have occurred in his past experience. Occasional refresher training which includes programmed simulated hazards may help. Such training is, however, likely to be both brief and somewhat artificial, hence of limited effectiveness. There seems to be no external operation that would serve

as an adequate alternative to (either replacing or supplementing) operator initiatives. The operator himself must periodically check his own scanning skill, and deliberately modify and improve it in order to prevent deterioration.

An operator may go through the motions of habitual scanning and see nothing; if so, the detection process is not at work. The operator needs occasionally to test himself on this score. Noting that he has just looked at the rear view mirror, for instance, he may ask himself "What is behind me?" If a moment after scanning he cannot recall what he saw in the mirror, he is not processing effectively. A friend of mine was overheard telling an associate that he had driven to work that morning, as he had for years, but couldn't remember a thing about the entire trip. This was disconcerting to him; he decided to revise his processing activities including scan and detect behavior while driving.

Awareness of impairment. Aware that he is drowsy, tired, or tense, the operator may compensate by deliberately putting more effort into scanning to avoid tunnel perception. If he is unable to do so, he should take the operational precautions available to him. The motivation for doing so may be stimulated by information regarding the effects of failure to respond to the signs of impairment. This is one basis for highway safety ads on TV and in the newspapers that graphically and/or verbally depict consequences of drunk driving, not wearing seat belts, etc.

Ambiguity and stress. Under conditions that combine ambiguity of environmental cues and operator stress, the operator may become dogmatic about what he has detected and apparently identified. The rational strategy under conditions of stress and ambiguity is to consider a conclusion as merely an hypothesis and "collect more data" -- by further scanning for cues that support or nullify the earlier conclusion. This strategy demands a high level of rationality, learning from a series of recent unpleasant experiences, or a combination of both. The application of this principle demands an unusual form of professionalism on the operator's part.

Peripheral scanning. In some time-constrained tasks, it may be desirable to scan a wide perimeter even though little time is available for doing so. Instruction and exercises can be directed towards increasing the effectiveness of scanning with peripheral vision. Football and basketball coaches teach this with apparent success.

It is possible to detect an object peripherally without being able to identify it. It is also possible to detect an object in central vision but be unable to identify it (due, for example, to lack of time, urgency, etc.). This phenomenon has been seen in tachistoscopic experiments. Under time pressure, a driver who is unaccustomed to the use of a side mirror may glance rapidly over his left shoulder and return his gaze to the roadway ahead in a fraction of a second; this activity may be sufficient to detect a shape but insufficient to identify the shape. Identification may not be necessary and may,

in fact, be counterproductive if split-second reaction is necessary. It is unlikely that any novice to a task will refrain from the temptation of spending the time to identify something which he has detected. The extra few tenths of a second he takes may mean the loss of an option for successful evasive action. The advantage of a few tenths of a second multiplied by many exposures can have a significant effect on accident and other failure statistics.

In time-critical circumstances (and perhaps others as well), the operator should gather no more information about the situation than is necessary for selecting an effective operational response or discarding an ineffective one.

Gaps in scanning. Like other behavior, scanning is likely to have discontinuities in effectiveness, gaps between fixations -- especially in visual fields that are noisy and without reliable references. A set of superimposed grid lines is an example of a reference for scanning. The scanning problem may be that of trying to detect crash survivors in a turbulent body of water from an aircraft. Two scanning strategies may be used to ensure scan "interleaving". One is to deliberately overlap segments of the area scanned. This principle is used in radar scanning for early detection and warning systems. A second strategy is to successively scan the same field with different scan patterns, one vertical sweep and once diagonally across the field. If the field has a definite directional texture, three scan patterns over the same field are more likely to be effective -- one with the grain, one against it, and one across the grain.

## IDENTIFY

What is it and what is its name?

Methods for characterizing a message by type or source, used ordinarily to recognize an object or entity and apply a label to it.

The definition extends to a variety of contexts in which the identification function operates. Identification requires a referencing action which produces the name or same equivalent symbolic response to be attached to the sensed input. In human behavior, the content of this symbolic response may not always be explicit. One may "recognize" an individual even though his name is not recalled, nor the explicit situation in which you met.

In automatic information processing, two sets of reference codes may be necessary for adequate identification. One reference structure may apply to the universe outside the processing system (for example, the name and address of the sender of the message). The other reference structure is to the physical and/or functional location of the message within the system. These two identity codes may require a set of cross-referencing rules or codes.

### Discussion of the Behavioral Process

The learning of an "identification" consists essentially of two parts: learning to recognize a pattern of cues that constitute a real or conceptual entity (which may be a process or condition as well as a thing, or the class to which the thing belongs); and learning the name to be attached to the entity and to associate the name with the entity, the entity with the name.

The name can serve in short-term memory as a transcript code for the thing or condition conceptualized. This transcript or code may take up less "space" in short-term memory than might be required to hold the image of the entity in mind, especially where a list of items must be kept in mind for procedural processing.

The learning of an identification combines the processes of acquired discrimination and acquired generalization. Within the context of a succession of experiences with the entity, cues are sampled which become at least sufficient for discriminating the entity from competing entities -- again, within the experience pattern of the learner. A name or other symbolic gesture becomes associated with the cue pattern. With extensive repetitions, only structural elements in the cue pattern sufficient for the identification (in the experienced contexts) tend to be used. This abstract of cues gives rise to the object constancy phenomena. It leads to progressively fewer cues being sampled for making the identification, down to some limit adequate for discrimination of the entity. The abstracting process fosters stereotyped perceptual response. The operator may have difficulty in actually "seeing the object as presented to him" in terms of actual sensory input; he sees substantially what he expects to see.

Identify

If an individual is required to identify individual members in a class of members with which he is unfamiliar, another process seems to take place. Consider an American visiting a Chinese city. At first, most of the faces seem alike; he has difficulty in remembering the distinction between the doorman and desk clerk. In a few days or weeks, this difficulty tends to disappear. It is as if he developed a new perceptual matrix for differentiating members within the new object class, and thus for identifying individual entities. It is unlikely that learning a new perceptual "set" or perceptual matrix can be facilitated by deliberate cognitive analysis of the new matrix. (Recall the aircraft identification procedures developed in World War II which were effective when samples of the entire aircraft species were displayed for recognition of the pattern, but relatively ineffective when taught by analytic methods.)

Every work environment will have several classes of entities, the members of which must be identified by the operator. If, as a student, the operator does not learn the identifications of the tools, objects, or operations of his work environment, he is handicapped in learning work procedures and in remembering/following instructions that deal with these entities. That is, he lacks subjectively clear pairings of names and image with which to translate the words in the instructions into a picture of what is to be done, or to transalte the appearance of a work object into a name which can be linked to a verbalized instruction.

## Behavioral Tendencies

The following are, for the most part, normal behavior tendencies which can sometimes be liabilities occurring at different levels of training and experience.

Recognition despite noise. The operator fails to recognize an object presented in the presence of perceptual noise, unless the correct conceptual matrix is presented. The perceptual matrix is the equivalent of an appropriate class set. Consider the case of a noisy radio channel over which words in English speech become barely recognizable. Some French words are spoken. Although the listener may comprehend French nearly as well as English, he tends not to recognize the French. Once some pattern of sounds becomes audible he may begin to recognize the French words.

Differentiation of cues within an entity. When the identification of an object has been highly overlearned in experience, the operator tends to fail to differentiate cues within the identified entity and/or between members in the entity class. Failure continues unless and until a new perceptual matrix for such differentiations is learned, or invoked, requiring that such differentiations be made. An indifference zone in perception tends to develop within which variations in an object are not noticed. For instance, unless maintaining a clean car is a matter of concern, one normally does not notice the day-by-day variation in dirt that accumulates. Habitual recognition leads to a reduction in sampling of presented cues.

Projection of expectations. Identifications of members of a class of entities can perceptually degenerate into the sampling of minimum cues that confirm a perceptual stereotype. Failure to differentiate members of the class results, of course, in failure to differentiate experiences from different members of the class. Hence, the operator is unable to profit from such experiences. In order to reverse this state of affairs, the operator must be induced to pay attention to cues he has learned to ignore. The stereotyped perception must be inhibited. Changed stimulus sampling habits must be substituted. Even assuming cooperative effort on the operator's part, these changes can best be brought about in a new work environment which will not provide associative support for the old perceptual habits.

Attributes sampled. After considerable experience on a task, identifications by the operator become limited to specific attributes of the entity essential to the task. If a clerk's job is to sort orders on the basis of the color of paper on which they are printed or written, only that feature of the orders will be identified; he will tend to ignore other attributes (e.g., kind of paper, written content, texture, and so on). Here too, if the operator's task is changed so that he must consistently note and identify an additional characteristic or two, task retraining virtually from scratch may be required in order to assure reliable performance -- and there may be occasional regressions after the new discrimination has become psychologically "automated".

Identifiers emphasized. The art of the caricaturist consists in perceiving and overemphasizing the pattern of distinguishing characteristics of people and other subjects. The ease with which the person caricaturized is recognized suggests a general tendency for selective emphasis of shape elements. This selective emphasis on distinguishing characteristics has a functional value in retrieval of image content from memory, and suggests an hypothesis for training. Training for identification of members of a class of objects should include artificial enhancement of distinguishing cues early in training, and progressive elimination of enhancing cues as training proceeds. Caricature, in this sense, would be useful only where a large number of class members must be differentiated and identified, and where it is desirable to have the student learn these identifications without the benefit of working contexts. The policeman who is required to memorize the appearance of a large number of fugitives is a case in which caricaturization would be useful.

Identification without naming. It is possible to identify a perceived entity without recalling its name. ("I recognize your face but I can't remember your name.") If the name is also given, the operator may recognize it as belonging to the percept. Work situations exist in which it is important that name and percept be reliably and rapidly associated and interchanged. In such work situations, practice of recognition that requires overt naming when the object is present, or the percept recalled, should be required in benign work circumstances. There may be large

individual differences in ability to recall these associated elements; some persons may be more prone to forget the name, others to forget the image -- face -- that goes with the name. One can readily imagine the difficulties which would occur in an operating theater if a surgeon could not readily recall the names of the tools he needs to perform the necessary activities.

Identification by progressive subsetting. Scanning may lead to the detection and identification of a hand tool lying in the grass beside a workshed. Approach and further scanning leads to identification of the hand tool as a screwdriver. Still further scanning permits the tool to be identified as a phillips head screwdriver. It is assumed here that as the operator approaches the object, progressively more cues become available.

In many cases, an object or situation may be scanned and subsetted for the primary purpose of determining whether the object justifies concern (that is, indicating whether the object is instrumental to some current functional or potential purpose) or justifies indifference and no further attention.

The example cited is not intended to imply that the logical order from more general to more specific classification is necessarily characteristic of the psychological process. Rather, the sequence tends to be determined by the kinds of cues that are perceived and integrated into the pattern of cues making up the entity as an object or condition for further interest. Gestalt theorists have emphasized the integrative aspects of perception as fundamental and essential. For practical operational purposes, adoption of an either-or choice does not seem necessary.

Studies of pattern recognition generally point to the conclusion that if entities (enemy versus friendly aircraft, for instance) must be rapidly identified from minimum cues in any of various orientations, learning the entire pattern enables identifications to be made from fewer cues and with more speed than by analytic cues. But these results can also stem from a well-known principle -- the more closely conditions of the training stimulus simulate those of the task stimulus, the greater the transfer of training. (This may not, of course, be the whole story.) In addition to learning to perceive the entire pattern all at once, analytic training has value in teaching the operator to test perceptual hypotheses -- when time and opportunity permit. A general pattern or shape may be "identified" as an enemy aircraft in the sky; the identification may be an hypothesis that requires some confirmation. When fuselage cues become visible, analytic knowledge that enemy aircraft have a characteristic bend in the fuselage, whereas similar but friendly aircraft have a straight fuselage, can enable positive confirmation of the identification. In World War II, American infantrymen in Europe never wore overcoats. German infantrymen did. The silhouette pattern at night provided the basis for enemy identification.

This discussion suggests that identification of entities that are fully and unambiguously presented may profit from a somewhat different training regimen than identification of objects of features under conditions of what might be called "stimulus deprivation", i.e., where the object is obscured,

incompletely displayed, or displayed at near-threshold sensory values. In the latter condition, recognition at any stage should tend to be accepted as an hypothesis, and scanning should be directed toward cues that confirm or deny the hypothesis. Directed scanning would be based on the operator's ability to apply analytic operations to the scan activity and to assemble partial cues into a test of a recognition hypothesis. Our discussion in a preceding paragraph about the use of the emphasized identifier would apply here.

Task Strategies

The following strategies assume that the task demands reliable and correct identifications, that recognition habits tend toward low levels of cue sampling, and that tests for a tentative identification are desirable.

Cue sampling. Taking into account the risks and penalties in delayed identifications, attempt to get more than a minimal variety of cues from the entity in question before making an identification. Cues may include the environmental or behavioral context of the entity. Adding more cues increases the probability of correct identification -- assuming the operator has an adequate reference concept or percept of the entity. In other words, observe the entity with full rather than perfunctory attention. The cost involved may consist of greater effort or concentration rather than extended response time.

Stress. Cue sampling for identifications may become especially poor under any of a variety of stress conditions. If an operator is aware of this tendency, he may deliberately compensate for the liability by more intensive checking for confirmatory identification cues. If a patrol in enemy territory is under acute stress, deliberate effort needs to be made to differentiate the color of the uniform of an approaching soldier so as not to shoot a friend. This strategy has a tradeoff -- not shooting a friend versus shooting before the enemy gets close enough to do damage.

Forgetting the name or the percept. As noted previously, one may forget the name that goes with the percept or forget the percept that goes with the name. The recall strategy is to search memory for associative context. (The reader should refer to Recall Enabling Information (Long Term Memory) strategies.)

An obstacle or block in recognition of an object, or in recall of a name, may be learned and persist in future encounters with the object, even though its name is learned again following each experience. A formal reconditioning process may be necessary to assure reliable recall when such a block occurs. (No Freudian interpretation is necessary.)

Tests of an identification. Although it is logically impossible to certify absolutely that two entities are identical, it is logically possible to prove non-identity of individuals. (The reader may recognize the same

logic in the null hypothesis in statistical reasoning -- one cannot prove the null hypothesis because one cannot logically prove from finite samples "no difference" between populations.) Tests of blood type cannot prove that the samples of blood were taken from the same man; they can, however, prove that the samples were taken from different men. Thus, in a difficult identification, a single negative cue may be given more weight in rejecting the hypothesis of an identification than several positive cues may have for accepting the hypothesis of identity. There are, of course, limitations in the practical operational value of the strategy of negative signs. Unlike blood type, many identifying cues can be altered. The strategy should be applied with an awareness of facts and a sense of probabilities.

Key differentiators. Some variables are more important than others in establishing an identification or in rejecting a tentative identification. Key variables in the classes of entities in the work situation should be learned and applied. Knowledge of secondary variables may support the testing of a tentative identification when correct identification is important.

If the analytic process must be used in reaching or testing an identification, categorization strategies may be applicable.

Training Implications

Percept and name. The learning and practice of some jobs is heavily dependent on reliable memorization of a large number of identifications. Medicine is an example. The student must learn to recognize the appearance of the entity or condition and to distinguish it from the appearance of other similar entities. He must also learn the appropriate name or symbol for the entity and differentiate it from other names in the vocabulary. He must learn to think of the object when he sees or hears the name, and think of the name when he sees the object. The operator may have to recognize the object in a variety of perceptual and operational contexts, sometimes in difficult perceptual environments. These constitute variables in effective learning for identifications.

To these variables, we must add individual differences in the ability to learn and remember percepts and in the ability to learn and remember names and other symbolic labels. If the student has a deficiency in either of these abilities, his training should clearly have a different emphasis -- assuming that training is to be fine-tuned to a well-defined set of "identifications", as a working task vocabulary preliminary to or concomitant with learning of task procedures. If the conditions of training impose a heavy requirement for verbal learning as practice for task performance, this requirement is imperative. (It is also a requirement for useful conceptual learning -- in this type of material, "identification" is the equivalent to "definition of the concept".)

Some individuals with good verbal memories may be able to learn the verbal content of procedures relatively quickly and may, therefore, do well on early classroom tests. Deficiency in the translation of verbal content into perceptual concepts permits individuals with poorer verbal memories, but better perceptual and perceptual-motor memories, to overtake those with good verbal memories in actual task performance.

If computer assisted instruction has a graphic capability, it becomes an excellent instructional device for adapting individual differences in rate and kind of learning of the identifications associated with a task, and for achieving adequate criteria of learning, at least outside the operational context of the actual work itself.

Enhanced distinguishability. The distinguishability of the percept of the object can be enhanced by simplification and emphasis on the object's primary characteristics; i.e., caricature. Diagrams in many modern textbooks follow this principle of selective enhancement and simplification. (Illustrations of this sort require a special skill, guided both by technical knowledge and communication insight.)

Caricatures should probably be used after the student has been initially exposed to samples of the "real" object; they should be discontinued as the student becomes able to reliably and automatically make the identification (along with identifications of the other objects in the set to be learned.) It is possible that the use of an artificial caricature in training may establish a learning and recall strategy for the student which he will carry into operational activities. Thus, it could serve as a supplement to learning the identifications of entities in the real work situation. Learning identifications in the actual work environment is ideal only if the right conditions prevail -- individualized tutoring on object-name and name-object with immediate knowledge of results and correction as necessary, continued for the many trials that lead to dependable recall.

Contextual cues for identification. The method used to learn identifications can make their recall highly dependent on contextual cues. Training in context is efficient and effective when those contexts are present in the work situation. Keep in mind, however, that a high degree of practice tends to lead to minimum sampling of presented cues before an "identification" is made. If after such training and experience, the operator must make the identification in a strange context, he may be unable to do so reliably.

Thus, if identifications must be made in a large and somewhat unpredictable range of contexts, practice on absolute (as contrasted with relative or contextual) identification is prescribed. Identification should be learned in a minimum context (excluding secondary matters, except for other members of the set to be discriminated from each other), and in a wide range of randomly sequenced conditions. The geologist, archeologist, and detective share this kind of learning and performance problem.

Interpretation and identification. The operator builds an identification from a number of contextual and inferential cues. An inexperienced diagnostician makes a number of tests and, by a deliberate inferential process, reaches a diagnosis. An experienced practitioner recognizes the pattern of symptoms all at once and identifies the trouble. In computer jargon, this is equivalent to translating a computational operation into a "pattern matching" operation. The pattern of elements is apprehended more or less as a whole and matched with a pattern in memory to which a name is attached.

Identify

Training has the option of mimicking the extensive array of work experiences so that a large proportion of the neophyte's tasks are performed by identification rather than interpretation. Costs of this kind of training increase as the number of work situations is increased. Expenditures may be justified if the mission is highly significant, and if task performance time is operationally critical. The lunar space-missions are examples; training was undoubtedly directed to the recognition and identification of troubles, insofar as conditions could be anticipated, rather than to time-consuming deductive and interpretive processes.

There are operational tradeoffs between the identification mode and the interpretive mode. Spontaneous identification may be based on inappropriate cue sampling and on irrelevant contexts. The interpretive process, although slower, is essentially one of hypothesis-forming and hypothesis-testing and tends to be more careful and sometimes more accurate. If time permits, and mission importance justifies, the best arrangement is redundancy of both, using spontaneous identification in creating the hypothesis and applying the interpretive process to test that hypothesis.

## INTERPRET

What does it mean?

Rules for translating the symbolic context of a message into a reference or meaning, usually by the addition of reference context from within the message itself, but at times from outside the message.

Interpreting requires response to a pattern of cues and applies to events or conditions that go beyond input data or symbols as such. Input data are only a part of the total information required for interpretation. This is the way we differentiate interpretation from decoding.

An interpretation is an inference about a condition, state of affairs, or source of data.

Examples

- Automatic analysis and "recognition" of an English word as a pattern contained in the physical wave form of an utterance.
- Human conclusion that the unannounced approach of foreign aircraft, detected and identified on radar screens, means invasion and war.
- Human conclusion that a given pattern of symptoms signifies that a system failure must be caused by a programming error rather than a machine failure.
- Language translation from Greek to English expressions.

Process Variables

- Degree of statistical certainty regarding correctness required of the interpretation.
- Amount of redundancy in the form of context available in the message.
- Range of variability among elements in the pattern to be determined.
- Proportion of irrelevant transients in the message which act as noise to interpretation.
- Number of elements necessary and sufficient to match with a reference set ("dictionary") of meanings or interpretations.
- Number of alternative meanings or identifications in the reference set available for the matching effort.
- Opportunity for interpreter to query message source for additional information for testing hypotheses about an interpretation.

Discussion

Inducing or projecting a "meaning" on a stimulus pattern or on message components in terms of some reference context, is one of a variety of thumbnail definitions of interpretation. The essential ingredients are generally those of responding to more than what is immediately present or perceived, and the capacity of the presented cues to signify subjectively a cognition of state or purpose. Some process of logical or material inference is implied, and a translation of a set of signs conceptualized. The translation may be from a symbolic representation, such as text or diagram, to physical representation or action. Or, the translation may be in the reverse direction; from a perceived actuality to a symbolic representation in thought. A meaning (in the sense of interpretation) may be expressed in what the operator thinks, what he does, or by a combination of both.

Definitions of this kind are invariably incomplete, vague, or trivial because a condition of awareness is connoted and objective definitions about states of awareness are likely to be vague or trivial.

Examples of interpretation abound. The concept of the interpretive process may be among those which are useful mainly when they are rooted in some relatively definable operational context. Thus, language interpretation, map interpretation, radar scope interpretation, animal track interpretation -- each suggests a fairly specific combination of environmental input, purpose, and process which is pragmatically manageable. Note, however, that interpretation does not include (psychologically) literal code translation such as translating English text into Morse code according to a fixed (to the operator) set of rules. When an operator, through experience, does find and apply a set of rules for responding in some class of situations, the activity becomes either a matter of decoding or an identification process rather than an interpretive process. The rules may be implicit and the operator may not be able to articulate them. (This point will recur later.)

An interpretation is at least a subjective technique for the reduction of uncertainty presented by a complex of environmental signs that do not (according to the operator's programs) directly evoke goal-relevant responses, or that tend to evoke inconsistent or conflicting responses. If we may anthropomorphise, it is as if the human abhors ambiguity, at least in its subjective state where ambiguity is translated into uncertainty. Interpretation is an anxiety reducer. (A second class of anxiety may follow one's knowledge or belief in knowledge of a set of conditions -- that is, what to do about it -- but that problem takes us into decision-making.) An insight is an interpretation, and the phenomena and strategies associated with the psychological literature on insight are directly applicable here.

The analyses of decision-making, interpretation, and identification come together and overlap somewhat. (See earlier subsection, Identify.) With repeated experiences, adaptive processes in the operator tend to change what at one time is an interpretive process into an identification process. This change does not invalidate the distinction between the two processes, nor the value of separate but overlapping strategic variables for each of them.

The overlap does make it difficult for judges who must try to distinguish one process implication from another in examining a task or collection of related tasks. The semantic distinction in itself should not be considered important except to suggest operations and strategies of relevance to task performance, task design, selection, training, and so on.

Behavioral Tendencies

As in other behavioral processes, repetitions in a task context that require a class of interpretations (such as language translation or determining the intent of an opponent in a given kind of war game), lead to various regularities of sequence, standardizations of processing format, selection, and prioritization of cues which may potentially be attended to in a given situation requiring an interpretation. These may include cues available for "testing" an interpretation subsequent to making the interpretation.

By definition, all of the cues necessary and sufficient for arriving at a conception of meaning in terms of a task situation, are not immediately present or, if present, are not given immediately to apprehension. There is opportunity and need for the operator to project information into what is given objectively. An interpretation is, therefore, an hypothesis, which may be held with varying degrees of tentativeness or certainty. The hypothesis may be more or may be less valid according to some criterion independent of the operator's concept.

The translation of a foreign language affords a convenient example of progressive change in processing with practice. The novice begins by translating words, more or less literally, one word at a time. As he progresses in vocabulary and syntax, he translates a phrase as a unit, buffering in short-term memory the several words of the phrase that he reads or hears until the phrase unit is more or less completed. With still more practice, he tends to use the clause or similar "unit of thought" as the context for interpreting a meaning of the text. Thus, he becomes able to "translate" words that are not entirely in working vocabulary because of their context. If he is translating from German into English, he must acquire a somewhat different structural pattern (in short-term memory) for retaining elements in the symbolic pattern which yield a meaning. That is, he learns different message formats from those he is accustomed to in English. Ultimately, he may be able to "read for sense" without recasting the syntactic structure of the language he is reading into that of his native language.

Quite literally, the student translator is building up an hypothesis of the meaning of a sentence and paragraph in the course of reading its elements. The test of the hypothesis is, "Does the sentence make sense with respect to some kind of reference to the context and the reader's experiences with sensible discourse?" This test may, unfortunately, be omitted in many interpretive acts of any kind when the operator is preoccupied with literal transcription of the component symbols. Perhaps this is why one of the

tests of sophistication in a foreign language is the ability to understand a joke told in that language, which would elicit amusement if told in the native tongue. Jokes usually require the perception of an incongruity within a pattern of references.

Let us now focus on an outline of the factors in the learning process associated with interpretation in a class of environments.

- Cue minimization. With continued practice, an hypothesis (conclusion or interpretation) is developed from fewer and fewer cues.

- Standard test sequencing. Depending on frequency of failure data ("hypothesis is incorrect"), standard test sequences in the examination of cues are set up in order to test a tentative hypothesis, or to develop it in stages. Tests that fail to make differentiations tend to be eliminated.

- Short-term memory content. The number and kind of cues that are clumped in short-term memory before reaching an hypothesis become standardized. For example, a careful translation of a statement made in Chinese into English may not be initiated until major segments of a sentence have been completed, or perhaps until the entire sentence has been heard or read. The sentence becomes the unit or pattern of cues from which the "interpretation" of meaning is based, and this concept of the meaning is what is coded by the translator into English.

- Prioritizing of cue types. Some cues become more important than others in establishing an interpretation or a concept of meaning. The priorities are likely to be highly individual because they are linked to code hierarchies in long-term memory that are specific to the individual's experience, and, possibly, also to his internal preference for one kind of code over another (e.g., auditory preferred over visual, spatial, or kinesthetic).

- Influence of recency. Recent events in the operator's experience tend to dominate or at least influence interpretations, especially where the cues are ambiguous or incomplete. In other words, the interpretation is governed by the phenomena subsumed under behavioral "set".

- Dropping out of cognitive mediating operations. With high degrees of successful practice with the interpretive content in a given task, the interpretive mode -- in terms of the active processes of implication -- disappears and merges into an "identification" type of response. In other words, implicit verbalization and image-making become reduced as the operator's repertoire of standard response to standard situation is expanded (even though the situation is complex).

- Stereotyped repertoire. Differentiations in response, according to subtle differences in the input messages, may become reduced to a relatively small stereotyped repertoire. This is most likely to

occur if the operator must interpret under time pressure and according to a quantitative criterion rather than a qualitative criterion. Stereotypes may crystallize around the verbal code repertoires that are in the task vernacular. The reduction of alternatives from which selections are made, and the standardization of the cues for selecting an alternative, clearly are reductions in data processing complexity.

Task Strategies

Task strategies aimed at improving the interpretation process are, for the most part, aimed at avoiding or minimizing the behavioral liabilities already described. More positive and specific task strategies are likely to depend on the specifics of the task(s) and of the environment(s) to be interpreted. In general terms, these will be the cliches of rational as contrasted with impulsive behavior -- form hypotheses tentatively; accumulate evidence through extensive sampling; correct hypotheses accordingly; test the conclusion by reference to some larger pattern or context in which the samples of data appear.

The distinction between a training technique and a performance strategy becomes highly blurred in these complex orders of behavior.

Avoid stereotypical response. Reducing error probability in interpretation follows from reducing the tendency to stereotypical response. This avoidance consists of taking more perceptual samples of the situation to be interpreted, or larger groupings of samples to be inspected as a pattern (thus getting more context), and reducing the tendency to semantic oversimplification. That is, avoid the tendency to impose a name on the phenomenon without checking further for data that qualify the name (as by subscripting it) or, qualify the interpretation indicating that extrapolation and generalization or conclusions based on the data examined would be risky.

Offsetting the spontaneous behavior tendencies requires either continuously active motivation by the operator to do so, or the control of the programming of work samples to which the operator is exposed, and giving him immediate error feedback when he makes mistakes. The latter is done in training. It may be difficult in operations unless training activities can be interspersed. Thus, what tends to happen is that the operator may become fast and reliable in interpreting standard situations, but unreliable for interpreting novel circumstances because of his stereotypical behavior.

Consider the interpretation to be tentative. In amplification of the foregoing point, the operator should be trained (and motivated to continue after training) to treat any interpretation as a tentative hypothesis that can be confirmed only to a degree by (a) more data samples, and (b) testing other hypotheses against wider contexts of the data presented. One is tempted to say, "Check the conclusion against common sense." Failure of the conclusion to fit "common sense" is not sufficient basis for denying it, but should be a basis for examining more data if they are available, or for making the interpretation very tentative.

The capacity for this kind of semantic sophistication may involve substantial individual differences that may counter-balance even lengthy and dedicated training.

Optimize chunk of information for interpreting. A significant performance strategy would aim at optimizing the unit of data that is sampled in accordance with the unit of what is being interpreted. Some optimum or at least workable unit of pattern should be selected. In language translation, this unit would be the phrase, possibly the sentence. Interpretation of the intent behind a political maneuver may not have any clear unit of pattern structure, so that the following may be required.

Identify key variables. Identify key variables and search for data samples of these key variables as a foundation for the interpretation (hypothesis). This strategy assumes that interpretations are made in some reasonably well-defined situational context. It may be a rather explicit proceduralization of the steps to be taken in getting data samples to be interpreted. If key variables are examined by the operator in a consistent order, he will be formatting the activity. To the extent that the format he uses is complete (and to the extent that the complete format is maintained in task behavior), the chances for valid interpretation are increased.

A strategic delay in action. A strategic action, whereby the operator deliberately imposes delay between the sampling of data and deriving an hypothesis or conclusion from that data, is used to offset a behavioral liability and has performance validity. "Look again before you leap." "Think before you act." It is the pause of critical, rational reflection before commitment. The length of the delay may be very brief (e.g., a few tenths of a second). Imposing the delay for critical examination is probably context-dependent when learned. Thus, the college professor may pause when offered a conclusion about an experiment by a colleague, but reflexively respond immediately to a student's remarks that he thinks the tests are unfair because ... How the delay is filled is what is important -- merely counting to ten before responding is beside the point. The probable value of the cognitive interval to task performance is that it tends to avoid spontaneous stereotype response to the stimulus of the immediate present, and to substitute a broader reference base of information in arriving at and testing the hypothesis or conclusion which is the "interpretation". This is a learned strategy in coping with input information (as it also is with emotional impulses), and is readily unlearned in task environments in which unusual patterns requiring interpretation are rare.

Watch for qualifying cues. In many task situations, a correct interpretation (as distinguished from many acts of "recognition" or identification which depend on the similarity underlying various cue patterns) depends on the perception of differences between the instance at hand and the reference set of instances. (Thus, the statement, "Orientals tend to be more polite than Occidentals", may be incorrectly interpreted as "All Orientals are

always more polite than any Occidentals at any time." This interpretation is a dangerous guide to behavior and is subject to disillusionment and rejection of the correctly stated assertion -- assuming it is actually true -- and a denial of the credibility of the source of the assertion.) The operator's failure to detect cues to critical difference(s) in the pattern to be interpreted makes progressive improvement in his ability to interpret a class of situations difficult or impossible.

It is often necessary for a subordinate to interpret the orders he receives from his superiors. Failure to distinguish between the following statements, for example, is likely to lead to trouble. "I want you to use your initiative but you will be accountable for a high level of judgment." "I want you to use your initiative even though it may take a lot of courage to carry out the action." The first admonishes daring and implies conservatism and caution. The second reverses these priorities.

Each class of task and environment probably has its own sets of key qualifying cues which must be learned and applied for the operator to gain interpretive expertise. These cues rarely enter the classroom or instructional syllabus. If they are transmitted at all, they are likely to be passed on informally from the expert to the novice in the work situation. Such instruction has the advantage of direct relevance, but is subject to liabilities of verbal instruction.

Predictive interpretation. The purpose of many kinds of interpretation is to make a prediction. Meteorology is a technique for interpreting data about past and present weather conditions in order to predict weather in a given locale. Interpreting the behavior of a motorist at an intersection is for the purpose of predicting what he is going to do as it may affect your own plans and maneuvers. Observation of samples of the behavior of a maintenance technician who is checking out your aircraft has, as its practical purpose, your prediction as to whether you will have trouble with your aircraft in flight.

Predictions are inherently more unreliable than the interpretation of a present state of affairs. It should follow that a broader range of samples should be taken and assessed in interpreting the future than interpreting the present. Prediction of the future implies a date at which something will happen; trend data must be sampled in order to make the temporal projection.

Task strategies need to be developed for estimating rates of change and projecting points in time when various events will intersect. When will the baseball thrown by pitcher X be over home plate in batting range? If the man up is well instructed, he will have learned to take a systematic series of samples of the ball en route to the plate. If the sampling series is systematic with respect to standard time intervals, he has an experience reference against which to evaluate present data on the ball's motion. (For the moment we are disregarding the problem of the direction of the ball's trajectory as if this were a separate problem, which psychologically it probably is not.) If the rate is constant, two observations

of relative position are enough theoretically to predict its moment of arrival, assuming a constant distance between the pitcher and batter and fixed distances at which the position of the ball is observed.

The same principle of time sampling is used by rational managers in assessing whether a project will be completed by a given date. Of course, management also is aware of the dynamic properties of work and workers on a given kind of project, and thus can project where changes in relative rate are likely to occur. Samples are taken, not randomly, but at certain key points in progress. These key points are learned through a background of experience. The professor in a graduate school can predict whether the student's dissertation will be completed within a year by considering the data on which the student defines the problem and the date on which the first datum is collected.

Closely Related Topics

"Interpret" is closely related to Identify and Decision Making.

## DECIDE/SELECT

### Choosing a response to fit the situation

> In a broad, inclusive sense, decision making consists of organization and processing of the following classes of information: need or want variables and situation variables (two classes of variables that characterize the "problem situation"); response alternatives; and (possibly) some strategy, policy, or rule for matching the implications of a response alternative or resource available to the profile of needs and situation.

Choices are usually made in a condition of some uncertainty about actual situations, criterion or need, and uncertainty as to how a given choice will work out.

In mechanized decision making, the response alternatives are exclusive of each other, and the classes of data and data content are sufficient for operating the rule which selects the response from the response repertoire. The rule may extend to handling probabilistic data, or even include random selection devices (in order to break action deadlocks). The designer of the rule includes an implicit definition of "purpose" in the formulation of the rule and principles for selecting a response to a situation.

Purpose is rarely simple in real-life human decision making, where substantial commitments are made by putting a choice into action. Intentions and wants are numerous, interactive, and tend to remain in flux. Ordinarily, one must trade off one kind of objective with another objective, for example, low cost versus high quality or dependability. This is a flux situation (like a stewpot) rather than a matrix formulation of values arranged systematically according to magnitudes of x and y arguments.

Human decisions in real life tend to be characterized by uncertainty about many things: what one wants; how much one will pay for what he wants in terms of penalties or loss of resource; what the situation really consists of, or even what one should know about the situation in order to define "the problem;" the range of responses from which choice may be relevant; implications of the response in terms of commitment; or probability of success or ensuing entanglements. The imposition of probability estimating on correctness of interpretation -- what the facts actually are below the presented facade -- or on response capabilities (for success or failure) may or may not materially contribute to the rationality of the choice-making operation.

As an example of the interplay of these factors, recall some major, non-impulsive purchase such as that of an automobile or a dwelling. Or, consider a decision to overtake and pass an automobile on a wet, unfamiliar two-lane highway with a curve looming ahead.

The actual operation of making a rational choice implies that all of the available (and hypothesized) information is taken into account. In come cases, decision situations are formally structured so that the process can be segmented and each segment treated serially. The so-called "decision tree" is an example

of segmenting a complex decision into units that can be treated one at a time. In operational situations, however, the operator's rational choice tends to be limited by what he can hold in mind at one time and, thus, is subject to the limits of his working or short-term memory. This limitation implies a psychological screening process. The filter in this screen may consist of preferences, stereotypes, projections, dramatized cues and wishes -- the variety of factors which we have examined under the rubric of Interpret. In fact, the definition of the process of interpreting precisely fits the "situation analysis" aspects of decision making. Interpreting is normally a part of decision making.

The limitations of working memory for holding information makes it necessary to impose simplifications in what is thought about and short cuts in "logical" processing. Constructive thinking may consist in large part of the examination of a series of facets of the situation and sifting out those factors which are marginal context from those which are central to the choice. One major factor in effective skill in complex choice-making may consist of a pattern of learning experiences which enable quick separation of marginal from central factors.

A second factor in decision making skill would consist of the functional increase of the information which working memory can hold in the process of reaching a choice. The subsection on decision making task strategies discusses hypotheses for ordering the assimilation of information content about a given situation so as to facilitate its retention in working memory.

As a person works on a job, he tends to separate decisions which, from his point of view, have marginal consequences, from those with dramatic consequences. He tends to make marginal decisions by impulse, with little or no reflection. The impulse may be founded on an extended series of decisions and consequences in his experience, so that, in effect, he "recognizes" the proper choice from the data presented or inferred. Or he may become adept at mental coin-flipping because he does not expect that further thinking or further information (if available) is likely to improve the quality of the decision he can make in that situation. (This assertion assumes the operator is not clinically disturbed.)

With practice and a subjectively reasonable batting average, the operator tends to develop format characteristics for classes of decision that continue to require reflection. The format is much like an implicit, standardized questionnaire of conceptualized variables. If possible, the decision maker structures his inquiry so that the questions are answered in a standard, habitual sequence. The ordering of the content may be based on the sequential ordering of data variables from the information source, or the ordering may be based on the ability of the decision maker to control the sequence of inquiry. The experienced decision maker also tends to structure his inquiry by acquired criteria of relevance. (Relevance is determined by the answer to a question: Does this kind of information contribute to the selection of a response I am able to make?) This filtering process obviously simplifies the amount of information which the decision maker must process. Although psychologically desirable, this tendency can, on occasion, lead to errors in decision making that are serious from an operational standpoint.

Just as many repetitions of the interpretive process in a class of situations can result in reducing the processing activity to an "identification" of an

individual "member" in that class, so too can the repetition of decision making activities (originally requiring both interpretation and response selection through vicarious testing of response implications) lead to virtually procedural response at the near automatic level of behavior. This process is behaviorally adaptive according to the processing economy of the human as an adaptive system. On occasion, internal adaptation of this sort has operational liabilities. Where such liabilities can be anticipated, the training process should attempt to inhibit the progress of the reflective process towards mere automatic response. But arresting this development has several penalties: longer delays between the psychological onset of the problem situation and the action response (thinking takes time); diminished ability to attend to other things going on at the same time (thinking uses up channel capacity).

Most of these factors are itemized in the following outline of behavior tendencies.

Behavior Tendencies

Short cuts can be expected in sampling and processing all classes of information cited in the definition with which we began this section on decision making.

Standardization of goal variables. Need variables or goal variables become standardized and formalized and may eventually be dropped from consideration when the decision operation is reduced to a procedure or habitual formula. Short-term goals tend to predominate over longer term goals. Some goal variables may be given inordinate priority over others, despite unhappy experiences arising from this neglect (e.g., deciding to have those additional drinks despite the inevitability of tomorrow's hangover or tonight's traffic hazards).

Situation variables. Restricted sampling of the situation variables tends to occur as decisions in the subject domain become habitual and the internal decision format is stabilized.

Response alternatives. There tends to be restricted testing of the implications of response alternatives, and limited searching for new ones. There is a tendency to over-generalize successful and unsuccessful responses, depending on prevailing mood.

Rationalizing choice policy. The operator tends to rationalize that a policy or principle has been followed after a choice has been made, rather than as a rationale and guide to choice selection.

Formatted structure. Repetitive decision making as part of a job dealing with more or similar classes of situations tends to become formatted. The same set of variables is examined in the same sequence. Fewer variables in the problem are considered, unless the decision maker works from an objective checklist that requires him to fill in data in each category. Even the use of a checklist can become a ritual in which only a restricted set of data is treated as relevant. The range and variety of response choices tends to shrink radically to a few prepotent favorites. (Observers may call such a decision maker "prejudiced.") The cognitive operations of weighing and thinking through the implications of situation, needs, and alternatives, tend to be reduced and the choice

tends to be elicited automatically. These outcomes may be positively adaptive to performance demands if a limited set of patterns is frequently repeated and the response repertoire and effectiveness of respective responses does not change.

In many cases, decisions must be made about events taking place in the future, which means there is some degree of uncertainty regarding conditions, priority of needs, availability of resources to implement a choice. A conservative strategy or policy will hedge on commitment or lean toward choices that have traditionally been successful and never disastrous. A more daring policy may project optimism into the uncertainty and commit more dangerously.

Behavioral strategy in dealing with uncertainty is a function of individual personality variables, mood, and, of course, the interpretation of a pattern of experiences.

## Task Strategies

Task strategies proposed in this section are restricted to those intended to reduce the liabilities and limitations of general behavioral tendencies in decision making -- where these tendencies do constitute liabilities. The proposals will, therefore, seem general rather than specific. The application of some may seem inconsistent with others, but this is the nature of the tradeoffs, compromises, and qualifications which make up a complex human skill.

The central idea of the following task strategies is the structuring (not reduction) of a class of decisions in a job to a procedure. This is not necessarily equivalent to making the decision process altogether mechanical, although where practicable, it is likely to be desirable. The aspects of the procedure are intended to control, by a combination of task design and training regimen, the difficulties which the novice has in a class of complex decision situations.

In organizational practice, this is commonplace. A format is eventually prepared for decision-making situations encountered many times, perhaps as routine operations in an office. Consider an admissions office in a college where decisions are made to accept or not accept applicants. A standard questionnaire is designed to cull information about the applicant on a set of relevant variables. Questionnaire data may be supplemented by interview data; the trained interviewer tends to work from an implicit or explicit check list of factors which are an extension of the questionnaire. The staff also develops a more or less well-defined set of requirements for admission. These requirements, of course, may be modified by circumstances. The criterion variables for acceptance should approximate the variables in the questionnaire which describe the applicant.

Thus far, the collection of data relevant to the decision has become "well-structured." As a result of historical data and experience, "standard operating procedures" can be propounded. The data describing the case can be ordered in a sequence to match the "model" of acceptance or of rejection, thereby reducing what the human decision maker has to bear in mind at one time. He stores it in a "message format".

Decide/Select

The process for reaching a choice may now begin. Factors in the situation that match equivalent factors in the acceptance model can, henceforth, be generally ignored. The decision policy may make rejection (an answer of "no") automatic if some subset of negative factors is not matched. (Females, for example, used to be automatically rejected if they applied to a boys school.) Some factor(s) may be given priority and outweigh some deficiency; e.g., athletic ability may be given priority over the applicant's overall academic standing. A high value in one desirable variable is traded against a low value in another desirable variable.

Clearly, although this process is not mechanized, it can become well-organized through task design. When a mass of information becomes organized, the decision maker can better cope with a multi-variate problem, and better approximate a rational model even with semi-rational or non-rational information such as beliefs, values, and preferences, as well as subjective estimates of probability.

Operations research is a technical example of the attempt to formalize decision structure, but with the addition of metrics, quantitative assumptions, and explicit policy rules for optimizing criterion variables. According to critics, practical difficulties with it in some complex situations have arisen from inappropriate assumptions and a reluctance to allow the human to interact intelligently with the problem. Other severe problems arise from having to treat a single variable of purpose or utility at a time, and/or from questionable assumptions in converting multiple purposes into a single "utility" scale.

The following kinds of format operations are intended to facilitate the learning of decision making in a given task environment. All issues are simplified, in many cases oversimplified.

Establish the range of response options. Determination of the range of responses from which a particular decision maker may properly select is one facet of defining the man's job. It is the bounding of lines of authority. In some cases, as in the case of the college admissions officer, this may be relatively easy to do; in other cases, as in the case of the leader of an exploratory platoon, such boundaries may be practically impossible to predict. Where a response class can be meaningfully specified, criteria of what information is relevant and what is not, become established. Information in a given decision situation is relevant if it contributes to choosing a correct or adequate response from the permissible response set.

The liability in limiting the permissible response set is that the decision maker is deterred from innovative behavior (e.g., inventing unanticipated new alternatives) which may be more operationally adaptive and useful than any already considered. This is an example of the usual tradeoff between reliability or efficiency versus flexibility.

Structure of hierarchy of decisions. Some complex decisions may be formatted into a sequential set of subdecisions. "If decision A is yes, go on to B; if A is no, consider X. If B is yes, go on to consider C." The decision to take a job with a new employer might be sequenced as follows: Is the pay likely to be

acceptable, at least as a minimum? If the answer is "no," there is little point to proceed with inquiry because the final decision will be to reject the job offer. Assuming a "yes" answer, the next question and decision may be: Can I do the work? Rarely can an unqualified "Yes" or "No" decision be made, but this is not always necessary. Rather, if the decision maker must make many decisions of this kind, he will be better off if he attempts to sequence the issues in a standardized order. One outcome of his experiences will be a consistent reference pattern.

The decision tree paradigm is a formal example of constructing a hierarchy of decisions. It includes the additional variables of payoff and probability of given "states of nature."

Develop formats for acquiring and remembering situation data. A class of choice-making situation may be described in as few as two variables or as many as a score or more. The same variables appear in each occasion of this kind of decision, although a different value, magnitude, or content is likely. Left to his own experiences in making decisions, the decision maker spontaneously develops an ordered list of inquiry variables which he addresses to a given situation. Training that is directed to the formatting and sequencing of these situational variables can accelerate the learning process. The student learns more quickly how to acquire and hold in mind the data describing the specific situation confronting him. As a desirable by-product, the ability to hold this information more readily in mind gives more mental "work-space" for thinking towards a decision. It also provides work-space to inquire about and hold in mind contingencies that do not fit the standard inquiry format. In layman's language, this is called "sizing up the situation."

An example of this development is in order. A military policeman patrolling a city makes decisions as to whether to ignore a "trouble" situation involving military personnel, intercede with verbal advice or orders, have the offender picked up and returned to camp without arrest, or formally arrest and charge the offender. He may examine the situation for data responsive to the following criteria: Is he damaging prestige to the uniform and service? Is the person creating or likely to create a progressively worse disturbance? Is he damaging persons or property or likely to do so? Is he breaking a civil or military law? Should he be apprehended for his own good or protection? Is the attention and resource necessary to intervene in this case justified compared to potential need to address more serious problems that may arise elsewhere? The appearance of indecision in the military policeman is a liability to his exercise of authority. He should make up his mind quickly. The more quickly a complete format of inquiry can be applied, the more quickly he can decide. If he has learned to apply criteria automatically in a given sequence, he can apply them more quickly and more reliably. This is the rationale for serializing the format for inquiring about the status of a situation.

Getting situational data. The business executive trying to make up his mind about a proposed merger and the would-be vacationer trying to make up his mind whether to commit a down payment for Resort A or Resort B, complain about not having "enough data" to make a reasonable decision. Where choices have only probabilistic outcomes, there never is "enough" data for certainty.

Enough data for making a decision has at least three kinds of meaning. One has to do with the subjective sense of assurance that a given choice of action is better than known alternatives. On this, there is some evidence that there are large individual differences. The so-called intuitives require relatively little data for making an intuitive leap to a choice; others continue to be uncertain even with logically complete information for making a choice. If this is, indeed, a fairly cross-sectional characteristic of personality, selection procedures of one kind or another seem desirable for the decision maker in a given kind of environment.

Enough data also has meaning in a rational context. If a conceptual model of situational variables in a class of decision, such as initiating a battle campaign or making a merger of businesses, has been developed, then absence of data about one or more of these variables is, indeed, inadequate data for making a choice. In such a case, two principles apply. One principle is that there usually are a few central variables which, having given values, should lead to peremptory rejection or acceptance of an hypothesis for the outcome of a given action. Data on these variables are likely to be worth a high price compared to data about other variables. The principle of selectivity applies. Put more effort into getting key data for accepting or rejecting a tentative choice. The popular literature about leadership emphasizes the ability to seize on these key variables and to deal exclusively with them. It is not certain that different individuals operate well with different key variables in a class of decisions, or that key variables can be abstracted for generalized training. The latter hypothesis is worth inquiry where instruction about important decisions is prepared.

A second principle in gathering information for decisions is, in effect, the law of diminishing returns. After some minimum level of information, the amount of additional useful information decreases for each unit of additional cost. For his own choice-making purposes, the seasoned decision maker probably learns subjectively when the inflection point has been reached.

A third principle for information gathering also applies. Much less information is generally required to reject an alternative that to accept it. An alternative may be rejected because it fails to meet some one or more necessary conditions. Ordinarily, an alternative is reasonably accepted only when it fulfills sufficient conditions for acceptance. Generally, sufficient conditions consist of more than one necessary condition. If there are few alternatives, the most attractive is that which remains after the others have been rejected on the basis of failing to meet a necessary condition. For example, a secretary must be assigned to a job which requires nominal typing and dictation speeds, but requires fluency in the Greek language. In getting data about American candidates for the job, the most efficient first question to ask would be: Do you speak Greek?

Where a type of decision is recurrent, either for an individual or an organization, formats for the collection and organization of situational data become standardized. Standardized formats have advantages for efficiency, and occasional penalties of inflexibility. An instructional milieu may assist the decision maker in helping him to test the effectiveness and efficiency of the

existing data formats he uses, and in proposing others that may be more adequate because (a) they are more complete, (b) they are shorter and more efficient, or (c) they are up-to-date.

Astute bargainers know that timing is important -- the time at which new information is introduced into a decision may have influence disproportionate to its value if introduced earlier. Thus, a cancer patient may be told that he can live for perhaps six months without surgery, but with surgery he has a fifty-fifty chance of dying in the operating room. The patient vacillates. After an extended period of indecision, the physician may tell him that his chances are closer to 60-40 in favor of survival after surgery. He may then be more likely to choose surgery. If, initially, he had been told that his chances were 60-40 in favor of survival, the effect might have been about the same as being told his chances were 50-50 -- indecision. If a genuine deadlock among alternatives has been reached, anything, no matter how minor, which tips the scale one way or the other, is logically justified in swaying the decision. Decisions are rarely reached by such precise weighing of factors.

Processing the information in making a choice. The thinking process for reaching a choice after reflection is likely to be recursive. One set of factors after another is weighed. One liability of recursive action is the likelihood of circular activity which leads to no conclusion at all, and where, in final desperation, the choice is based on a kind of coin-flipping.

Another liability is that because of information overload, a solution is sought by abandoning the original criteria for choice, and selecting some criterion that has a particularly attractive value which is highly visible in one of the alternatives. Thus, one approaches the purchase of an automobile with multiple criteria -- estimates of durability, economy, serviceability, versatility in function, attractiveness -- and the choice is finally based solely on which car looks most attractive.

A strategy for coping with either or both of these liabilities is to firmly reject a candidate alternative when the application of rational criteria has shown that it should be rejected. This means, in effect, put further thought about this alternative out of mind. By definition, the sophisticated decision maker is able to do this.

In human affairs, the final act of decision is often an intuitive action. (Calling it intuitive is a confession of ignorance about the process.) After a decision has been announced, many persons feel obliged to make their decision appear rational, to rationalize. The credibility of explanations of the process for reaching a conclusion may be dubious, although statements about factors that influenced or were decisive in shaping a choice may be valid.

The reader is reminded that the kind of decisions we have been discussing do not have strictly deductive or calculational procedures for producing answers which then are accepted as given.

If reaching a positive decision to act is preceded by treating the impending choice as an hypothesis, remote as well as immediate consequences of the choice should be conjectured. This is best done by imagining the train of consequences

in as concrete terms as possible. If the decision will affect the interests and actions of a group of subordinates, consider the effects on various individual members of the group. It is easier for a preferred action to be rationalized by thinking of abstractions (which invite stereotypes) than by samples of reality. This is likely to hold to some degree even when the "samples of reality" occur in the imagination.

Exploratory testing of partial decisions. A strategy used by cautious decision makers is to commit only tentatively to a course of action, gaining information about the situation relevant to further commitment or withdrawal from the consequences of tentative action. This is probably a widespread practice in our daily life as well as in institutional life. Its liabilities are obvious. The sample data obtained from a temporary and partial commitment may not be representative of response to a full commitment extended over time. If the exploratory outcome is negative, a resource may have been needlessly lost. If the outcome is positive, the crucial test may still remain.

These assertions must be qualified. Where an entire plan can be put into effect, but restricted to representative samples of the population to be affected, the advantages of exploratory or pilot testing are clear. It differs from the procedure of taking only one step at a time in the equivalent of a campaign, in order to determine the probable effectiveness of the campaign.

Modeling, simulation, and gaming exercises fill the role of exploratory testing of an hypothesis, where time and resource permit. These procedures are extensively described in their respective literatures, and are not considered applicable to our present purposes. What is germane is the decision by one or more people whether or not to put into practice an hypothesis after these data have been collected. A judgment has to be made on the extent to which these models and the data derived from them are sufficiently valid for committing to a choice in the real world.

Comment

In this section, we have not dealt with formal decision-making strategy represented by such disciplines as game theory, operations research, and simulation. If these disciplines are regarded as data-generating tools (rather than as automated decision makers), they provide input to an individual who chooses to be guided or not guided by their output. There is an extensive literature on human behavior in choice-making situations. One excellent analytic summary of this literature was prepared by Schum (1970)*. The extent of the relevance of much of this literature, based on experimental conditions having well-structured problems (e.g., gambling-type games), is open to discussion, and perhaps subject to the interpretive skill of the reader who is seeking behavioral generalizations.

*In DeGreene, K.B., Editor, 1970. Systems Psychology. N.Y. McGraw-Hill.

# CONSTRUCT - PLAN

Matching resources over time to expectations of needs

Rules and facilities for predicting what future sets of conditions will occur, what responses to make to them, and in what order, so that given goals are likely to be achieved.

## Planning Operations

- Predicting the future -- using historical and present information to anticipate which of a set of alternative states will occur at some future date or time interval.
- Exercising priority rules for determining which of several anticipated states to give priority of attention.
- Determining the set of response capabilities required for effective response to the expected condition or state.
- Scheduling the resource in making the response so that the resource is available when the expected condition occurs.

The planner combines the functions of predictor, resource selector, and resource scheduler.

## Discussion

Planning is a form of decision making. But planning consists of constructing an action pattern based on the outcome of a number of choices, rather than merely selecting from among choices. Since a plan deals with the future and the future is never absolutely predictable, planning involves uncertainty, hence, choosing from among various probabilities. Inevitably, there are planning alternatives with respect to goal commitment, goal routes, and resource selection and scheduling. Instruction in planning must provide explicit awareness of these fundamental variables in the planning operation, or it will be inefficient except for prescribed, restricted, and highly formalized "planning".

A planning job or task performed by an individual is usually restricted to an information domain; the planning task deals with a restricted set of variables in terms of goals, relevant environmental states, and relevant resources. Economic planners deal with cost, revenue, and profit variables; inventory planners deal with goods flow and storage variables; aircraft mission planners deal with the variables of payload, distance, targets, routes, equipment, personnel. There are short-term planners and long-term planners, and each works in a somewhat different domain of variables (including goal variables). Any planner's job deals with a relatively defined and restricted context of information.

The planner, like any other decision maker, tends to learn or to create an implicit structure or "model" of the variables associated with his areas of responsibility. In some cases, this model may become as explicit as a checklist.

Anticipation of requirements can be standardized if, in every planning cycle, the requirements tend to be about the same. Allocation of resources tends to be about the same if, on every planning cycle, the pool of resources is the same, and all priorities are about the same. Under such conditions, planning becomes the operation of a set of rules and formats.

Since planning is a special form of decision making, the reader should refer to the entire subsection on Decide/Select. The material in that discussion is not repeated here.

Behavior Tendencies

See Behavior Tendencies described under Decide/Select.

Task Strategies

The Task Strategies cited under Decide/Select should be referred to, along with the following.

Critical path schematics. The concept underlying PERT (Program Evaluation Review Technique) and critical path methods is the fundamental structure for any kind of planning operation. In summary, this consists of (a) constructing a scenario of the major points along the route towards completion of an objective, and (b) determining, for each of these major points, necessity for desirable resources for proceeding into the next phase of activity towards the objective. It is, in effect, a sequence chart of parallel and converging actions. A major point may be defined as a position in a path where a new pattern of resources is required, or some condition or state must be achieved.

Consider a plan for a business trip to another city. Planning is required for: getting off on time, transportation to the airport, an airplane ticket to the destination, transportation from the destination airport to the office to be visited, arrangements for meeting the desired people there at an expected time, transportation back to the airport, return passage, and so forth. This scenario suggests the elements to be planned for; i.e., transportation to airport, airplane reservation, and so forth.

Naive planners expect transportation to be ready when called, airplanes to be strictly on time, hotel reservations always to be in order. Where success is extremely important, good planning anticipates contingencies and prepares some fallback for them. Planning for contingencies inevitably calls for redundant or additional resource(s) to be available. Judgment (based on a combination of knowledge and imagination) estimates the chances of given things going wrong, the chances of an impromptu remedy being available, and balances these against the cost of providing a fallback resource.

One class of resource can often be balanced against another. If you are concerned about having a reservation for a given flight at 10 o'clock in the morning, you might (if unethical) arrange booking for an alternate flight at about 10 o'clock to the same destination on another airline. This could cost dollars or reputation. If you had ample time resource and were willing to wait until the 11

o'clock flight in case the one booked at 10 o'clock did not work out, this would be a fallback.

Strategic planning -- taking into account contingencies -- seeks for resources that are least costly in terms of the organization's resource and most versatile in terms of potential mission contingencies. In civilian and garrison operations, money is a highly versatile resource, but it has little value when a carrier-based aircraft is running out of gas one hundred miles from the deck.

The tighter the plan in terms of permissible resource to be committed (especially time), the more vulnerable is success to the occurrence of the unexpected. This is why a vast amount of planning went into thinking through, in advance, the variety of contingencies that could occur in manned space missions. Every mission has had one or more contingencies. Incidentally, one should not forget the human as a planned resource to be treated as a range and degree of competence whose costs include selection, training, and maintenance.

In summary, a dimension of strategic planning consists of creating a schematic or scenario of the flow of events in a mission and of checkpoints where a new class of resources is required. That schematic should suggest what resources are needed, and when, and should also point to the possible contingencies requiring fallback resource.

Contingency resources. Here, we continue a theme from the previous discussion. A statement in quantitative terms is proposed which is based on a variety of experiences and recommendations from both formal and informal planners. After careful planning and resource budgeting, allow approximately 20 percent more of the budgeted resource for contingencies, if the mission occurs on a well-known route with well-known resources. But, if the route is unfamiliar or uncertain, and/or the resource capability is not well known under the mission conditions, allow substantially more than a 20 percent reserve in budgeted resource.

These may be a pseudo-quantification except where dollars, time, or materials are concerned. The actual values may be challenged, and if there is a better empirical background for selecting a different value for a class of planning operations, the better value should be used as a training and operating guide.

## Training Implications

Few duties and responsibilities do not entail some planning. Formal curricula would profitably develop conceptual and practice content in the art and discipline of planning in the context of the given duty and responsibility. In daily life, at work or in private, the fact is that few individuals seem to be very good planners. Planning is not a skill that is necessarily picked up spontaneously through on-the-job experiences.

At the last, training might provide examples of structural planning formats for various relevant job contexts. The "format" is not merely a printed form, but also includes some exercises in constructive thinking.

RECALL TASK-CYCLE INFORMATION (SHORT-TERM MEMORY)

Holding something temporarily

Rules and facilities for holding messages or parts of messages in temporary storage for use at later times during a task or duty cycle, or for combining with other information during the cycle.

The above is a convenient definition for short-term memory, perhaps more appropriately called "working memory."

In general, operations are equivalent to those described for Recall Enabling Information (Long-Term Memory).

Examples

- A typist reading a sentence and holding it in mind while her fingers key the symbols.
- A computer register holding data presently to be combined with other data in an operation.
- The retention of symbols or messages in a buffering device for translating into a different transmittal rate or frequency.
- A decision maker holding in mind the objectives, problem information, and choice-making policies in the course of reaching a decision.
- A troubleshooter keeping in mind the tests he has already made and his inferences from those tests, while selecting the next test.

Factors

- The greater the number of input channels, variables, codes, and chunks of information input that must be integrated over time to reach a decision or select a response pattern, the larger the short-term storage capability required. Human short-term memory is limited (according to a variety of factors) but can be functionally increased by practice of context and by regularizing or formatting the input, by mnemonic aids, and by map-like job aids.
- The greater the variations among message sizes and message rates of transmitted and processing data, the more important the design of short-term storage facilities is to the efficiency of the total system. The greater the kinds and ranges of random variability in messages, message sources, interruptions, and noise, and the greater the variety and complexity of response pattern alternatives, the greater the burden on short-term memory.
- Information elements in short-term storage must be functionally addressable as and when relevant to the decision to be reached or the problem to be solved. Some address codes, or mnemonics, are more efficient

than others in a given system. A given "system" in this context is an individual who is likely to differ from others in his mnemonic preferences.

Discussion

The complexity and variety of short-term memory phenomena, and the central importance of this function to tasks that have cognitive or perceptual content, make short-term memory the most fruitful of all human functions for strategy design. In fact, practically every function in the present set has direct or indirect bearing on short-term memory, and many of the strategies recommended for other functions might as readily have been cited here under short-term memory.

Individual differences in cognitive ability should nowhere show themselves more significantly than in short-term memory, except perhaps for long-term memory. This would seem a truism. Clearly, the complexity and scope of thinking and problem solving seems to consist largely in the kind and amount of information an individual can hold in mind at one time. The ability of some individuals to hold in mind long strings of mathematical code, for example, while others can hold in mind large amounts of information in the form of a map, while still others can hold the representation of an intricate model or processing operations in mind -- and the ability in each case to "think" with that content -- clearly implies at least some of the vast differences in our individual mental capabilities.

We have individual "preferences" for the kind of code or cognitive representation of data presented to us for thinking purposes in short-term retention. Experienced tutors learn that one way of representing a concept or pattern of relations and operations to a student may be almost completely useless to his comprehension, whereas another symbolic structure of the same content may quickly communicate the ideas.

Individual differences in the kinds of code that can be readily apprehended and retained in short-term memory partly explain the emergence of different patterns of performance ability among individuals at different stages of learning. At early stages of learning, the ability to remember and translate verbal instructions regarding "what to do next" may be the major differentiator among rapid and slow learners. But at higher levels of task learning, when these self-instructing mediators tend to drop out, the code patterns and "conceptual models" of the task content itself dominate performance levels. A person who is poor at remembering strings of verbal instructions in learning how to go about reading a map, may be very good indeed at remembering the map content itself, once he has mastered the procedural operations for inspecting maps for a given task purpose.

One individual may be quick to learn the verbal self-instructional content of a set of manual procedures, but be relatively poor at later stages of learning that depend on muscle coordination and perhaps on the ability to code patterns of perceptual information and transform it "spontaneously" (rather than cognitively) into patterns of muscle activity.

Recall Task-Cycle Information

The implications for instructional technique of knowledge about individual differences in short-term "coding" preferences and abilities are almost certain to be more important to training technology than the practice of letting each student practice from the same content at his individual learning rate.

The content of short-term is not necessarily limited to what the operator can tell about or to what he is aware of. Short-term memory seems to have subliminal fringes. One may be aware of not having completed some task action without remembering its content. While reading a page of text, an individual may be interrupted. When he returns to reading the text, his eye tends, spontaneously, to find the location on the page where the interruption occurred. He spontaneously begins reading where he stopped at the interruption. The place where "the eye" was interrupted must have been stored in short-term memory.

Short-term memory may well be the basis for the organizing of data that results in the selection of a "set to respond." Data organization may be quite complex, as when one speaks and listens in French to the dinner companion on the left and in Chinese to the guest on the right. In sight reading of music from a score, the key signature indicates the pattern of notes to be struck when a given symbol for a note is shown on the staff. This key signature invokes a very specific repertoire set. But sometimes an "accidental" occurs -- a symbol in front of a note that countermands the signature. The key signature may indicate that a note should be flatted, which the accidental symbol says should be played "natural." The accidental value for the note applies throughout the measure, and the musician must remember to play the same note with the accidental value whenever it reappears in that measure; in the next measure, the accidental value no longer applies. This is an example of a set within a set which must be managed within short-term memory.

It is not necessary to imply that the code to an entire response repertoire making up a "set to respond to a context" must be held in short-term memory work space -- if indeed there is such a "space." But it is necessary to postulate some kind of code representation in short-term memory which selectively accesses that bounded repertoire.

In short-term memory the structure for a command to search long-term memory is created. We are now speaking of a voluntary search into deep memory. "How in the past did I remove a gasket from an engine block without tearing the gasket?" Individuals differ in the format and code that is congenial in long-term memory, just as they do in short-term memory -- and probably in quite parallel ways. From our personal history of successes and failures in memory searches, we know that starting with one kind of picture or pattern seems to have better chances of uncovering the information we seek than do other patterns. (The subsection on Recall Enabling Information (Long-Term Memory) contains an extended discussion of this issue.) To the extent that education and training are not concerned merely with getting students to pass tests, they could be directed to the design of what logicians call "search arguments" in the psychological sense. The construction of a search argument is the equivalent of a strategy, used deliberately by the student for searching "what he knows." Unless the search picture (or argument) can effectively be held in short-term memory as a single piece or pattern, the capacity for search is limited.

Recall Task-Cycle Information

In an associative system (in the stimulus-stimulus sense rather than the stimulus-response sense) when a "response" is made, it elicits the predisposition to make other responses with which it has associative links. As these responses occur (implicitly and subliminally or explicitly with awareness), they generate an expanding web of still other responses. The fact of the occurrence of the response, even subliminally, strengthens the predisposition to the entire response family in the web. It is like initiating a reverberation into a self-powered network with an internal positive feedback. It is this process of associative arousal of a set -- a predisposition to respond with a large vocabulary code of responses -- that takes time. This way of conceptualizing the problem enables a considerable number of variables and hypotheses to be deduced about relative lengths of time that might be required to induce various kinds of sets. In forming these hypotheses, one should remember that in an associative system the information "content" and the "code" in which it is stored tend to be identical to each other, at least from an operational standpoint.

These general comments about short-term memory may serve less as direct tutorial guidance for procedures that generate short-term memory strategies, than to inspire confidence that short-term memory phenomena present rich opportunity for the development and application of behavioral strategies, both in the shape of human engineering job supports and in instructional technique.

Behavioral Tendencies

With continued practice of a task, and the processing of information associated with that task, a number of tendencies can be expected.

Reduction of content. The amount of information that passes through cognitive awareness tends to be reduced to some level established by the monitoring practices of the operator for feedback sampling. That is, progressively less "meaningfulness" is projected by the operator from long-term memory onto standard data than is perceived and processed. This can be tested roughly by determining how many events the operator is able to report that were unique to a given task-cycle or set of task-cycles.

Standardized formats. More or less standardized formats or matrices for the short-term retention of information develop. An example of some of these formats for tasks with complex non-repetitive dependencies between input information and output response is that of imagery about objects and processes. Imagery is one major kind of stable memory reference. The implicit complex image has components updated by samples of input. (Some innate mechanism seems capable of regenerating this image and selectively updating it.) An example is the pilot's image of the attitude of an aircraft; understanding this property enables one to predict when the "outside-in" representation is better than "inside-out" and vice versa. Another example is that of the schematic image a mechanic has of an engine when he is making inferences from diagnostic tests.

Standardized formats for holding information in short-term memory are identical to those posited for decision making in a later subsection.

Sampling operations. There are interactions between the perceptual sampling process and short-term memory capabilities with respect to size of clump of

information sampled at one time. Too large a clump for a given level of skill results in a reduction of performance effectiveness. Size of clump is also influenced by time pressures from competing demands for attention, and by its conformity to individual level of subjective comfort. Unless modified by deliberate operator intent, or by specialized training, the size of clump stabilizes at some size less than that of the capability of the operator, and quite possibly less than optimum for the task. This tends to happen among many readers of straight text -- at least according to the proponents of high speed reading for the general population.

Task Strategies

Anticipatory sampling. Where the task imposes time dependent relationships between input and output, one objective is to sample from information sufficiently in advance of the time that effector response needs to be made to that information, so that the effector response can become organized. Sampling ahead can provide time for checking supplementary channels of information. Most important, the sampling ahead of effector response enables maintenance of a relatively even rate of effector processing flow -- and avoids working by fits and starts. The training strategy is to force the operator to scan ahead of his effector activity, after some degree of automaticity and organization of effector activities has been acquired, or more or less coincidental with that stage of learning.

Conceptual structure. Where relatively large amounts of variable information must be held in short-term storage, suitable retention of that material is required in a form that may be independent of the sequence in which it is converted into effector response. The task strategy is to develop a conceptual "model" which may include the support of imagery (of various kinds including visual, auditory, kinesthetic) which serves as an updatable reference. Where possible, the image should partake of the goal image content and should be organized with similar content. The image may be supported by a matrix of verbally specifiable variables of relevance to sampling and to effector execution. Ideally, the reference image is comprehensive enough to provide a single reference for all, or most, of the most critical channels of information. A mental picture of the attitude of an airplane in reference to the horizon embraces the variables of roll, pitch, and yaw; information about each of these variables may be transmitted through a separate display channel.

Short and long-term memory code. The content and code of short-term memory should be consistent with the code and "indexing" of information in long-term memory, so that retrieval of information or "programs" from long-term memory is fast and reliable. This is a function of training.

Stereotypical performance. The tradeoff against formatted short-term memory may be stereotypical projections, and the belief that old regenerated data are really new data as presented from input sources. Good short-term memory is dependent upon attentive observation. These issues were discussed in our treatment of Detect, Identify, and Interpret. Obviously, all of these processes interact both behaviorally and in their consequences in performance. Redundant sampling of the situation may mitigate against stereotyping that is maladaptive in performance. Fundamentally, stereotypical performance is adaptive

from an internal, behavioral standpoint -- it saves effort and time in perceptual discriminations, choice making, and effector response.

Impulse control. Short-term memory should also guard against localized impulsive behavior. The impulse to drop an uncomfortably warm object when it is grasped, should be counterbalanced when the object is an expensive vacuum tube. The impulse may be to swerve to the left when the car ahead brakes suddenly, but short-term memory that recalls another car approaching fast on the left may block the impulse out of the dominance in the response hierarchy.

Filtering in short-term memory. Since short-term memory is (or consists of) holding the cognitive content that is at least one level of associative content which is "set to respond," memory is also the basis for selective response to information "relevant" to goal objectives or operator "purpose." Note that criteria of relevance must be applied not only to environmental input, but also to internal content from the operator's long-term memory. The clarity with which a conceptual model is established determines the precision with which relevant information is selected and information "non-relevant" to the model is filtered out. The mechanism or principle of action for this filtering (aside from the metaphor) is admittedly obscure.

Goal image and conceptual guidance. Unless the task has been proceduralized, the image of goal objectives must be active in the guidance of perceptual-cognitive-effector behavior, and establish both relevance and priorities of information processing content. The goal image must also be active in short-term memory when there is any kind of improvisational behavior by the operator. It is possible, but not necessary, that the operator's concept of a model of "what is happening" in the field in which he is operating overlap with his concept or model of the goal state he is attempting to create or maintain.

A performance strategy for short-term memory: Ideally, the conceptual model the operator should learn and exercise representing his "picture of what is going on" in his field of operation should be consistent with, and at least partly coincidental with, his image of a model of what should be going on with respect to the achievement of goal states. For example, the driver should have a goal image of what his driving "slot" should be for safety, comfort, and so on. The way this picture or image of the idealized slot appears to him conceptually should enable a kind of image "overlay" of what he actually observes to be fact during his psychological present while he is driving. His actual driving behavior thus becomes a compromise between the exigencies of the environment, and the deviations from the pattern or image of the "idealized" state compared with that of the actual state. It is not necessary to stipulate the capacity of the operator to modify the image of idealized state to take into account various constraints in the environment and in himself. For example, when he is searching for route indicators (such as street signs) in a downtown area, his idealized image should have larger buffer zones in terms of distance of cars ahead and especially behind his car, than in the absence of this contingency. If he is aware of drowsiness and lack of alertness, he may similarly expand his conceptual image of margin of safety or buffer zone for permissible action to occur.

### Recall Task-Cycle Information

Performance strategy also demands, ideally, that the operator's active conceptual model be inclusive of all the major task variables about which status data should be obtained and retained in short-term memory. This point has been underlined in those topics which have emphasized the formatting of task information in task behavior.

# RECALL ENABLING INFORMATION (LONG-TERM MEMORY)

Holding something permanently

Rules and operations for holding messages and message content for retrieval in terms of where, how, and in what form (code). These include rules for filing and retrieval search. The contents of storage are information about data and information about procedures.

In the human, the distinction between information about data and about task procedures may be arbitrary. The major emphasis here will be on that form of memory that is available to thought and awareness.

## Deep and Surface Memory

A distinction between deep and surface memory is an artificial one, made to emphasize a point. If you are asked your current telephone number, or for a general description of your child, your answer is likely to be direct and immediate. This is what may be called surface memory. If you have moved as often as the average man and are asked your telephone number of ten years ago, or if you are asked to describe your 12-year old child as an infant, you are likely to pause, reflect, and search through various trains of ideas and associated contexts in order to retrieve the information necessary to respond. An attempt is made to elicit the information by building up an associative context that serves as a key to the target information. This is probing deep memory.

The distinction between surface and deep memory is mostly a matter of degree and of the availability of context keys for search. The important point is that on some occasions, as in the handling of rare contingencies, the operator may not have the requisite information at the "surface level", but may have it at deeper levels where memory search strategies have practical meaning.

## Major Tradeoffs

Storage in form of rules or principles versus specific content. Task information may be stored in the form of rules and principles which require logical operations in order to deduce or induce the specific "answer" to an immediate situation; or, the equivalent task information may be stored as specific content to be elicited by specific situations. Thus, a student may learn the rules for calculating the square root of a number, or he may memorize a square root table. Storage in the form of rule, procedure, or principle, may use less "memory space" but requires computational time and is subject to computational error. It is, however, capable of extensive extrapolation to situations not encountered in direct experience.

Memorization of tables of data and rote procedures, on the other hand, requires more memory space -- it takes longer to learn -- but requires less time to produce -- recall -- and is free of computational error. It is subject to memory error and the interference effects characteristic of rote materials (i.e., materials having little associative context).

In the case of arithmetic, educational practice combines both storage methods. We memorize the multiplication table of numbers from 1 to 12 (very likely with

the exception of multiplication by 10) and learn rules for deriving products of larger numbers.

Material that is used very frequently should be stored for rapid and direct access; material used less frequently or less repetitively may more efficiently be stored as a rule or principle for application as needed.

A liability in teaching and performing tasks by "principle" is that the operator may not be able to recall the correct identification of the principle when a situation calls for its application.

If the information system has a fast processor and a small rote memory capacity, computed answers are obviously the preferred choice. If the processor (perhaps some kind of "intelligence") is slow or restricted by small working memory, dependence must be made on the basis of rote memory and "table lookup."

Parsimony versus richness (redundancy) in storage content. Here we have a second major tradeoff. Thus, a procedure may be learned by direct repetition in one hundred trials to a high degree of reliability, perhaps automaticity. Another training regimen may consist not only of practice in the procedure in a rote fashion, but also include conceptual content in the sense of making the procedure "meaningful," perhaps by indicating the effects of each part of the procedure and of the procedure in its entirety.

Mnemonic richness, or associative context -- or meaningfulness -- may support retention and recall of the operative task information. Its effectiveness depends upon the art by which the mnemonics are designed and associated by the learner with the task content. A mnemonic may be psychologically irrelevant, thereby imposing an information handling burden rather than serving as an aid. The proportion of learning time devoted to direct practice and that given to mnemonic aids may also require intuitive judgment, often on the basis of differences among individual learners. (We assume that in real work situations the luxury of extensive experimental research is prohibited.)

Recall by actual temporal association versus association in thought. The primary basis for the association of cognitive content in memory is temporal contiguity in the experience of the content. This contiguity may have occurred in the original experience. For example, meeting a man named J. J. Roe, who was wearing the uniform of a military officer, on the steps of the Lincoln Memorial -- any two of the three sets of cues might be sufficient to elicit many of the undescribed cues in that experience. The greater the number of cues present (spatially and temporally proximate in the original experience), the greater the probability of recall (or identification or reproduction) of the remaining cues in the experienced situation. The greater the number of pieces that make up an experienced pattern presented in a retention test, the greater the chances that the remainder of the pattern can be filled in by recall. But, mental rehearsal with various cognitive contexts established another temporal contiguity of content in memory. When thoughts occur together, the future occurrence of one of these thoughts tends to elicit the other.

These assertions about recall probability assume equality of other influences on retention, such as interference effects, generalization, and stereotype.

Task Strategies

The following principles include operations for commiting information to long-term storage as well as operations for retrieving content from long-term storage. Clearly, some acknowledgment of individual differences must qualify any generalizations about memory processes. Different individuals undoubtedly have different "preferred" mnemonic codes -- verbal, visual, auditory, kinesthetic -- for storage and retrieval. And, any list of classifications is probably too simple for guidance.

Similarity of learning and recall contexts. It is axiomatic that recognition, recall, or reproduction from memory is facilitated to the extent that the learning conditions and the conditions in the retention test are similar. Similarity is a matter of degree. Psychological or implicit similarity is more important than objective similarity. That is, the contents of attention at the time of learning are of key importance to the formation of associative patterns. Thus, what is perceived and conceptualized in the course of attempting to learn Task A tends to be recalled in the process of attempting to perform Task A. Whatever was not perceived while learning or performing Task A will be relatively insignificant for the recall of cognitive or perceptual-motor content.

The matter can be stated another way. What is learned in the real context of performing Task A is perceived and thought about in the same terms as a later recurrence of the Task A situation presents. No change in coding of the content is required (as is needed when one learns about Task A from a textbook and must somehow "translate" the verbal content into the actual task situation). There is a corollary to this idea which is a commonplace recall strategy. If an operator is attempting to recall a fact or procedure that he once learned while performing Task A but is not now performing in the Task A environment, he should attempt to picture himself performing Task A.

It is possible to learn to perform a task so automatically that one cannot verbally describe its components. Tying one's shoelaces is an example of this sort. Ask most any highly skilled typist where the letter "f" is located on the keyboard, and she won't be able to tell you until after she has twitched her left forefinger. This example suggests a mnemonic strategy for recall of information under such circumstances.

Some operational specifics about learning and recall similarities are discussed in an earlier subsection on the Code function.

Intent to learn. Deliberate intent to remember what is being experienced increases the probability of its recall, even under varying circumstances of retention testing.

Clarity of content. The clearer the cognition, the better it will be remembered. An immediate test of clarity of cognitive content is the ability to paraphrase the content. If cognitive content is intended to support the recall or reproduction of procedures, or to provide a matrix for productive thinking, it must be grasped in the active, manipulative sense rather than merely in a passive way. For example, if an electronics technician must interpret and hold in mind test data relating to Ohm's Law, it is inadequate for him merely to memorize the

symbols "E = IR." Some mnemonic image for the "meaning" of E, I, and R not only aids retention of these relationships in the abstract sense, but also enables him to make tests and hold the data in mind more reliably in terms of a concrete analogy. The analogy can assist in mental manipulation of the terms in the equation while still attaching a picture of private meaning to the various patterns in which the relationship can be expressed. This sense of concept clarity may be irrelevant to classroom tests of a verbal kind; it is certain to be relevant to actual task situations where behavior is guided and interpreted -- and/or where the recall of a set of procedures is to be aided -- by the concept and principle.

As another example, consider teaching a novice what to do in the face of an impending aircraft stall. As a support to the proper procedure (whose execution is against a "natural" tendency), the student is also taught the aerodynamic concept of the relationship of critical velocity and lift. The student forms a mental picture of this principle so that his image of it and the verbal statement of the procedure are mutually supportive. If the image is clear, when stall speed is reached he will properly push forward on the stick in order to gain velocity with the help of gravity and thus get help in overcoming stall. Even though the principle is well rehearsed in non-stressful circumstances, if the principle is not sufficiently clear, it may interfere with proper recall and execution of the correct procedure.

Stored answers versus calculated answers. A stored answer is a response directly available in memory for use upon situational demand. A calculated answer, in the present context, is one which must be obtained by a procedure; the procedure may be logical, arithmetic or mathematical, or it may be the result of a search operation, such as looking for an answer in a reference manual. Psychologically, the application of a procedure uses temporary cognitive capacity as well as time, and may interfere with the operator's train of thought. For many tasks, a small number of "answers" is applicable to a very large proportion of situations. With extended practice on the job, frequently used answers are remembered so that they no longer require procedural or "figuring-out" derivation. This process may be shortened by spending some time in rote memorization of high frequency responses that are known, if adequate accuracy checks are available. An example is the new stock clerk who may find a requisitioned part by consulting a locator reference or by going directly to the shelf where the object is stored. (Note that an error check is built into the operation of the shelf if the object is correctly labeled.)

Redundancy of task procedures information. In order to maintain reliability in retention of infrequently performed procedures, the procedural content should be learned at more than one level or code. This is a key concept relating to the operational effectiveness of human memory. The perceptual-motor, verbal procedures, and "understanding how it works" are examples of different retention codes. The recall of verbal procedures enables an operator to perform a task with self-instructions, although perhaps rather awkwardly compared with perceptual-motor (automatized) performance. A conceptual picture of the processes that are interpreted and controlled by task behavior may enable the operator to deduce procedural requirements (situation-response patterns). This mode may be even slower and more awkward than performing from a well-rehearsed set of self-initiated instructions. Obviously, if the latter mode is to be

effective, it must on occasion be rehearsed. Rehearsal must be independent of the cues that can be generated by perceptual-motor performance, or else operational justification for the redundant habits does not exist.

The earlier example of the novice pilot in an aircraft about to stall is relevant here. The pilot may have acquired perceptual-motor reflexes that are properly responsive to the imminent stall. In the absence of these, he may remember what his instructor told him to do in such circumstances. Failing to remember his instructor's advice, he may have conceptualized the aerodynamic situation, and deduce from it the appropriate response(s).

There are many situations in which planned redundancy of procedural information is highly desirable. Emergencies which may happen rarely, thus affording little direct practice, are one such type. Practice is likely to be in a simulator rather than in circumstances of operational stress. Another candidate for procedural redundancy, whatever the amount of perceptual-motor practice, is a condition of operational stress -- especially where there are internal tendencies leaning toward erroneous response. Furthermore, even an automatized perceptual-motor series of responses can be disrupted and leave an operator helpless, like the piano student whose "finger memory" cannot overcome an inadvertent error, bypass it, and continue. Where there may be interference effects among a large number of fairly similar procedures which the operator must remember, an enhancement of appropriate differences can be gained by verbal and conceptual redundancies. On occasion, some adaptive flexibility (an exercise of "judgment") may be required of a procedural performance and effective response may depend on a cognitive reference for the mechanics of the procedure.

The training implication here is that the several levels or encodings of procedural information must be factually consistent with and operationally parallel to each other. Furthermore, the operator must not be required to sift and rearrange a melange of concepts, some relevant and some irrelevant to demands of the operational situation. In other words, _any_ "theory of operation" _will not do_. The conceptual content must be carefully selected for relevance, _and learned_ in the general context of procedures with which it should be associated, and also psychologically contiguous to the practice of those procedures. Only by these means can functional redundancy of procedural information in memory be assured.

_Accessing memory with compatible code_. If you briefly see a landmark along a roadway, you may not recognize a verbal description of it but you may recognize the object if you see it again, or if presented with a photograph or perhaps even a sketch of it. If a maintenance technician has serviced a number of pieces of electronic equipment with the help of a particular set of functional schematic diagrams, he is more likely to remember the procedures and idiosyncrasies of each of those equipment items if given the same diagrams to work with at a later date than if given a set of circuit schematics, even if these contain information more or less equivalent from an abstract or logical point of view. Even the content of a photograph or map, if inverted from its normal orientation to the user, is less reliably recognized, identified, or discriminated than when the orientation is the same as that commonly experienced in using the photo or map.

These are examples of code incompatibility (in the sense intended here) with the content of memory. These incompatibilities, in respective degree, impose liabilities not only upon recall of the content presented, but often more significantly to the factual and procedural context associated with them -- context which may be relevant to task performance. Code translation uses up cognitive capacity, as any student with bare mastery of a foreign language realizes when he is attempting to translate a conversation while it is going on. Cognitive capacity may be so overextended that the operator is not even able to retain the meaningful context of the messages which would enable him to reconstruct information not directly apprehended. He may not recognize that a story is being told that he knows well in his native tongue.

The particular "set" to respond to a given context of information may be thought of in functional terms as part of the code for appropriate recall of a class of data, or may at least be thought of as a basis for selecting a code set. (The pun here is deliberate.) Reading nearly illegible handwriting -- at least for some readers -- may be helped by knowledge that the writer, although writing in English, was educated in German schools. It may help to hear that a series of lines of symbols is FORTRAN code for a computer control program. The utility of cues that establish a set depend, of course, on the operator's selective predispositions to respond to such cues.

The practical significance in strategies of entering long-term memory content for recall and reproduction purposes is enormous. What may seem to be logical equivalent of information in two codes may be psychologically irrelevant for recall purposes.

The general strategy is simple: Enter information intended for long-term recall in the same form, structure, representation, and symbol sets that will occur under operational conditions for recall. Thus, if a maintenance technician is tasked with repair of various devices, his learning of the procedures for those devices should be from the same manuals and job aids he will use as references during actual task performance. The cues given him for introducing a task should be similar to cues given him in the operations which demand the selection of a task set preparatory to task performance.

Practical exigencies may on occasion demand that the operator translate information stored in one code into another code. The liabilities in doing so -- without extended practice, which is equivalent to learning the substitute code -- may be severe.

Although analogies between humans and machines should always be suspect, it is obliquely pertinent to note that the programming of a computer interpreter from one computer language to another (e.g., from FORTRAN to APL) requires a mammoth technical and financial commitment.

Assessment of the reliability of memory for task events occurring in a sequence can be based on the operator's ability to anticipate what will happen next. This means that the operator is not entirely dependent on the cues immediately presented to him for the recall of the appropriate action, nor is he entirely dependent on sensori-motor memory.

Recall Enabling Information

If the operator has conceptual mastery of a subject matter independent of any specific task actions, then a different training strategy is indicated for reliability of recall. The equivalent information should be coded in a variety of forms during training -- pictorial, schematic, verbal, etc. -- in relation to many contexts, and the operator should be required to abstract the relevant concepts from each form of presentation. Multiple code mastery lifts the operator from the tyranny of any specific set(s) of cues, and enables him to improvise responses appropriate to the concept despite the coding of the data in the situation.

Mnemonic reference codes. The hierarchical arrangement of subject matter titles in a textbook is an example of a reference code to a body of subject matter. If a student were to attempt to efficiently memorize and efficiently recall the material in his textbook, after a first pass of study of its contents, he would memorize the chapter titles, then the main topic titles within each chapter, and perhaps then the subject headings within each topic title. To the extent that he could project "meaningfulness" into this hierarchic pattern of relationships, the learning and remembering would be more efficient and effective. A relatively small amount of memorizing could serve to reinstate, in contextual as well as specific associational terms, a large amount of subject matter. This advice, commonplace in study procedures, has practical implications for storage and recall. Unfortunately, this excellent counsel seems rarely to be practiced, perhaps largely because students study to pass tests and tests are often directed to specifics of subject matter rather than to conceptual organization.

Many jobs in real life require knowledge of a large collection of facts. Randomly ordered, these facts might take weeks, months, or years to learn for recall. An example might consist of quartermaster work where even a segment, such as military clothing, may consist of thousands of individual items. If direct recall is desirable in many transactions, these items would be appropriately grouped into "logical" classes and subclasses with class and subclass names. A well-designed taxonomy can be a prodigious aid both in learning and to recall. The fact that it is easier to learn discriminations among items within a class means that a greater context of meaningfulness can be organized psychologically.

Memory search. The strategy of searching memory for content not immediately recalled consists of selecting associative keys and building a context that is likely to elicit the content. Describe over the telephone how to use the fire extinguisher that is mounted on the wall in the office corridor. How is it done? You once knew how to do it, but that was years ago. You have read the instructions for use, but have never used one. You visualize the extinguisher; this visualization suggests the ring mounted on its top. In turn, this calls up the instruction: invert the extinguisher. You visualize it in an inverted position and this may suggest the final procedural step: bang it on the floor upside down to break the internal container that releases the chemical agent. Your present visualization helps unlock the visualization of the action you made when you first read the instructions on the brass plate.

What did the instructor tell you to do if a side wheel tire blew out when you touch the runway? (This recall route must be rapid!) The memory may be of a

set of verbal instructions, or it may be a visualization of the principle at the time of instruction, or a combination of both. But the process consists of one or more convergent keys to the content. The recall process may occur in less than a second, or may be built up over months of moving through a succession of contexts as in psychoanalysis. The context that can be recalled first is the partial key to recall of the next more specific context, and the summing of these contexts cumulates through a series of recognitions towards the object of the search.

In terms of background learning, the better organized the mnemonic pathways, the more rapid and reliable the recall. The mnemonic organization may consist of hierarchic groupings and subgroupings of subject matter (potentially characteristic of formal and technical subject matter) or it may be "coordinatively indexed" by classes of environment and situation (such as in personal experiences). Coordinate indexing is a librarian's expression for using a number of descriptors which, taken together, describe the subject matter target of the search.

Strategy in searching deep memory also consists of trying to guess the code in which the content is likely to be represented -- verbal, pictorial, diagrammatic, kinesthetic, abstract conceptual. The code may not be understood explicitly in these terms, but rather in situational terms. Another facet of deep memory search strategy is to guess at the likely environmental setting in which the learning experience occurred. Examples described earlier are relevant.

The accuracy of the recalled content is, of course, subject to a variety of distorting influences well known in the psychological literature. These distortions may arise from conditions at the time of the experience (stereotype, selective attention, inappropriate set, perceptual defense mechanisms) or from intervening experiences which are assimilated into old memory contexts and thus alter them perhaps irrevocably. A given memory content almost certainly interacts with the conditions of attempted recall, and is potentially distorted by that interaction.

The logical implication of this proposition is that a recall route should not be attempted which takes the search through somewhat similar but different classes of content. Rather, the strategy should consist of an attempt to work with mnemonic content that is likely to be unique context to the target content to be recalled. For example, in attempting to recall the street number of the house lived in as a boy, it would seem poor strategy to work backward from more recent addresses to the address in question. Interference effects among the various addresses are virtually certain. A better strategy to apply in attempting to evoke the old house number would seem to be that of picturing the house in question and the experience contexts associated solely with it. (At least one subject has been able to recall extraordinary details from deep memory by following this method of what might be called "experience reconstruction." Practice at it seems to improve the capability in a general sense. It is as if one can be trained to be more sensitive to delicate internal cues.)

Additional techniques and strategies for searching and uncovering deep memory content remain to be discovered and elucidated as procedures. Although many

of the examples cited above have a personal flavor, the same principles most certainly apply to content relevant to work contexts.

When a search strategy is successful in eliciting a memory content, that content tends to become more accessible to future searches -- as if it were brought from background to foreground, so that savings in search effort per trail are very large. This phenomenon should be a useful guide to the design of refresher training of "forgotten" or partially forgotten procedures, facts, and principles. For efficiency in relearning, do the relearning from the same textbook used in the original learning.

## Closely Related Topics

Storage in long-term memory is closely akin to the following other terms in our information processing vocabulary: Identify, Interpret, and, of course, Short-Term Memory.

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