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ABSTRACT

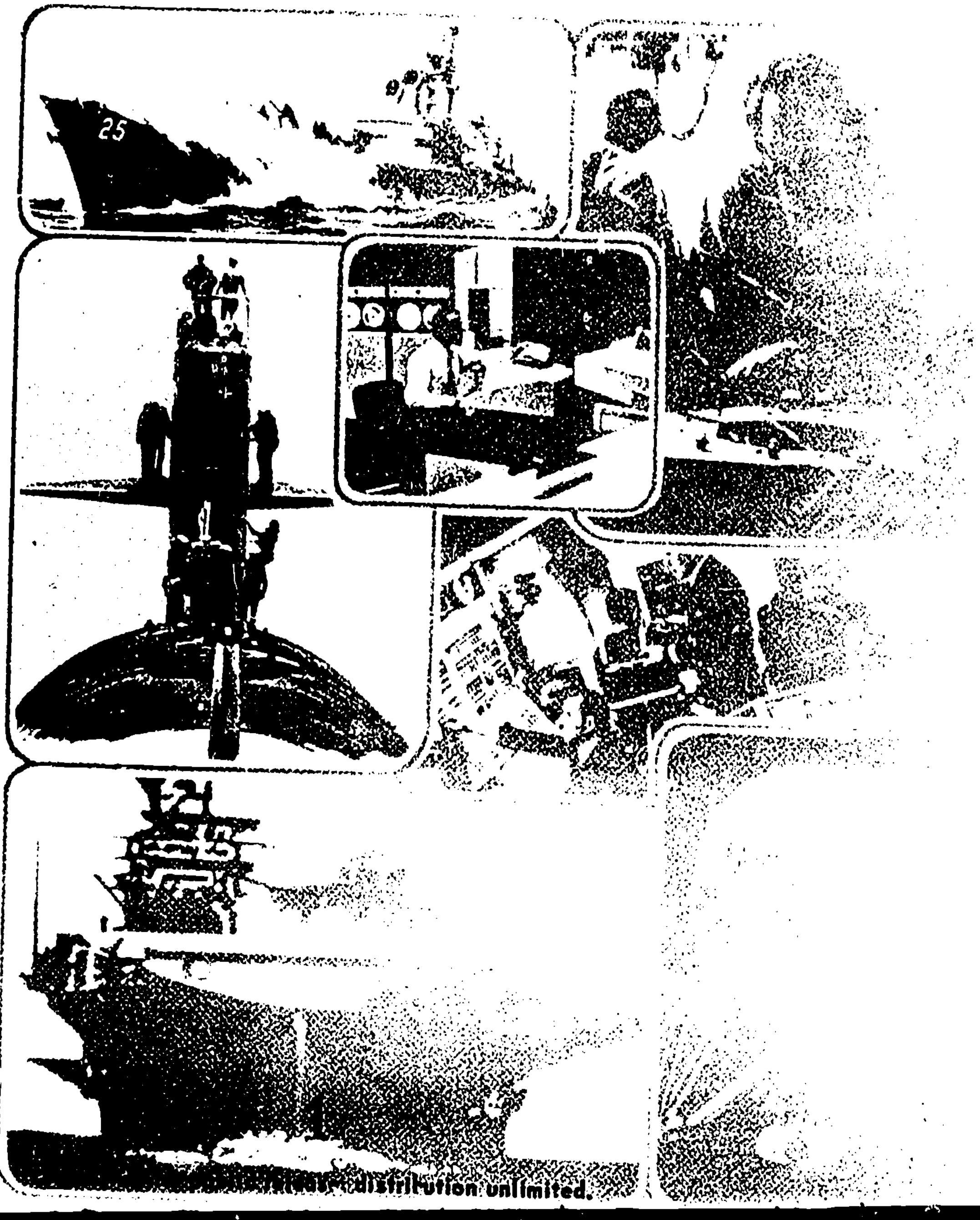
A study began the development and initial testing of a method for predicting cost and training effectiveness of proposed training programs. A prototype Training Effectiveness and Cost Effectiveness Prediction (TECEP) model was developed and tested. The model was a method for optimization of training media allocation on the basis of fixed training effectiveness and minimum cost. To test its feasibility, this model was applied to the TA-4 aircraft training system. A training analysis of the TA-4 training program was conducted to determine possible media substitutions. In conjunction with A-4 pilots, a mix of training media was selected for each task from possible media alternatives, such as classroom, cockpit procedures training, aircraft plus instructor, and actual carrier landing. Substitutions which the computer would be permitted to make among the various media were determined. Cost factors were developed for the TA-4 aircraft and training media. A comparison of costs between the existing system and the system developed chosen by the linear system showed the model was feasible and saved money. Further development and refinement of the model are discussed. (Author/JK)

NAVAL TRAINING EQUIPMENT CENTER
ORLANDO, FLORIDA 32813

TAEG REPORT 1
1972

STAFF STUDY ON COST AND TRAINING EFFECTIVENESS OF PROPOSED TRAINING SYSTEMS

TRAINING
ANALYSIS and
EVALUATION
GROUP



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NAVTRAEQUIPCEN TAEG REPORT 1

ABSTRACT

Staff Study on Cost and Training Effectiveness of Proposed Training Systems

This report describes the activities performed during a Staff Study on the cost and training effectiveness of proposed training systems.

Development of a Training Effectiveness and Cost Effectiveness Prediction (TECEP) Model was begun. It will eventually contain the following elements: task description and analysis; characteristics of student population; training tasks and training stages; a method for the determination of useful media options; media cost factors; guidelines for substitution and transfer; training program of primary media and allowable substitutions; linear program to optimize for least cost; and a report including economic analysis and recommendations.

An application of the TECEP Model using the TA-4 advanced jet training system was performed to test the feasibility of the Model. Included in the discussion of the application are a training analysis, training media mix options, cost factors for the TA-4 aircraft and training media, and TA-4 training system cost/training effectiveness.

NAVTRAEQUIPCEN TAEG REPORT 1

STAFF STUDY ON COST AND TRAINING EFFECTIVENESS OF PROPOSED TRAINING SYSTEMS

1972

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FOREWORD

This report (and a separately published supplement entitled, Analysis of the Transfer of Training, Substitution and Fidelity of Simulation of Training Equipment, TAEG Report 2) documents the results of a four-month staff study undertaken by a four-man team of the Naval Training Equipment Center's Training Analysis and Evaluation Group (TAEG). The goal of this study is to develop a procedure for evaluating alternate training systems and for selecting from among them the most cost effective one.

This procedure can be used to look at existing training systems, as well as at projected training programs where significant roles are planned for training media and devices. The reader is encouraged to "try out" the system on his own problems to determine its workability and usefulness in making resource allocation decisions. Computer programs for the computation of media cost factors and optimizing for least cost can be obtained from the Naval Training Equipment Center, Orlando, Florida 32813 (TAEG/Code 10). Feedback from such efforts directed to this address will be quite useful in improving the system since continuing development by TAEG is planned if initial "try outs" warrant it.

This study was conducted by a team of engineering, psychological, educational, and operations research personnel. They are: Dr. R. Braby, Dr. G. S. Micheli, C. L. Morris, Jr., and H. C. Okraski, P.E.

SUMMARY

STAFF STUDY ON COST AND TRAINING EFFECTIVENESS OF PROPOSED TRAINING SYSTEMS

The objectives of the Staff Study were to: (1) begin development and initiate testing the feasibility of a method for predicting cost and training effectiveness of proposed training programs; and (2) prepare a paper on the training effectiveness of simulators. The results of the first are contained in this report; the second is separately bound.

A prototype Training Effectiveness and Cost Effectiveness Prediction (TECEP) Model was developed and tested. It is a method for optimization of training media allocation on the basis of fixed training effectiveness and minimum cost. The overall Model consists of three sub-models, each of which could function independently if so desired by a user. They are media substitution and selection, life cycle cost, and optimization.

Elements of the TECEP Model and their interactions are shown in Figure 1. The purpose of each element is briefly noted below.

1. Task Description and Analysis. Identify the tasks involved in the system being studied and obtain information about those tasks required for the training analysis.

2. Personnel Characteristics. Describe the skills required of personnel to be assigned to the operational system and the characteristics (including entry skills) of the student population.

3. Training Tasks and Training Stages. The tasks are grouped into a series of stages in order to develop a curriculum for the training system. Types of learning tasks encountered in each stage are classified according to a task taxonomy.

4. Determination of Useful Media Options. A matrix was developed to assist in the selection of a training media mix. The matrix consists of a list of tasks grouped into learning blocks, learning guidelines associated with each task category, a set of implications for media selection associated with each learning guideline, and a list of training media.

5. Media Cost Factors. Nineteen factors are used in calculating life-cycle costs and to generate cost per utilization hour at various use rates.

6. Guidelines on Substitution and Transfer. To assist with the following element, which involves determining the media which can substitute for other media, guidelines in the form of media substitution options are derived from transfer and substitution data available from the training effectiveness literature, or, when data are not available, from estimates of the percentage substitution for the tasks involved.

7. Primary Media and Allowable Substitutions. The primary and alternative mixes of media, which are all considered capable of producing personnel equally trained to a specified level of proficiency, are recorded for each stage. The number of hours of all acceptable alternatives are recorded.

The feasibility of the TECEP Model has been demonstrated. It is believed that the method used would result in considerable savings to the Navy if applied during the conceptual stages of training system development. Where and how the Model can be further developed and refined is discussed.

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SECTION I

OBJECTIVES OF THE STAFF STUDY

The Naval Training Equipment Center (NAVTRAEQUIPCEN) has been actively conducting independent programs on measuring cost effectiveness and training effectiveness of training devices. Building upon this background, the staff study team focused its attention on two aspects of training system design that have not previously been emphasized. They are (1) integration of cost effectiveness and training effectiveness measurement, and (2) prediction of the cost and effectiveness of proposed training systems.

A Training Effectiveness and Cost Effectiveness Prediction (TECEP) Model was developed and tested. It is a method for optimization of training media allocation on the basis of fixed training effectiveness and minimum cost. The overall Model consists of three sub-models. They are media substitution and selection, life cycle cost, and optimization. The Model will be further tested by applying it to training analyses performed by TAEG teams.

This report describes the activities performed to accomplish the objectives of the staff study, specifically, to test the feasibility of a generalized method for predicting cost and training effectiveness.

SECTION II

TECHNICAL APPROACH

A. INTRODUCTION

The Training Effectiveness and Cost Effectiveness Prediction (TECEP) Model depicts the process of translating task descriptions and learning principles into prescriptions for the design of training systems. The output of the Model is to be a basic description of a proposed training system thought to be (1) powerful enough to accomplish the training tasks with the assigned student population, and (2) incorporating the lowest cost mix of media capable of achieving that goal.

The act of prescribing or proposing the characteristics of a training system is a complex decision-making task with numerous unspecified and unknown alternatives. The design of these systems is both a science and an art; a science to the extent that the scientific method, including the use of theory, is employed, and an art to the extent that a subjective feel for training or individual expertise is relied upon.

The TECEP Model described in this report is an attempt to focus learning theory, economic analysis and other evidence acquired through the use of the scientific method on the task of training system design. The Model is also intended to sensitize the skilled educator to perceive the possible outcomes of alternative training approaches. Both the scientific and the artistic approaches are imperative and must be melded together to achieve a functioning design.

B. TECEP MODEL

The TECEP Model is presented as Figure 1. A description of each element in the Model is presented below. Those elements within the Model that were developed within this study will be described in greater detail than those that were adapted from other sources.

1. Task Description and Analysis. Numerous task analysis methods have been devised, any one of which could probably be applied. However, the Naval Training Equipment Center has supported a program of research concerned with the development of task analysis techniques specifically for use in the development and use of training equipment. One such task analysis method is described in Chenzoff, A.P. and Folley, J.D., Guidelines for Training Analysis (TSA), NAVTRADEVCEN Technical Report 1218-4, 1965, (AD 472155). Within these task analysis methods, each task to be performed by man within the operational system is described. The description should include an inventory of skills and knowledges that operators, sub-teams, teams, and multi-team forces must possess in order to carry out those functions assigned to man within a man-machine system. Where possible, the tasks should be described as specific behavioral objectives, i.e., what should be done, under what conditions, and how well.

2. Personnel Characteristics. The characteristics of personnel to be assigned to the operational system, and to a related training program, must be defined along with an estimate of the pertinent knowledges and skills they will have prior to system training. The number of students to be selected for training should be stated.

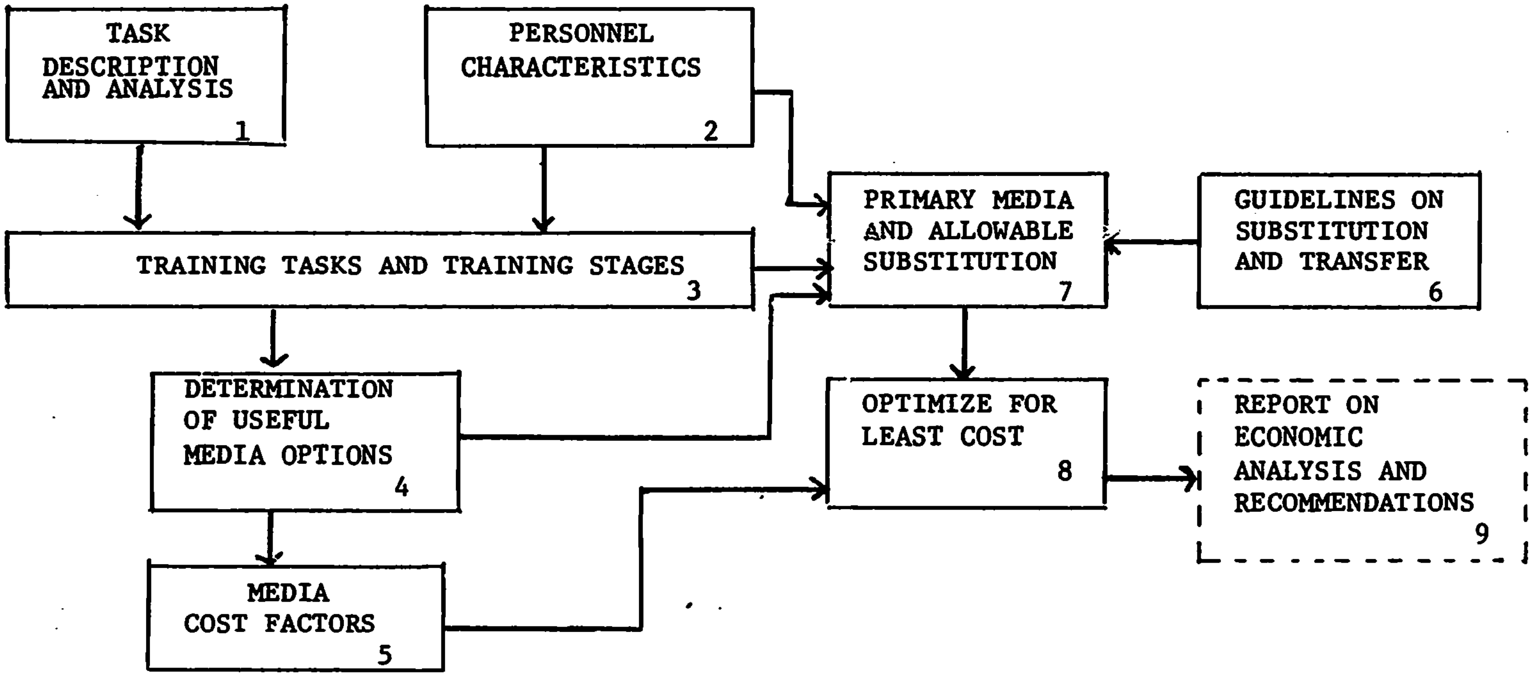

Figure 1. Training Effectiveness and Cost Effectiveness Prediction (TECEP) Model

3. Training Tasks and Training Stages. A preliminary curriculum outline should be developed for the training system, grouping the tasks into natural groups and sequences of groups. At this stage, the curriculum outline should consist of a series of phases or stages in a training program. A stage should contain fundamentally similar tasks. The stages should be ordered so prerequisite skills are acquired before advanced skills are attempted. Individual tracks will be required for each position in a tactical team. These tracks will converge into a single track as the stages of training move from operator part-tasks and operator tasks to sub-team, team, and multi-team stages. The general characteristics of tasks to be accomplished in each stage should be categorized in terms of task/behavior categories listed in Table 1. Most stages in a training program, and specific tasks within a stage, will be described as complex tasks involving two or more task categories. As an example, Table 2 depicts one of eleven stages in the TA-4J Advanced Jet Syllabus in the Navy Undergraduate Pilot Training Program. Primary task categories for each task and for the stage are presented.

4. Determination of Useful Media Options. Media options or alternatives are identified, without regard to cost, through the use of the media selection matrix. The matrix was developed to aid the training system designer in identifying a cluster of training media suited to the characteristics of specific training tasks. It provides a means for ranking media in order of pedagogical power to deal with specified training tasks. It should be noted that final media selection is based not only on the pedagogical power of the media to achieve training

Table 1

TASK CATEGORIES

1. Recalling Facts and Principles
2. Recalling Procedures
3. Non-Verbal Identification
4. Non-Verbal Detection
5. Using Principles, Interpreting, Inferring
6. Making Decisions
7. Continuous Movement
8. Verbal Detection and Identification
9. Positioning and Serial Movement
10. Repetitive Movement
11. Written Verbalization
12. Oral Verbalization
13. Other Verbalization, including Signs

Task categories are based on the 19 categories identified in M. Paul Willis and Richard O. Peterson, Deriving Training Device Implications from Learning Theory Principles, Technical Report: NAVTRADEVCEN 784-2, 1961.

Tasks categories are listed in order of their priority in Naval Tasks as reported in B. R. Bernstein and B. K. Gonzales, Learning, Retention and Transfer, Technical Report: NAVTRADEVCEN 68-C-0215-1, 1971.

See Appendix A for descriptions of these task categories.

Table 2

Categorization of Tasks in the Familiarization Stage in the TA-4J Advanced Jet Navy Undergraduate Pilot Training Program.

Stage	Tasks Within Stage	Primary Task Categories
Familiarization	Cockpit Procedures	Recalling Procedures Non-Verbal Identification Positioning & Serial Movement
	Preflight Inspection	Recalling Procedures Non-Verbal Identification Making Decisions
	Normal Operating Procedures	Recalling Procedures Non-Verbal Identification Continuous Movement Positioning and Serial Movement
	Nosewheel Steering and Taxi Procedures	Recalling Procedures Non-Verbal Identification Continuous Movement Oral Verbalization
	Take-Off/Climb/Level Off	Recalling Procedures Non-Verbal Identification Continuous Movement Positioning and Serial Movement Oral Verbalization
	Aerobatics	Recalling Procedures Non-Verbal Identification Continuous Movement
	Landing	Recalling Procedures Non-Verbal Identification Continuous Movement Positioning and Serial Movement Oral Verbalization

objectives, but also on the broader view of an economic trade-off analysis of the use of alternate media, as described in later steps.

Media selection is accomplished by identifying media that facilitate or make possible the use of specific learning guidelines based on learning theory. Further, the matrix is based on the assumption that the greater the number of learning guidelines that can be facilitated by a medium, the greater the productivity of that medium to accomplish a training task in that specific task category.

One page of the matrix is presented as Table 3, and the entire 19-page matrix is located in Appendix A. The first column of the Media Selection Matrix, entitled Task Categories, contains descriptions of the common behavioral attributes and examples of each of the thirteen task categories incorporated into the matrix. The next column, Task Elements, divides each task category into elements so that learning guidelines can be associated with standard elements of a task, e.g., learning guidelines associated with the stimulus aspect of a task. The column, Learning Guidelines, contains rules-of-thumb, based on learning theory, for designing and using a learning system for a specific type task. A total of 105 Learning Guidelines are identified and associated with the thirteen task categories.

In the next column, Implications for Media Selection, one or more implications are associated with each "Learning Guideline." They serve to simplify the task of determining if a specific medium facilitates the use of the learning guideline.

Twenty media options are listed on the matrix. This represents a wide, but not exhaustive, set of options. Table 4 further identifies these media. In an effort to keep the size of this report to a minimum, these media options are not further defined. For a detailed description of many of these media, the reader is referred to Rhode, et al, Analysis and Approach to the Development of an Advanced Multimedia Instructional System, Technical Report AFHRL-TR-69-30, Vols, 1 and 2, Westinghouse Learning Corporation, 1970.

Additional media options can be added to the matrix, as required.

An "F" appears at the intersection of the column for a specific medium and the row containing an implication for media selection if the medium automatically facilitated the application of the guideline. An "M" appears in the matrix if the implication for media selection and its related learning guideline can be carried out manually by the instructor within the context of the medium.

The matrix aids the training system designer in determining which media will allow him to apply a significant number of learning guidelines for a specific training task.

5. Media Cost Factors. The process of developing media costs by way of life cycle cost analysis is outlined in Figure 2 and includes: (a) the identification of cost elements and the categorization of these elements into cost factors; (b) the estimation of cost factor values, and (c) the use of the cost factor values in calculating cost per utilization hour for each medium. The Model was programmed for the digital computer in FORTRAN and run on the XDS Sigma 7 computer.

Table 4

MEDIA IN MEDIA SELECTION MATRIX

CCTV	Closed Circuit Television Without Feedback
PI(L)	Linear Programmed Instruction Text
PI(B)	Programmed Instruction Text With Branching
SRS(T/S)	Student Response System, Feedback to Teacher and Students
SRS(AV)	Student Response System with Audio-Visual Program
PIA	Portable Instructor Aids (projectors and recordings)
CAI(MM)	Computer Assisted Instruction with Mixed Media
LCD(AV)	Learner-Centered AV Devices - Carrel
VTR	Portable Video Tape Recorder System
LECT/TEXT	Conventional Classroom: instructor, lecture and textbook
PA	Performance Aids
Carrel/Mock-Up	Audio-Visual Carrel with Equipment Mock-Up
SIM	Simulator
SIM/AA	Simulator with Automatic and Adaptive Features
PROC TNR	Computer Activated Procedure Trainer
PROC TNR/AA	Computer Activated Procedure Trainer with Automatic and Adaptive Features
Manual PROC TNR	Manual Procedure Trainer
C/Gaming	Computer Gaming Trainer
OP/SYS	Operational System
OP/SYS & SIM	Operational System Plus Simulation

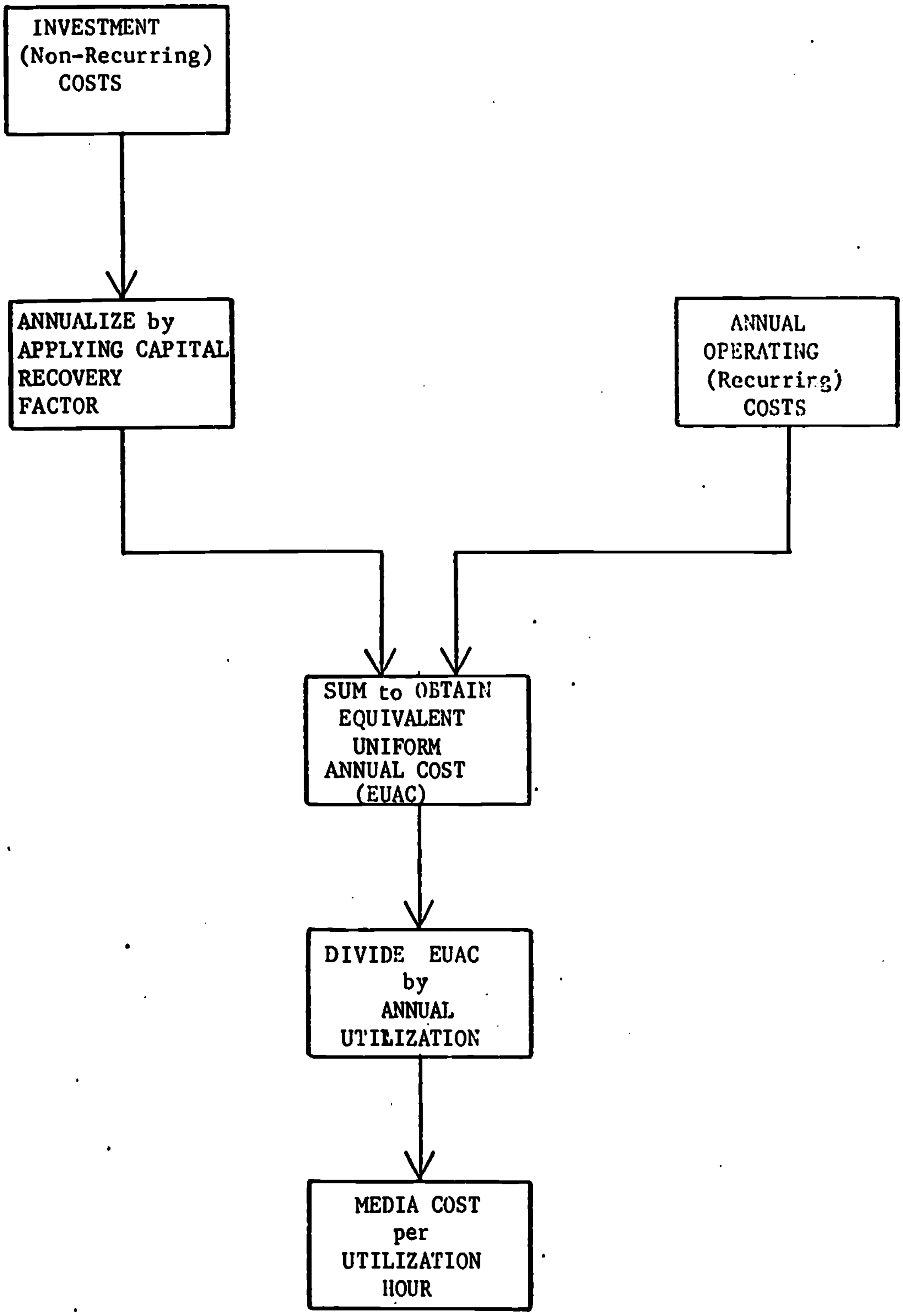

Figure 2. Training Media Life Cycle Cost Model

Alternative training systems are compared on the basis of training media cost per utilization hour. Total life cycle costs are used in the comparison, and all costs, non-recurring and recurring, are transformed to an Equivalent Uniform Annual Cost (EUAC) for each training medium. The EUAC is a cost that represents the annual equivalent of a non-uniform distribution of actual costs. This parameter facilitates the comparison of costs where money has a time value and the disbursements are non-uniformly distributed. The EUAC can be viewed as a series of equal annual payments occurring at the end of each year throughout the life cycle of the training medium.

The application of the Capital Recovery Factor requires an approximation of the economic life of the training medium. The economic life is that period of time over which the benefits to be gained from the training medium may reasonably be expected to accrue to the Department of Defense. The economic life of training equipment begins in the year in which the equipment is first utilized for training and ends in the last year of utilization. The analysis assumes zero salvage value for training equipment at the end of its economic life. The Capital Recovery Factor also necessitates the assumption of an interest rate. Interest is treated as a cost to all Government expenditures. This position is based on the premise that no public investment should be undertaken without considering the alternative use of the funds which it absorbs or replaces. As a consequence, this analysis includes a ten percent discount rate in the life cycle cost model.

Once the Equivalent Uniform Annual Cost (EUAC) for each medium is determined, the cost per utilization hour is computed by dividing the

EUAC by the annual utilization rate of the medium. The resultant cost rate is the figure of merit used for comparison purposes. The cost rates are displayed on the computer printout as functions of various utilization rates.

As a requisite to using the life cycle cost model, it is necessary to identify the cost elements and factors associated with training media. Table 5 lists the majority of the cost elements considered in viewing training device life cycle costs. Operational equipment used for training purposes have published cost factors which encompass related cost elements. Following the identification of cost elements, the media cost elements must be grouped as necessary and the resultant grouping reidentified as cost factors. Figures 3 and 4 identify 17 cost factors and show how these factors are combined in computing life cycle costs. Appendix B provides definitions for each of these factors. Equations and directions for combining these factors are also provided. Table 6 is a computer generated listing of cost factors for each of 17 media. Column headings are defined in Table 5. These cost factors were an input to a linear program to optimize for least cost in the media mix study reported in Section III of this report.

6. Guidelines on Substitution and Transfer. Transfer of training studies have demonstrated that training devices can be used effectively to reduce time spent in training in operational situations, with associated cost savings. Therefore, as a normal operating procedure, attempts should be made to identify training areas in which proficiency can be achieved at lower overall cost through increased emphasis on the use of training devices.

TABLE 5

TRAINING DEVICE COST ELEMENTS

INVESTMENT COSTS (C_{ACQI})	
Cost Factor	Cost Element
C_{HD}	Material Engineering Development Production, Installation & Testing
C_{MOD}	Configuration Changes Contractual Improvement Changes
C_{TD}	Engineering Reports/Drawings/ Computer Programs Logistic Support Data Management Data
C_{LS}	ILS Management Engineering & Tech Services Training Course(s) Provisioning Conference
C_{FACA}	Building Space Power Air Conditioning/Heating Lighting Shielding
C_{PSEA}	Initial Supply System Stock Initial Outfitting Cataloging & Supply Item Introduction
C_{GFE}	Operational Equipment (Unmodified) Operational Equipment (To be modified)
C_{MTSA}	In-House Engineering Monitoring Project Management Training Device Introduction Logistics Management
C_{OTHA}	Conferences Reliability Program

ANNUAL OPERATING COSTS (C_{OMNI})	
Cost Factor	Cost Element
C_{PSEO}	Replacement Spares, Repair Parts & Support Equipment Supply System Replinishment Repair of Reparables Test Equipment Calibration Consumables Supply Processing & Item Retention
C_{PRS}	Government Engineering & Tech Services Contractor Services Record Keeping & Mod Installation Military Instruction, Maintenance Operation
C_{FM}	Modification Design, Material & Logistic Support Modification Installation, Test & Checkout
C_{OMTG}	Retraining of Military Technicians Retraining of Civilian Technicians
C_{FAOV}	Electrical Power Water (cooling)
C_{FAOF}	Deck Space Janitorial Services
C_{MTSO}	Government Monitoring Quality Assurance & Revalidation
C_{OTHO}	Reinstallation Storage Rework

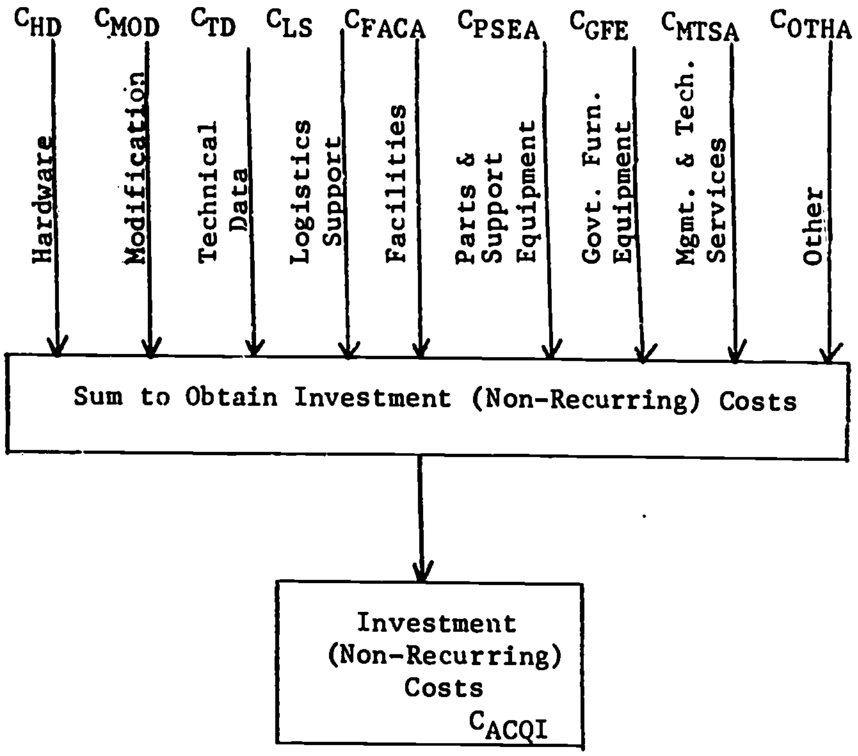

Figure 3. Development of Investment Costs

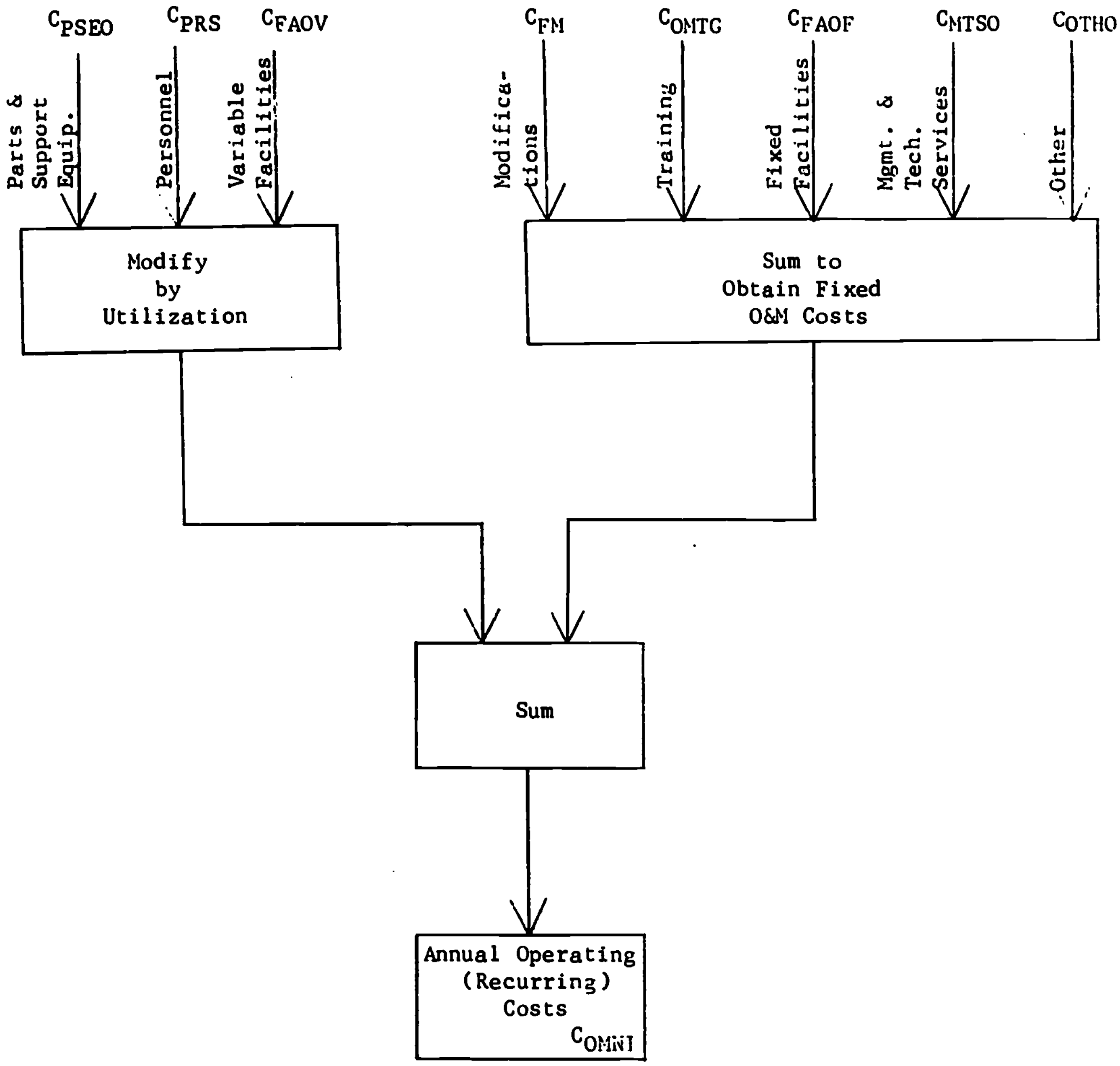

Figure 4. Development of Annual Operating Costs

TABLE 6
COST FACTORS
(IN THOUSANDS OF DOLLARS)

```
UTILIZATION COST 17 MEDIA     INTEREST=.100

COST COEFFICIENTS
        FC       MOC      TC       LS       FACA     FSEA     GFE      MTSA     BTHA
   1    3.000    .0000    6.000    .5000    10.00    .5000    .0000    2.000    3.000
   2    .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000
   3    1.200    .2000    4.000    .5000    10.00    .5000    .0000    2.000    2.000
   4    24.00    6.000    12.00    1.400    9.000    4.300    .0000    1.000    1.000
   5    115.0    28.00    23.00    6.900    15.00    22.80    .0000    5.000    4.000
   6    330.0    80.00    66.00    19.60    150.0    65.90    .0000    12.00    12.00
   7    400.0    100.0    80.00    24.00    200.0    79.20    .0000    15.00    18.00
   8    1000.    250.0    200.0    60.00    220.0    193.0    .0000    25.00    45.00
   9    427.0    45.00    108.0    38.00    .0000    127.0    .0000    10.00    20.00
  10    427.0    45.00    108.0    38.00    .0000    127.0    .0000    10.00    19.00
  11    427.0    45.00    108.0    38.00    .0000    127.0    .0000    10.00    21.00
  12    427.0    45.00    108.0    38.00    .0000    127.0    .0000    10.00    20.00
  13    1100.    250.0    200.0    66.00    220.0    217.0    .0000    25.00    55.00
  14    854.0    90.00    216.0    76.00    .0000    254.0    .0000    20.00    42.00
  15    654.0    90.00    216.0    76.00    .0000    254.0    .0000    20.00    42.00
  16    512.0    54.00    128.0    46.00    .0000    151.0    .0000    10.20    25.00
  17    725.0    725.0    198.0    66.00    .0000    215.0    .0000    17.00    34.00

        FM       BMTG     FACF     MTSB     BTHB     PSEB     PRS      FABV     YR       AVHR
   1    2.000    5.000    1.000    2.000    5.000    .1000    70.00    .5000    30.00    1680.
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   8    38.00    2.200    14.00    12.00    6.000    11.70    30.00    8.000    15.00    1680.
   9    26.30    19.70    .0000    20.00    21.00    97.00    80.00    15.00    13.00    650.0
  10    26.30    19.70    .0000    32.30    24.20    103.0    167.0    60.00    13.00    650.0
  11    26.30    19.70    .0000    32.30    24.20    103.0    97.50    60.00    13.00    650.0
  12    26.30    19.70    .0000    64.60    30.00    103.0    98.00    3189.    13.00    650.0
  13    41.80    2.500    .0000    12.00    9.000    12.90    30.00    8.000    15.00    1680.
  14    52.60    39.40    .0000    64.60    48.40    206.0    334.0    120.0    13.00    650.0
  15    52.60    29.40    .0000    64.60    48.40    206.0    264.0    120.0    13.00    650.0
  16    30.00    23.00    .0000    44.00    28.00    123.0    187.0    72.00    13.00    650.0
  17    40.00    27.00    .0000    51.00    40.00    173.0    235.0    100.0    13.00    650.0
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Substitution and transfer can only be considered in terms of specific behaviors. An initial and basic effort in a training situation analysis, therefore, should be to identify each of the behaviors to be developed. The definition of training (or behavioral) objectives is critical. A training objective will identify: (1) specific knowledges, skills, and attitudes required of the trainee following completion of training, and (2) the knowledge and performance criteria used in measuring the trainee's level of achievement within specific behavioral objectives. In addition, behavioral objectives can be used to define the psychological processes involved in their attainment, including media alternatives, substitution of one medium for another and the transfer from one training situation to another. It is important that attention be given in the analysis of training objectives, to identifying those which relate not only to essential knowledges and skills, but to attitudes and motivations as well.

The TECEP Model involves media substitution options. With the aid of digital computer techniques, a determination can be made concerning which media can be substituted for other media. Using transfer and substitution data that could be applied from related tasks as guidelines for the limits and ratios of substitution, media substitution options have been estimated for certain projects. The technical report prepared as part of this study, but published separately, gives the data available from the training effectiveness literature from which estimates of the amount of simulator training time that can be substituted for operational system training time can be derived. When the data are not available or are of limited applicability, it will be necessary to estimate the percentage substitutions for the tasks involved.

7. Primary Media and Allowable Substitutions. The media Substitution Option Form, Figure 5, is used to record the primary and alternative media selections for each stage in the proposed training program. Separate forms are used for each task. The primary and all alternative mixes of media are considered capable of achieving criterion performance.

Under the heading "Recommended Hours" per medium, the initial selection of media, and the hours per medium per student are recorded. Under the heading "Minimum Hours" per medium is recorded the hours in that medium that cannot be traded away. Under the heading "Difference" is recorded the number of hours that can be traded. In the remaining cells in the row, all acceptable trade-offs are recorded by inserting the number of hours in the alternate media that can be substituted for the "Difference" hours in the primary medium.

8. Optimize for Least Cost. In the process of defining training system alternatives, it is necessary to evaluate many mixes of training media. In most cases, various media combinations are equally effective for each stage of training and the problems of evaluating substitution ratios and life cycle costs become very complex. If 15 to 20 training media have possible application in any of 50 tasks and if the hourly cost of each medium varies inversely with utilization, a linear program for evaluating alternatives becomes a desirable analytic tool.

The linear program[1] adapted for use in this application is one in which the analyst can use up to 75 constraint equations and 75 variables.

---

[1] Mr. Paul R. Little of the TAEG Staff adapted the program for use with the TECEP Model.

STAGE____________

TASK____________

MEDIA OPTIONS	HOURS PER MEDIUM			MEDIA SUBSTITUTION OPTIONS												
	Recommended Hours	Minimum Hours	Difference	1	2	3	4	5	6	7	8	9	10	11	12	13
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																

Figure 5. Media Substitution Option Form

The program uses the simplex method of solution and provides the minimum or maximum objective function, as well as slack and sensitivity. A sample computer printout of a linear programming problem used for TA-4J training system media selection and a brief description of the tabulated results are shown in Appendix A.

An economic analysis of a training system can only be as good as the confidence level associated with media substitution ratios and life cycle cost estimates. If it is assumed that the approach to the development of this information results in high confidence estimates, the only remaining problem is one of optimizing media mix in order to achieve lowest cost. The linear program described accomplishes this very effectively and the variable slack and sensitivity information provided enables the analyst to assess costs associated with system variations.

One limitation of the linear programming cost optimization approach is the necessity for multiple computer runs. Media cost varies inversely with utilization rate and the final utilization rate cannot be determined before linear program media selection is accomplished. Consequently, an iterative approach to final solution is necessary and media cost per utilization hour is recomputed between each linear program iteration. Considering the manual operations required between iterations, it would appear that manpower and computer time requirements would become prohibitive. This is not the case, however, because cost per utilization hour is computed in 5% increments, and substitute media cost differences are generally significant. As a result, the solution will seldom require more than five iterations. In addition, a linkage program is presently being considered which will eliminate manual operations between iterations. When this is accomplished, the only additional time required will be computer time. As an example, four iterations will increase computer time by a factor of four. However, total time will be measured in seconds and will not affect computer cost significantly.

9. Report on Economic Analysis and Recommendations. The TECEP Model provides basic cost factors required in the economic analysis of alternative proposed training systems. Additional information, outside the scope of the Model, will usually be required.

Economic Analysis, as its name implies, is an analytic study of the economic factors associated with a proposed course of action. Accordingly, it includes all of the analytic techniques embodied in cost-effectiveness and cost-benefit analysis. In addition, it includes classical economic theory and financial analysis methodology. It can be thought of as a discipline which encompasses all economic analytic techniques and as such, it is considered to be the best method available for estimating resource requirements associated with proposed training systems.

In order to establish a particular economic analysis methodology for training systems which will provide usable, high confidence results, it is first necessary to determine a value base for training which will allow for estimates of training systems worth. This becomes an impossible task if value is to be measured in dollars only because value is based on benefit gained which is often a subjective quantity. When a free market system operates, as in the private sector of the economy, value is equated to a dollar amount which buyers exchange for value received. Since this mechanism does not allow for value determination of training systems used within the Department of the Navy, other methods must be employed.

As an example, it can be stated that the value of a training system is proportional to the number of trained men out per unit time (assuming a fixed entry level and minimum acceptable output level). If this definition is accepted, system benefit can be increased by increasing the number of men out per unit time or by maintaining a constant number out while increasing the minimum acceptable standard of the output. In either case, only relative values can be estimated and the relative ranking is based on identifiable and quantifiable attributes. The decision maker must recognize these limitations, and in many cases, must modify value factors based upon his broader knowledge base of strategic, political, and social considerations. For this reason, an economic analysis should be designed to provide the decision maker with the type of information needed to assess costs and benefits of alternative courses of action. This will allow him to increase his confidence level of risk and payoff assessment.

As stated in SECNAVINST 7000.14, "Economic Analysis of Proposed Department of the Navy Investments", "...the objectives of an Economic Analysis should be to assist in providing a basis to recommend and select a plan of action. It applies both to situations in which the alternative outputs or benefits can be quantified and to situations in which the alternative outputs cannot be easily quantified. In both of these situations, the objective is to identify;

a. The least costly alternative of several equally effective ways to achieve a required objective;

b. The alternative which is expected to produce the greatest benefits or effectiveness for a given cost level;

c. The relative cost of various alternatives and the effectiveness that can be provided so a judgment can be made as to whether the increased effectiveness is worth the additional cost;...."

This study has been limited to an approach which is to select the least costly alternative of several equally effective ways to achieve a required objective. It is probably the most widely used economic analysis method because alternative systems need only meet a certain minimum criterion effectiveness level. As explained previously, alternative training systems were analyzed, each of which was considered capable of producing a trained man at a minimum acceptable skill level. The life cycle costs associated with each of these systems was then determined. The costing approach used considered the time value of money and included 17 cost factors. Estimated utilization was also considered for each alternative which allowed for the development of a life cycle cost per utilization hour. If the decision maker feels that alternative systems do, in fact, perform equally well and that the life cycle cost figures are reasonable, he will most likely select the lowest cost system.

In most cases, this approach will suffice. However, both the variable effectiveness case for a given resource expenditure and the variable effectiveness case for a variable resource expenditure provide more realistic approaches to many investment decisions.

It is in this area of training system effectiveness value measurement that a fertile field exists for further research and model development. When the strategist can use a high confidence model to assess the value of training as it applies to weapon systems effectiveness, he will be able to more efficiently allocate available resources. Based upon the judgment of researchers within NAVTRAEQUIPCEN, model development in this area will provide a tool for training system value assessment which is not currently available. Consequently, the application of a model such as this should result in significant savings to the Navy.

SECTION III

APPLICATION OF TECEP MODEL TO TA-4 AIRCRAFT TRAINING SYSTEM

A. INTRODUCTION

The TECEP Model was applied to the TA-4 training system in order to assess the practicality of the proposed analysis approach. The TA-4 training system was selected for a number of reasons. The Undergraduate Pilot Training Program has been studied by North American/Link; the TA-4J Operational Flight Trainer has been developed and is currently being used; transfer and substitution studies are being conducted; and cost factor support data are available. Building on this foundation, an attempt has been made to use learning principles, instructional media option knowledge, substitution guidelines, and cost optimization techniques to describe a system which would provide increased training efficiency at a reduced cost. The application of the Model was performed prior to the completion of the Media Selection Matrix. Therefore, in this application, media were selected without the aid of this matrix.

B. TRAINING ANALYSIS

A training analysis of the system was conducted to determine, in conjunction with A-4 pilots, possible media substitutions.

Task descriptions produced by North American/Link for the Navy Undergraduate Pilot Training Study and the TA-4J Advanced Jet Syllabus used at Naval Air Station, Kingsville, were analyzed in order to derive a list of tasks which describe the behaviors the trainees must learn and for which meaningful blocks of training can be developed. The list of tasks was reviewed with two A-4 pilots. Based upon comments made and insights gained during this discussion, a revised list of tasks was prepared. This list is shown in Table 7.

The number of hours for each stage of training was obtained from the TA-4J Advanced Jet Syllabus, and the A-4 pilots were asked to apportion hours to each task of each stage.

C. TRAINING MEDIA MIX OPTIONS

In conjunction with the A-4 pilots, a mix of training media was selected for each task from possible media alternatives, namely, classroom, tutor, carrel, cockpit familiarization trainer, cockpit procedures trainer, Device 2F90, Device 2F90 with narrow-angle visual (Simulator "A"), Device 2F90 with wide-angle visual (Simulator "B"), simulated carrier landing aircraft (non-flight), aircraft plus instructor, aircraft solo and actual carrier landing. Finally, substitutions which the computer would be permitted to make among the various media were indicated for later translation into a computer program. Guidelines for the substitutions were obtained from the estimated amounts of flight time that can be substituted for by training devices which were developed by North American/Link for the Navy UPT study and Lockheed and Northrop for the Air Force UPT studies. Table 8 shows the North American/Link TA-4 flight substitution recommendations. Figure 6 shows the media substitutions made for one of the tasks.

Table 7

TA-4J PILOT TASKS

Stage	Task
Familiarization	Cockpit Procedures
	Preflight Inspection
	Normal Operating Procedures
	Nosewheel Steering and Taxi Procedures
	Takeoff
	Climb/Level Off
	Aerobatics
	Landing
Basic Instruments	ITO
	Climb/level Off
	Aerobatics
	Penetration
	Missed Approaches
Instrument Navigation	Clearance Training
	TACAN
	ADF
	Missed Approach
	GCA
	Cross Country
Formation	Parade & Cruise Formation Positions
	Maneuver in Formation
	Breakups and Rendezvous
	Column Formations/Gunsight Tracking
	Combat Spread/Tactical Section
Night Flying	Takeoff and Rendezvous
	Maneuvers
	NAV/with/without Radio Aids
	Formations
	Landings
Operational Navigation	DR NAV (low level/night/day)
	Target Recognition
	Weapon Delivery Maneuvers

TABLE 7
(Continued)

Stage	Task
Applied Navigation	Cross Country
Air to Ground Weapons	Rockets Delivery Bombing Strafing
Tactics	Air combat maneuvers
Air to Air Weapons	Gunnery
Carrier Qualifications	Night field carrier landing practice Day field carrier landing practice Carrier qualifications

TABLE 8

NORTH AMERICAN/LINK TA-4 FLIGHT SUBSTITUTION RECOMMENDATIONS

STAGE	SYLLABUS HOURS	SIM A SUB HRS	SIM A SUB %	SIM B SUB HRS	SIM B SUB %
Familiarization	11.2	2.8	25	5.6	50
Basic Insts.	8.4	5.6	67	5.6	67
Inst. Nav	36.1	29.6	82	29.6	82
Formation	12.6	0.0	0	2.8	22
Night Flying	8.5	1.5	18	5.6	67
Oper Nav	9.3	0.0	0	4.0	43
Appl. Nav	4.5	3.0	66	3.0	66
Air/Grnd Wpns	12.1	0.0	0	5.5	45
Tactics	9.9	0.0	0	4.4	44
Air/Air Wpns	4.0	0.0	0	1.0	25
Car Qual	12.4	1.6	13	4.8	39
	129.0	44.1	34%	71.9	56%

STAGE B. BASIC INSTRUMENTS, TASK: ITO

MEDIA	HOURS PER MEDIA			MEDIA SUBSTITUTION														
OPTIONS	Recommended Hours in Media	Minimum Hours in Media	Difference	1. Classroom	2. Tutor	3. Carrel	4. CFT	5. CPT	6. Sim. No Vis.	7. Sim. "A" Vis.	8. Sim. "B" Vis.	9. AC Non Flight	10. AC & Inst.	11. AC Solo	12. AC Carrier Landing	13. Sim Carrier Landing		
1. Classroom																		
2. Tutor																		
3. Carrel																		
4. CFT																		
5. CPT																		
6. Sim. No Visual	0.5	0	0.5							0.5	0.5		0.5					
7. Sim. "A" Visual																		
8. Sim. "B" Visual																		
9. AC/Non-Flight																		
10. AC & Inst.	0.5	0.3	0.2						0.1	0.1	0.1							
11. AC - Solo																		
12. AC Carrier Landing																		
13. Sim. Carrier Landing																		

Figure 6. Worksheet for Media Substitutions. (TECEP Model Block "7")

Table 9

MEDIA LIFE CYCLE COST PER UTILIZATION HOUR

MEDIA	COST PER UTILIZATION HOUR ($) 70% UTILIZATION	90% UTILIZATION
1. Classroom	57.0	53.7
2. Tutor	50.9	49.3
3. Carrel	19.7	17.0
4. CFT	12.0	10.1
5. CPT	42.4	35.3
6. SIM - No Vis.	122.4	98.2
7. SIM - "A" Vis.	157.0	126.8
8. SIM - "B" Vis.	314.3	251.1
9. A/C - Non-Flt.	726.4	630.1
10. A/C + Inst.	972.4	869.2
11. A/C Solo	866.1	762.7
12. A/C Car. Lndg.	5764.2	5642.2
13. SIM Car. Lndg.	324.3	259.0
14. Two A/C + two Inst.	1946.1	1739.3
15. Two A/C + one Inst.	1816.4	1614.5
16. 1.2 A/C + one Inst.	1149.0	1024.3
17. 1.7 A/C + one Inst.	1741.4	1528.1

Table 10

TA-4 TRAINING - MEDIA HOUR COMPARISON

MEDIA	MEDIA HOURS PER TRAINEE	
	EXISTING TRAINING SYSTEM	CONCEPTUAL TRAINING SYSTEM
1. Classroom	49.5	14.0
2. Tutor	154.0	154.0
3. Carrel	-	27.9
4. CFT	-	5.0
5. CPT	-	17.5
6. SIM - No. Vis.	57.0	53.1
7. SIM - "A" Vis.	-	4.0
8. SIM - "B" Vis.	-	31.9
9. A/C - Non-Flt.	3.9	3.4
10. A/C + Inst.	65.6	35.6
11. A/C Solo	15.3	11.3
12. A/C Car. Lndg.	1.6	1.6
13. SIM Car Lndg.	-	1.2
14. Two A/C + two Inst.	8.4	7.3
15. Two A/C + one Inst.	12.7	8.9
16. 1.2 A/C + one Inst.	6.6	4.3
17. 1.7 A/C + one Inst.	4.0	4.0
TOTAL	378.6	385.0

Table 11

TA-4 TRAINING - TRAINING STAGE HOUR COMPARISON

TRAINING STAGE	TRAINING STAGE HOURS PER TRAINEE	
	EXISTING TRAINING SYSTEM	CONCEPTUAL TRAINING SYSTEM
1. Flight Support	53.5	43.9
2. Familiarization	24.6	28.1
3. Basic Instruments	28.4	28.2
4. Instrument Navigation	102.4	101.4
5. Formation	30.6	34.1
6. Night Flying	18.4	19.2
7. Operational Navigation	9.3	14.4
8. Applied Navigation	10.5	11.0
9. Air to Ground Weapons	18.6	20.5
10. Tactics	27.9	29.9
11. Air to Air Weapons	12.0	12.0
12. Carrier Qualification	42.4	42.3
TOTAL	378.6	385.0

Table 12

TA-4 TRAINING - ALTERNATIVE COST COMPARISON

STAGE OF TRAINING	YEARLY TRAINING COST ($ x 1000)		
	EXISTING SYSTEM	CONCEPTUAL SYSTEM	POTENTIAL SAVINGS
Flight Support	1,617	499	1,118
Familiarization	4,082	2,367	1,715
Basic Instruments	3,902	2,679	1,223
Instrument Navigation	14,510	9,479	5,031
Formation Flying	8,971	7,158	1,813
Night Flying	4,087	3,888	199
Operational Navigation	3,637	2,918	719
Applied Navigation	1,722	1,295	427
Air to Ground Weapons	3,306	2,720	586
Tactics	7,592	6,590	1,002
Air to Air Weapons	2,927	2,927	000
Carrier Qualification	8,432	7,782	650
TOTAL	64,785	50,302	14,483

NOTES:

1. Yearly costs are computed on a life cycle basis as outlined in Section II.
2. Costs shown above were developed for the purpose of testing economic analysis techniques and do not have the necessary accuracy for official estimates.
3. Costs are based on 450 trainees per year completing each stage of training.

SECTION IV

CONCLUSIONS AND FUTURE ACTIONS

The feasibility of the Training Effectiveness and Cost Effectiveness Prediction (TECEP) Model has been demonstrated. Field testing of the Model, in conjunction with TAEG Task Analysis efforts, are planned. Further development and refinement are warranted. Specifically:

1. Task Description and Analysis

FUTURE ACTION. An analysis should be made of the many existing task description and analysis methods to determine a format that would have the greatest utility for use with the TECEP Model.

2. Media Selection Matrix

CONCLUSION. The matrix, in its present state, demonstrates a useful approach to the task of media selection for specific learning tasks.

The approach is based on identifying media that facilitate the use of specific learning guidelines (based upon scientifically derived principles of learning) for achieving specific types of learning tasks.

In its present state of development, the matrix can be used to explore various media options, and propose a useful set of options. Further development will increase the usefulness of the matrix. It should be noted that the matrix is designed so that frequent revisions can be incorporated, to include new media as they are developed, and new learning guidelines as they are identified.

FUTURE ACTION. Further develop the matrix as follows:

a. Accommodate additional media options as they are required for specific training systems.

b. Add additional learning and implications for media guidelines, as they are identified.

c. Evaluate by having several psychologists, education and training specialists and military officers apply the matrix, and reclassify as necessary, the implications for media selection cells.

d. Develop computer programs, as required, to allow the designer to interact with the matrix in an exploratory, iterative manner, until an acceptable set of options is identified.

This improvement program should involve the routine application of the matrix to real media selection problems, in a continuing effort to develop a more practical technique. In the process, information should be acquired about the use of the Media Selection Matrix, such as its reliability (i.e., the consistency of media selection among users) and its practicality for application.

3. Life-Cycle Cost Data

CONCLUSION. The model identifies 19 cost factors and the computer program treats these factors to produce a media cost schedule for various utilization rates. This produces a comprehensive look at projected life-cycle costs. In its present state of development, the model is a demonstration of an approach, and is a rudimentary cost projection system. Certain refinements, however, will make the model more precise.

FUTURE ACTION. Improve the cost model by incorporating multi-year funding, extending utilization in increments to 200%, and identifying required funds by year and by source, i.e., RDT&E, O&MN, PAMN, OPN, etc. Standardize the development of cost factors to insure consistency in the estimates.

4. Computer Programs

CONCLUSIONS. The linear program is functioning and solves for the lowest cost mix of media capable of handling the projected curriculum and student flow. Presently, it is capable of solving problems with 75 variables and 75 constraint equations, which appears to be adequate for most training systems.

FUTURE ACTION. Update the computer programs as follows:

a. Develop a linkage program to connect the cost utilization program to the linear program.

b. Refine the programs to incorporate certain bookkeeping functions presently being done manually.

c. Develop additional techniques to accomplish such tasks as manpower projections, and scheduling/time requirements.

5. Economic Analysis

CONCLUSION. The economic analysis of a proposed training system should systematically identify the benefits and costs associated with alternative training system options.

FUTURE ACTION. Apply economic analysis techniques to TAEG projects in order to identify training system benefits and related costs.

6. Alternative Training Systems

CONCLUSION. An assumption of the TECEP Model is that the alternative training systems proposed will all produce men trained to an equal level of proficiency. In other words, it is assumed that each alternative is designed to have equal training effectiveness. Then the least costly of several otherwise equal alternative training systems is selected by the linear program.

FUTURE ACTION. The Model should be expanded to handle the following situations:

a. For a given cost, select the training system alternative with the greatest training effectiveness.

b. Trade-off between training system alternatives having different costs and different training effectiveness values.

7. Evaluation of the Utility of the Model

FUTURE ACTION. The Model should be applied to the real-world situations of TAEG training analyses. The usefulness of the Model should be evaluated in terms of:

a. Output of the Model as a basis for making decisions on training system configuration.

b. Limitations, weaknesses, or assumptions inherent in the Model.

c. Costs of using the Model.

APPENDIX A

MEDIA SELECTION MATRIX

MEDIA SELECTION MATRIX

Purpose. By using the Media Selection Matrix, a training system designer can identify a set of useful training media suited to the characteristics of specific training tasks. It provides a guide for ranking media in order of pedagogical power to deal with specified training objectives. Final media selection should be based not only on pedagogical power, but also cost and other factors, as provided for in other parts of the TECEP Model.

Directions for Use

1. Classify tasks with one or more of the task categories listed in Table 1. Most real-world tasks are complex tasks which can only be described with two or more categories.

2. Locate those pages of the Media Selection Matrix that represent the task categories of a specific training task.

3. Tentatively rank each medium recording to the number of times "F" and "M" appears under a specific media heading. Count only the times "F" and "M" appear on the pages identified in step 2.

NOTE: F = medium automatically facilitates the application of the learning guideline.

M = medium enables an instructor or student to manually carry out the intent of the learning guideline.

4. Review the tentative ranking in Step 3 to ensure that it is realistic in the specific instance under study, as the matrix was designed to represent typical tasks in each task category, but may not fully represent the specific task under study.

RECALLING FACTS & PRINCIPLES

TASK CATEGORIES	TASK ELEMENTS	LEARNING GUIDELINES	IMPLICATIONS FOR MEDIA SELECTION	MEDIA OPTIONS																			
				CCTV w/of	PI(L)	PI(B)	SRS(T/S)	SRS(AV)	PIA	CAI/MM	LCD(AV)	VTR	LECT/TEXT	PA	CARREL/MOCKUP	SIM	SIM/AA	PROC TNR	PROC TNR AA	M PROC TNR	C GAMING	OP/SYS	OP/SYS & SIM
a. Common behavior attributes: 1. Concerns verbal or symbolic learning. 2. Concerns acquisition and long term maintenance of knowledge so that it can be recalled. b. Common Examples: 1. Recalling equipment nomenclature or functions. 2. Recalling system functions, such as the complex relations between system input and output. 3. Recalling physical laws, such as Ohm's law. 4. Recalling specific radio frequencies and other discrete facts.	Stimulus	Organize training around intrinsic cue components (key words, formuli, or key letters) within the fact or principle. Use these cue components as mediators to trigger recall of complete facts or principles.	Provision for trainee to associate cue with fact or principle by highlighting cue within the presentation of fact or principle.	F	F	F			F	F	F				F								
			Provision for student to practice recalling fact or principle which is presented first with the cue and then without the cue.		F					F	F				F								
		Use mnemonics (associating recall of facts or principles with imagery, rhyme, rhythm,etc)	Provision for students to associate mnemonics with facts or principles.	F	F	F			F	F	F		F		F								
			Provision for students to practice recall by using mnemonics.		F	F				F	F				F								
		Prevent decay of recall by increasing the meaningfulness of the material to be learned by providing organization to the related facts or principles.	Provision for the use of system flow charts, diagrams, or by other means, to establish meaningful relationships among the facts and principles.	F	F	F	F	F	F	F			F	F	F								
		Prevent decay of recall by overlearning the original material - facts or principles.	Provision for practice in recall.		F	F	F	F		F	F				F								
			Provision for measuring student performance to determine when student achievement has reached a stabilized final criterion level - i.e., a specified degree of overlearning.				F	F		F	M				M								
		Prevent decay of recall by providing periodic refresher training.	Logic for scheduling refresher training.							F	M				M								
			Provision for confronting student with novel variations (in content and format) of basic material to be recalled.							F	F		F		F								
	Response	Make an overt response indicating the recall of facts and principles, enabling measurement. 9	Provision for measuring student performance in terms of both diagnostic and student achievement measures.		F	F	F	F		F	F				F								
		Response Generalization - Make job performance type responses.	Provision for exercising recall in vicarious or realistic job situations, at least in the final phase of training.													F	F	F	F	F		F	F

RECALLING FACTS & PRINCIPLES (Continued) TASK CATEGORIES	TASK ELEMENTS	LEARNING GUIDELINES	IMPLICATIONS FOR MEDIA SELECTION	MEDIA OPTIONS																			
				CCTV w/of	PI(L)	PI(B)	SRS(T/S)	SRS(AV)	PIA	CAI/MM	LCD(AV)	VTR	LECT/TEXT	PA	CARREL/MOCKUP	SIM	SIM/AA	PROC TNR	PROC TNR AA	M PROC TNR	C GAMING	OP/SYS	OP/SYS & SIM
		Guide or prompt response, especially in the acquisition phase of training. 16	Provision for error detection logic.		F	F				F	F				F								
			Provision for various modes of prompting and guiding.		F	F				F	F				F								
			Logic for scheduling prompts and guidance.							F													
	Feedback	Schedule KOR soon after response for maximum reinforcement. Error identification function of KOR is significant.	Provision for scheduling KOR soon after response - emphasis on error identification.		F	F	F	F		F	F				F								
	Personal Environment	Both rate and style of learning depend upon characteristics of the individual learner.	Individual control over rate of progress through learning steps.		F	F				F					F								
			Individually defined sequence of events selected for individual learning style (for both initial learning and review).							F													
		Facilitate acquisition of material by pointing out the relevance of the to be learned material to on-the-job duties, responsibilities, advancement, or survival.	Provisions for confronting the student, either vicariously or realistically, with the consequence of successful and unsuccessful performance.										F										

NON-VERBAL IDENTIFICATION

TASK CATEGORIES	TASK ELEMENTS	LEARNING GUIDELINES	IMPLICATIONS FOR MEDIA SELECTION	MEDIA OPTIONS																			
				CCTV w/of	PI(L)	PI(B)	SRS(T/S)	SRS(AV)	PIA	CAI/MM	LCD(AV)	VTR	LECT/TEXT	PA	CARREL/MOCKUP	SIM	SIM/AA	PROC TNR	PROC TNR AA	M PROC TNR	C GAMING	OP/SYS	OP/SYS & SIM
a. Common Behavioral Attributes: 1. Pattern recognition approach to identification - not problem solving. 2. Classification by non-verbal characteristics. 3. Status determination - ready to start. b. Common Examples: 1. Classify a sonar target as "sub" or "non-sub". 2. Visual classification of flying aircraft as "friend" or "enemy" or as an "F-4." 3. Determining that an identified noise is a wheel bearing failure, not a water pump failure by rating the quality of the noise - not by the problem solving approach.	Stimulus	Cues used in training should be nearly identical to job cues unless this fidelity increases problem difficulty in the initial phase of training to an unacceptable level. 5	High fidelity presentation of classification cues.													F	F					F	F
		Vary ratio of relevant and irrelevant (transient) cues, according to requirements of various stages of training. - Maximize relevant cues and minimize irrelevant cues in early stages of training - use a realistic mix of relevant, irrelevant cues in final stages of training. 4	Control over relevant and irrelevant cues per stage of training.	F	F	F	F	F	F	F	F					M	F						
			Logic for adjusting relevant and irrelevant cues per stage of training.	F	F	F	F	F	F	F	F					M	F						
		Emphasize cues which elicit mediating responses, e.g., "self-instructions," population stereotypes" and "natural associations." 6	Control over cue characteristics: exaggeration - simplification.	F	F	F	F	F	F	F	F						F						
			Cue coding and annotating.	F	F	F	F	F	F	F	F						F						
			AV program to present in-the-head models - "Self-instructions," "stereotypes", etc.	F	F	F	F	F	F	F	F						F						
			Logic for scheduling cue characteristics, coding, and model information.	F	F	F	F	F	F	F	F						F						
	Response	To-be-learned response should occur as soon as relevant cues are perceived. (Contiguous occurrences of cues and response.)	Provision for student to record identification type responses immediately upon identification.		F	F	F	F	M	F	M					M	F						M
			Measure time delay between cue presentation and identification.					F		F						M	F						M
		The strength of a given response typically increases as a function of practice.	Provision for student to practice making non-verbal identifications.													F	F					F	F
	Feedback	Immediate reinforcement (0.5 seconds delay).	Provision for immediate evaluation and display of student performance.													M	F					M	M
		KOR - automatic system performance feedback.	Provision for a target, identified with only a few cues, to bloom with a full set of cues.														F						

NON-VERBAL IDENTIFICATION (Continued)				MEDIA OPTIONS																			
TASK CATEGORIES	TASK ELEMENTS	LEARNING GUIDELINES	IMPLICATIONS FOR MEDIA SELECTION	CCTV w/of	PI(L)	PI(B)	SRS(T/S)	SRS(AV)	PIA	CAI/MM	LCD(AV)	VTR	LECT/TEXT	PA	CARREL/MOCKUP	SIM	SIM/AA	PROC TNR	PROC TNK AA	M PROC TNR	C GAMING	OP/SYS	OP/SYS & SIM
	Feedback (Cont'd)	Schedule KOR soon after response for maximum reinforcement. Error identification function of KOR is significant.	Provision for scheduling KOR soon after response. - Emphasis on error identification.		F	F	F	F		F	F					M	F					M	M
	Personal Environment	Both rate and level of learning depend upon characteristics of the individual learner.	Individually controlled rate of progress.		F	F				F	F					M	F					M	M
			Sequence of events selected for individual learning style.			F				F	F					M	F					M	M

NON-VERBAL DETECTION

TASK CATEGORIES	TASK ELEMENTS	LEARNING GUIDELINES	IMPLICATIONS FOR MEDIA SELECTION	MEDIA OPTIONS																			
				CCTV w/of	PI(L)	PI(B)	SRS(T/S)	SRS(AV)	PIA	CAI/MM	LCD(AV)	VTR	LECT/TEXT	PA	CARREL/MOCKUP	SIM	SIM/AA	PROC TNR	PROC TNR AA	M PROC TNR	C GAMING	OP/SYS	OP/SYS & SIM
a. Common behavior attributes: 1. Vigilance - detect a few cues embedded in a large block of time. 2. Low threshold detections - early detection of very small cues. 3. Scan for wide range of possible cues.	Stimulus	Transfer increased as the difference between reference and generalization stimulus decreases.	Provide signal-to-noise ratios required in the operational setting.													F	F					F	F
		Decrease signal to noise ratio as student achieves success at a given difficulty level.	Control over signal-to-noise ratio													F	F	F	F				F
			Logic for adjusting signal-to-noise ratio													M	F	M	F				M
	Response	To enable reinforcement of performance, the student, upon detecting a signal should respond so that what is detected, and time of detection can be recorded.	(while response is in-the-head, overt action is required) Record and evaluate student performance in detecting signals													M	F	M	F			M	M
b. Common examples: 1. Detect targets in background noise on radar/sonar scopes. 2. Visually detect submarine periscope at sea (snorkeling) 3. Detect status and change in status of an operating system - a bearing starting to burn out. 4. Instrument scanning in an aircraft cockpit.	Feedback	Feedback omission schedule programmed according to stage of training: high feedback during initial stages, decreased to equivalent to operational setting or lower. 2	Logic for adjusting feedback schedule.													M	F	M	F			M	M
			Provide feedback, as per logic, in terms of a description of student performance/criterion performance.													M	F	M	F			M	M
	Personal Environment	Vigilance training through extended duration practice with provisions to overcome fatigue and boredom. 3	Capability for extended duration practice (one complete watch). Control over number of targets to be presented.													F	F	F	F			F	F

USING PRINCIPLES,
INTERPRETING, INFERRING

TASK CATEGORIES	TASK ELEMENTS	LEARNING GUIDELINES	IMPLICATIONS FOR MEDIA SELECTION	MEDIA OPTIONS																				
				CCTV w/of	PI(L)	PI(B)	SRS(T/S)	SRS(AV)	PIA	CAI/MM	LCD(AV)	VTR	LECT/TEXT	PA	CARREL/MOCKUP	SIM	SIM/AA	PROC TNR	PROC TNR AA	M PROC TNR	C GAMING	OP/SYS	OP/STS/SIM
a. Common Behavioral Attributes: 1. Use of logic and/or natural law, and/or known relationships. 2. Limited uncertainty of outcome. 3. Usually little thought of other alternatives. 4. Usually related to on-going tasks. b. Common Examples: 1. Diagnosis of equipment malfunctions by using scientific laws or principles. 2. Dealing with the impact of natural forces in shiphandling - tides, currents, weather, momentum. 3. Psychological warfare. 4. Application of principles in computer programming.	Stimulus	Emphasize the logical relationships which exist between the general principle and the specific application. The unique or special features of each application should be minimized while the common relationships to the general principle should be emphasized.	Provision for the use of system flow charts, diagrams or by other means, to establish the relationship between the general principle and specific application.	F	F	F	F	F	F	F	F		F										
		Stimulus redundancy - apply principle in a large number of practice situations, while varying the stimulus context of repetitions. 21	Provision for practice using the principles in a large number of varied situations.							F						F	F				F	F	F
	Response	Make an overt response enabling the measurement of trainee performance.	Provisions for measurement of trainee performance.		F	F	F	F		F	M					M	F				F	M	M
		Performance differences which are due to individual differences in ability tend to be magnified as a function of increasing task difficulty. Identical performance among given trainees is not necessarily indicative of identical learning, hence the need for a better measure of the extent to which trainees are profiting from the training situation. 22	Provision for individualized training including a logic for selecting a special sequence of events for the trainee in response to his demonstrated ability to learn.			F				F						M	F				F	M	M
			Provision for training media capable of dealing with advanced problems, as well as basic ones, providing a wide range of problem difficulty at each level of training.							F						F	F				F	F	F
	Feedback	Schedule KOR soon after response for maximum reinforcement. KOR snould deal with both process and solution.	Provisions for evaluating process as well as final solution.													M	F				F	M	M
			Provision for confronting the student, either virariously or realistically, with the consequences of his choice.							F						F	F				F	M	M
	Personal Environment	Monotonous effects of repetition are reduced by varying the stimulus context.	Provisions for practice using the principles in a large number of varied situations.							F						F	F				F	F	F

MAKING DECISIONS

TASK CATEGORIES	TASK ELEMENTS	LEARNING GUIDELINES	IMPLICATIONS FOR MEDIA SELECTION	MEDIA OPTIONS																			
				CCTV w/of	PI(L)	PI(B)	SRS(T/S)	SRS(AV)	PIA	CAI/CM	LCD(AV)	VTR	LECT/TEXT	PA	CARREL/MOCKUP	SIM	SIM/AA	PROC TNR	PROC TNR AA	M PROC TNR	C GAMING	OP/SYS	OP/SYS & SIM
a. Common Behavioral Attributes: 1. Choosing a course of action when alternatives are given, unspecified or unknown. 2. A successful course of action is not readily apparent. 3. The penalties for unsuccessful courses of action are not readily apparent. 4. The relative value of possible decisions must be considered - including possible trade-offs. 5. Frequently involves forced decisions made in a short period of time with soft information. b. Common Examples: 1. Choosing frequencies to search in an ECM search plan. 2. Choosing torpedo settings during a torpedo attack. 3. Threat evaluation and weapon assignment. 4. Choice of tactics in combat - wide range of options. 5. Choosing a diagnostic strategy in dealing with a malfunction in a complex piece of equipment.	Stimulus	Trainees must have access to potentially relevant data. In final stage of training data should be limited to that expected in real world situations.	Provision for storing and displaying relevant data.							F						F	F				F	F	F
			Logic for retrieving and displaying data.							F						F	F				F		
		Guiding - early in training present logical implications of alternative choices.	Provisions for the trainee to select alternative choices and then through simulation and time compression, move the "tactical situation" ahead to the point that the major ramifications of the alternative choices become apparent so that these alternative choices can be compared.							F						F	F				F		
		Mediators - acquisition and use of mediators such as sterotypes or self-instructions facilitate the identification of response alternatives and the probability of success of each alternative.	Provisions for presenting candidate mediators (sterotypes, self-instructors, etc.) in conjunction with responses to be mediated.		F	F				F	F		F				F				F		
			Provision for exercising trainees in recall and application of mediators as a step in decision making.		F	F				F	F					F	F				F	F	F
		Stimulus load - toward the end of training, present trainee with a realistic data processing load (realistic number of significant signals plus realistic noise in real time).	Provision for adjusting data/noise load.							F	F					F	F				F		
			Logic to control data/noise load presented to trainee.							F	M					M	F				F		
		Stimulus generalization - vary the stimulus context of repetitions.	Provision for a large number of varied decision making situations.							F						F	F				F		F
	Response	Make an overt response enabling the measurement of trainee performance.	Provision for measurement of trainee performance.							F						M	F				F		M

MAKING DECISIONS
(Continued)

TASK CATEGORIES	TASK ELEMENTS	LEARNING GUIDELINES	IMPLICATIONS FOR MEDIA SELECTION	CCTV w/oE	PI(L)	PI(B)	SRS(T/S)	SRS(AV)	PIA	CAI/MM	LCD(AV)	VTR	LECT/TEXT	PA	CARREL/MOCKUP	SIM	SIM/AA	PROC TNR	PROC TNR AA	M PROC TNR	C GAMING	OP/SYS	OP/SYS & SIM
b. Common Examples (cont) 6. Choosing to abort or commit oneself to land upon reaching the critical point in the glidepath.	Response (cont)	Performance differences which are due to individual differences in ability tend to be magnified as a function of increasing task difficulty.	Provision for individualized training including a logic for selecting a special sequence of events for the trainee in response to his demonstrated ability to learn.							F							F				F		
		Identical performance among given trainees is not necessarily indicative of identical learning, hence the need for a better measure of the extent to which trainees are profiting from the training situations. 22	Provision for training media capable of dealing with advanced problems, as well as basic ones, providing a wide range of problem difficulty at each level of training.							F						F	F				F	F	F
		Apply decision making in a large number of practice situations while varying the stimulus context of repetitions.	Provision for trainees to practice making decisions in a large number of varied situations enabling the practice of general decision making skills.							F						F	F				F		F
		Stress - When trainee will be required to perform under stress, use overlearning of skill to minimize effects of competing responses.	Provision for extensive practice (overlearning) when trainee will be required to perform under stress.							F						F	F				F	F	F
	Feedback	Early in training, evaluate each alternative solution as it is identified, and when a final choice among alternatives is made evaluate the overall choice	Provisions for recording a single alternative solution, evaluating it according to criteria, and providing trainee with KOR concerning the merit of the alternative.			F				F	F						F				F		
			Provisions for comparing alternative solutions, in terms of criteria, and providing trainee with KOR concerning the merit of the selected alternative.			F				F	F						F				F		
	Personal Environment	For difficult decision-making skills, the rate, level and/or style of learning depends upon characteristics of the individual learner.	Provision for individualized instruction, including some self-pacing within each stage or level of training.			F				F	F				F		F				F		
			Provision for scheduling of advanced stages (difficulty levels) and refresher training according to individual rate and level of improvement.							F						M	F				F	M	M

CONTINUOUS MOVEMENT

				MEDIA OPTIONS																			
TASK CATEGORIES	TASK ELEMENTS	LEARNING GUIDELINES	IMPLICATIONS FOR MEDIA SELECTION	CCTV w/of	PI(L)	PI(B)	SRS(T/S)	SRS(AV)	PIA	CAI/MM	LCD(AV)	VTR	LECT/TEXT	PA	CARREL/MOCKUP	SIM	SIM/AA	PROC TNR	PROC TNR AA	M PROC TNR	C GAMING	OP/SYS	OP/SYS & SIM
a. Common Behavioral Attributes: 1. Tracking, dynamic control: a perceptual-motor skill involving continuous pursuit of a target or keeping dials at a certain reading such as maintaining constant turn rates, etc. 2. Compensatory movements based on feedback from displays. 3. Skill in tracking requires smooth muscle coordination patterns - lack of overcontrol. 4. Involves estimating changes in positions, velocities, accelerations, etc. 5. Involves knowledge of display-control relationships. 6. May involve scanning of complex displays to determine current status of system, and to predict the evolving state of the system.	Stimulus	Insure that the appropriate stimulus cues are available to the trainee continually during the performance of the task.	Provision for all significant task cues, in terms of the operation, to be realistically provided to the trainee.													F	F					F	F
		Emphasis on prediction of future states (thinking ahead).	Provision for the development and use of predictive type self-instructions and anticipating cues.														F						
			Use of predictive displays - a display that shows future conditions, such as 12 seconds ahead.														F						
		Expose trainee to a wide range of task difficulty.	Provision for creating tasks of varying difficulty level.													F	F					F	F
			A logic for controlling the difficulty of tasks presented to trainees.													M	F						
		In continuous control tasks, high fidelity is often required in (1) stimulus presentation, (2) operator response characteristics, and (3) dynamic system behavior, the evolving display-control relationship.	Provision for high fidelity display control mechanisms and dynamic model of system behavior, when training analysis shows this to be a requirement.													F	F					F	F
	Response	Repetition - highly skilled performance requires extensive practice.	Provision for extensive practice.													F	F					F	F
		Make an objective measurement of the frequency and type of errors - changes in total error pattern - throughout the course of training. Measurement should be based on specific behavioral objectives.	Develop behavioral objectives and measure trainee behavior (automatically where possible) in terms of criteria in behavioral objectives.														F						
	Feedback	Shaping - reinforcement should be contingent upon characteristics of trainee's response so that by a process of "successive approximations", the final desired proficiency is produced.	Assess trainee performance (fine discriminations required).														F						
			Sliding criterion success - different values for each stage of training.													M	F						
			Provision for providing reinforcement.													M	F						
			Logic for adjusting criterion of success and reinforcement schedules to assessed trainee performance.														F						

CONTINUOUS MOVEMENT
(Continued)

				MEDIA OPTIONS																			
TASK CATEGORIES	TASK ELEMENTS	LEARNING GUIDELINES	IMPLICATIONS FOR MEDIA SELECTION	CCTV w/of	PI(L)	PI(B)	SRS(T/S)	SRS(AV)	PIA	CAI/MM	LCD(AV)	VTR	LECT/TEXT	PA	CARREL/MOCKUP	SIM	SIM/AA	PROC TNR	PROC TNR AA	M PROC TNR	C GAMING	OP/SYS	OP/SYS & SIM
b. Common Examples: 1. Submarine bow and stern planes operators maintaining a constant course, or making changes in course or depth. 2. Tank driver following a road. 3. Sonar operator keeping the cursor on a sonar target. 4. Air-to-air gunnery-target tracking. 5. Aircraft piloting such as: - visually following a ground path. - Instrument flight. 6. Helsman holding a course with gyro or magnetic compass.	Feedback (cont'd)	Continuous KOR - because of the dynamic nature of the problem, the trainee should at times be presented with an on-going evaluation of his performance.	Provision for continuous KOR.													F	F						

VERBAL DETECTION AND IDENTIFICATION TASK CATEGORIES	TASK ELEMENTS	LEARNING GUIDELINES	IMPLICATIONS FOR MEDIA SELECTION	MEDIA OPTIONS																			
				CCTV w/oF	PI(L)	PI(B)	SRS(T/S)	SRS(AV)	PIA	CAI/MM	LCD(AV)	VTR	LECT/TEXT	PA	CARREL/MOCKUP	SIM	SIM/AA	PROC TNR	PROC TNR AA	M PROC TNR	C GAMING	OP/SYS	OP/SYS & SIM
a. Common Behavioral Attributes: 1. Involves the recognition of symbols, spoken or written language, or codes, diagrams, schematics, technical symbology, etc. 2. Symbols to be identified typically are of low meaningfulness to untrained personnel. 3. More cognitive than sensory - identification or interpretation is emphasized. 4. Involves storing queues of symbolic information and meanings and the recognizing of these symbols and/or meanings. 5. Basic components of most tasks. b. Common Examples: 1. Monitoring communication channels. 2. Reading schematics symbols. 3. Understanding verbal orders. 4. Map reading - symbol recognition. 5. Monitoring tactical status boards. 6. Reading signal flags.	Stimulus	Contiguity - The symbol and referent should be presented in close temporal contiguity.	Provision for trainee to associate symbol with referent (meaning).	F	F	F			F	F	F		F										
			Provision for trainee to practice recalling the meaning when presented with the symbol		F	F	F	F		F	F												
		Where appropriate, use mnemonics (associating recall of symbols with imagery, etc).	Provision for trainees to associate mnemonics with facts or principles where appropriate.	F	F	F			F	F	F		F										
			Provision for students to practice recall by using mnemonics.		F	F				F	F					F	F	F	F	F		F	F
		Prevent decay of recall by overlearning the original material symbols.	Provision for practicing recognition.							F						F	F	F	F	F		F	F
			Provision for measuring student performance to determine when student achievement has reached a stabilized final criterion level-specified degree of overlearning							F	F												
		Prevent decay of recall by providing periodic refresher training.	Logic for scheduling refresher training							F	M												
			Provision for confronting student with symbols to be recalled - drill		F	F				F	F												
	Response	Make an overt response indicating the recognition of the symbol, enabling measurement.	Provision for measuring student performance to provide KOR and scheduling of future drill		F	F	F	F		F	F												
		Symbol-referent associations (pairings) are especially amenable to "in-the-head" practice.	Provide opportunity and encouragement for self-initiated and self-paced practice in identifying the meaning of symbols.		F	F				F	F												
	Feedback	Incorrect as well as correct symbol-referent pairing can be strengthened by self-initiated "in-the-head" practice.	Provision for KOR during self-initiated practice to ensure that only correct symbol-referent pairs are strengthened.		F	F				F	F												
	Personal Environment	Rate, level and/or style of learning depends upon characteristics of the individual learner.	Provision of some self-pacing within each stage or difficulty level of training.		F	F				F	F												
			Adapt scheduling of advanced stages and refresher training according to individual's rate of improvement and style of learning.							F	M							F		F			
		Develop job-relevant achievement motivation to maintain trainee interest during otherwise boring drills.	Provision for relating training clearly to meaningful and job-related tasks.	F									F										

POSITIONING AND SERIAL MOVEMENT TASK CATEGORIES	TASK ELEMENTS	LEARNING GUIDELINES	IMPLICATIONS FOR MEDIA SELECTION	MEDIA OPTIONS CCTV w/of	PI(L)	PI(B)	SRS(T/S)	SRS(AV)	PIA	CAI/MM	LCD(AV)	VTR	LECT/TEXT	PA	CARREL/MOCKUP	SIM	SIM/AA	PROC TNR	PROC TNR AA	M PROC TNR	C CAMING	OP/SYS	OP/SYS & SIM
a. Common Behavioral Attributes: 1. Positioning switches, push buttons, knobs, levers, etc., either indivi individually or in sequence. 2. Highly coordinated motor tasks such as key board operations. 3. Motor aspects of equipment set-up and operating procedures. 4. Proprioceptive feedback is important. b. Common Examples: 1. Following equipment turn-on procedures - emphasis on motor behavior. 2. Typing or operation of computer terminal - card punch operation. 3. Switch throwing in any situation.	Stimulus	Cue development - emphasize the development and use of internal cues, such mediators, or kinesthetic cues.	Provide recall training prior to or concurrent with motor training.							F					F	F	F	F	F			F	F
			Emphasis on performing a series of correct responses.													F	F	F	F			F	F
		In training for lengthy serial movements, provision should be made for programming demonstrations of the lengthy serial or sequential performance according to the amount of demonstration which can be understood by the trainee. Contiuing a demonstration beyond the "saturation point" will result in the association of responses with incorrect cues.	Provision for student to view demonstration, preferably from operator perspective.	F					F	F	F				F	F	F	F	F			F	F
			Provision for determination of changing readiness of student to understand demonstration.														F		F				
	Response	Emphasize extensive motor response repetition or practice in order to (1) strengthen individual or component steps of the movement series, and (2) integrate these steps into a smooth sequence.	Provision for motor practice.													F	F	F	F			F	F
		Make an overt response enabling performance measurement as well as motor practice.	When applicable, provision for record of performance to be produced for use by student and instructors - mode of evaluation.														F		F				
	Feedback	Extensive response repetition (overlearning) by the trainee to take advantage of the built-in feedback properties of these types of tasks. Simple repetitive movements may be "automatically" reinforcing (kinesthetic feedback).	Provision for practice with emphasis on immediate correction of error so that associations are not strengthened.													M	F	M	F			M	M

POSITIONING AND SERIAL MOVEMENT (Continued) TASK CATEGORIES	TASK ELEMENTS	LEARNING GUIDELINES	IMPLICATIONS FOR MEDIA SELECTION	MEDIA OPTIONS																			
				CCTV w/of	PI(L)	PI(B)	SRS(T/S)	SRS(AV)	PIA	CAI/MM	LCD(AV)	VTR	LECT/TEXT	PA	CARREL/MOCKUP	SIM	SIM/AA	PROC TNR	PROC TNR AA	M PROC TNR	C GAMING	OP/SYS	OP/SYS & SIM
	Feedback (Contd)	Shaping - reinforcement should be contingent upon characteristics of trainee response, so that by a process of "successive approximations", the final desired proficiency, in terms of speed, accuracy and smoothness, is produced.	Assess in a precise manner, the performance of the trainee in terms of speed, accuracy and smoothness.													M	F	M	F			M	M
			Sliding criterion of success based upon stage of training.													M	F	M	F			M	M
			Capability to provide reinforcement														F		F				
			Logic for adapting training and reinforcement schedules.														F		F				
	Personal Environment	Both rate and style of learning depend upon characteristics of the individual learner.	Speed and accuracy requirements dependent upon achieved skill.														F		F				
			Individually determined schedule of review for maintenance of skill.														F		F			F	F

REPETITIVE MOVEMENT

TASK CATEGORIES	TASK ELEMENTS	LEARNING GUIDELINES	IMPLICATIONS FOR MEDIA SELECTION	MEDIA OPTIONS																			
				CCTV w/of	PI(L)	PI(B)	SRS(T/S)	SRS(AV)	PIA	CAI/MM	LCD(AV)	VTR	LECT/TEXT	PA	CARREL/MOCKUP	SIM	SIM/AA	PROC TNR	PROC TNR AA	M PROC TNR	C GAMING	OP/SYS	OP/SYS & SIM
a. Common Behavioral Attributes: 1. Perceptual-motor behavior-emphasis on motor. Premium on manual dexterity, occasionally strength and endurance. 2. Repetitive mechanical skill. 3. Standardized behavior, little room for variation or innovation. 4. Automatic behavior; low level of attention is required in skilled operator. Kinesthetic cues dominate control of behavior. 5. Fatigue or boredom may become a factor when skill is performed over an extended period of time or at a rapid rate. 6. Fine tolerances. 7. Often a component of a larger task. b. Common Examples: 1. Use of hand tools such as hammer, saw, wrench or power tools such as lathes, or grinders. 2. Running a drill press in an assembly line. 3. Loading ammo into artillery pieces or 5" gun. 4. Drafting - use of drafting instruments. 5. Painting - house painting or preserving ship hull, etc. 6. Marching - close order drill.	Stimulus	Early training - Use models of correct performance as basis for trainee to perceive critical cues of good form. Use models of component parts of task.	Provision for models of correct behavior.	F					F		F	F		F									
		Cue discrimination - perceive difference between correct and incorrect form.	Provisions for models of both correct and incorrect behavior.	F					F		F	F		F									
			Provision for trainee to discriminate between correct and incorrect form in own performance.	F					F		F	F		F		F	F	F	F			F	F
		Later stages of training - the kinesthetic cues - dominate (cues based on "muscle feel").	Provisions for guiding trainee to perform correctly to establish kinesthetic feel of correct behavior.													F	F	F	F			F	F
	Response	Extensive response repetition or practice by trainee to take advantage of built-in feedback properties of these types of tasks. Simple repetitive movements may automatically reinforce as a natural consequence of the movement.	Provision for trainee to practice.													F	F	F	F			F	F
	Feedback	Shaping - reinforcement should be contingent upon characteristics of trainee's response, so that by a process of "successive approximations" the final desired proficiency is produced. 50	Assess trainee performance (fine discriminations required.)											M		M	F	M	F			M	M
			Sliding criterion of success-different values for each stage of training.											M		M	F	M	F			M	M
			Provision for providing reinforcement.											M		M	F	M	F			M	M
			Logic for adjusting criterion of success and reinformcement schedules to assessed trainee performance.											M			F		F				
	Personal Environment	Fatigue - to reduce the effects of fatigue in learning motor skills, provide periods of rest-psychological and physiological recovery time - to minimize the development of competing response.	Logic for scheduling learning (practice) periods and rest periods.											M		M	F	M	F			M	M

WRITTEN VERBALIZATION

TASK CATEGORIES	TASK ELEMENTS	LEARNING GUIDELINES	IMPLICATIONS FOR MEDIA SELECTION	MEDIA OPTIONS																			
				CCTV w/of	PI(L)	PI(B)	SRS(T/S)	SRS(AV)	PIA	CAI/MM	LCD(AV)	VIR	LECT/TEXT	PA	CARREL/MOCKUP	SIM	SIM/AA	PROC TNR	PROC TNR AA	M PROC TNR	C GAMING	OP/SYS	OP/SYS & SIM
a. Common behavioral attributes: 1. Creating an alpha-numeric statement. 2. Frequently involves use of a formal or special language such as used to input data into a computer. 3. Less spontaneous than oral communication; more time is available to construct verbalization. 4. To translate an event into an alpha-numeric description. b. Common Examples: 1. Shipboard log keeping 2. Status board updating 3. Preparing tactical messages 4. Instructions to a computer	Stimulus	Performance Aids - Especially in early phase of training, use a performance aid or model, such as instructions, checklists or standard examples/formats to aid in perceiving need for and composing of messages.	Provide a standard set of performance aids.											F									
		"In-the-head" mediators - In later stages of instruction rely on "in-the-head" instructions, models, etc. to aid in perceiving need for and composing required messages	Provision for trainee to be exercised in the use of "in-the-head" models.							F	F				F	F	F	F	F			F	F
	Response	Make overt response - Compose message based on realistic event.	Provision for trainee to use performance aids and/or "in-the-head" models to perceive required message content and to construct messages.	F					F	F	F				F	F	F	F	F			F	F
		Stress - When trainee will be required to perform under stress, use overlearning of skill to minimize effects of competing responses.	Provision for extensive practice (overlearning) when trainee will be required to perform under stress.							F						F	F	F	F			F	F
	Feedback	Provide record of trainee's overt response to enable evaluation of trainee performance.	Provision for recording and evaluating student performance, to display KOR to trainee.							F						M	M	M	M			M	M
	Personal Environment	Rate, level and/or style of learning depend upon characteristics of the individual learner.	Provision for some self-pacing within each stage or level of training.							F	F				F		F						
			Provision for scheduling of advanced stages (different levels) and refresher training according to individual's rate and level of improvement.							F							F						

ORAL VERBALIZATION

TASK CATEGORIES	TASK ELEMENTS	LEARNING GUIDELINES	IMPLICATIONS FOR MEDIA SELECTION	MEDIA OPTIONS																			
				CCTV w/of	PI(L)	PI(B)	SRS(T/S)	SRS(AV)	PIA	CAI/MM	LCD(AV)	VTR	LECT/TEXT	PA	CARREL/MOCKUP	SIM	SIM/AA	PROC TNR	PROC TNR AA	M PROC TNR	C GAMING	OP/SYS	OP/SYS & SIM
a. Common Behavioral Attributes: 1. Speaking natural or specialized languages. 2. Often involves the use of a specific message model. - Standard vocabulary and format. 3. Also concerns clarity of voice, enunciation, speed, volume, etc. 4. Timing of verbalization is usually critical - when to pass information. 5. Typically characterized by redundancy in terms of information content. 6. Involves extensive use of previously overlearned verbal skills, or overcoming overlearned interfering patterns. b. Common Examples: 1. Officer giving oral orders. 2. Sonar operator passing oral information over communication net. 3. Lecture type teaching. 4. Instructions by GCA operator to pilot in landing aircraft.	Stimulus	Use models of correct performance as a basic for perceiving critical cues of good form.	Provision for models of good performance.	F					F		F	F	F	F									
			Provision for trainee to exercise in discriminating between good and bad form; in message format, voice clarity, and timing.									F				F	F	F	F			F	F
	Response	Emphasize overt responding in a social context. Practice to strengthen correct response.	Provision for realistic practice in dealing with the verbal communication aspects of complex tasks.													F	F	F	F			F	F
		Record responses in context. Since the response is typically complex involving subtle relations among components, the technique of measurement should provide for recording the total complex in a manner that permits analysis of such subtle relationships.	Provision for recording of trainee response (oral verbalization) including context of response; Record: (1) all interacting communication channels - identify participants; (2) temporal relationship of related communications; (3) other cues (including visual cues) that are critical in initiating or influencing communication.									F				M	F	M	F			M	M
		When skill is not regularly used, prevent decay of recall by providing periodic refresher training.	Logic for scheduling refresher training.											F		M	F	M	F			M	M
			Provision for oral verbalization practice.													F	F	F	F			F	F
	Feedback	Analyze oral verbalization recordings to evaluate trainee/team performance and provide KOR.	Provision to aid the instructor in recording and having access to segments of communication; i.e., storing, compiling and retrieving specific examples of trainee/team oral behavior for replay to trainees as KOR.									F				M	F	M	F			M	M
	Personal Environment	Provide opportunity to develop team cohesiveness and team member sensitivity to the specific message receiving and sending requirements of individual team members.	Provision for actual teams to practice together until criterion level team verbalization skill is achieved.												F	F						F	F
		Cross training - each team member should learn the jobs of other team members so that information needs of each team member is apparent.	Provision for cross training team members in various positions in team.	F	F	F			F	F	F		F	F	F	F	F	F				F	F

OTHER VERBALIZATION, INCLUDING
INCLUDING SIGNS

				MEDIA OPTIONS																			
TASK CATEGORIES	TASK ELEMENT	LEARNING GUIDELINES	IMPLICATIONS FOR MEDIA SELECTION	CCTV w/of	PI(L)	PI(B)	SRS(T/S)	SRS(AV)	PIA	CAI/MM	LCD(AV)	VTR	LECT/TEXT	PA	CARREL/MOCKUP	SIM	SIM/AA	PROC TNR	PROC TNR AA	M PROC TNR	C GAMING	OP/SYS	OP/SYS & SIM
a. Common Behavioral attributes 1. Communication other than oral or written. 2. Use of sign language such as hand signals. 3. Special emphasis on the motor skill required to execute sign language such as semaphore. b. Common Examples 1. LSO use of signals to communicate with pilot making carrier landing. 2. Traffic police directing traffic at a busy intersection. 3. Hand signals as used with deaf-mutes. 4. Sending code, such as semaphore. 5. Gestures used to communicate meaning in a speech.	Stimulus	Static and dynamic models - In early phase of training use models, such as still and moving graphic displays (video tape recordings) to establish the characteristics of criterion performance.	Provision for set of performance models.	F					F			F		F									
			Provision for trainee to exhibit desired behavior with the aid of the actual models.											F								F	F
		"In-the-head" mediators - In later stages of instruction rely on "in-the-head" instructions, models, etc. to aid in performing.	Provision for trainee to be exercised in the use of "in-the-head" models.							F	F			F								F	F
	Response	Make overt response - Use sign language or signals to communicate.	Provision for trainee to use signs or signals to communicate													F	F	F	F			F	F
		Stress - When trainee will be required to perform under stress, use over learning of skill to minimize effects of competing responses.	Provision for extensive practice (over learning) when trainee will be required to perform under stress.							F	F	F				F	F	F	F			F	F
	Feedback	Provide record of trainee's overt responses to enable evaluation of trainee performance.	Provision for recording and evaluating student performance, to display KOR to trainee.							F		F											
	Personal Environment	For difficult skills (such as signaling) rate, level and/or style of learning depends upon characteristics of individual learner.	Provision for some self-pacing within each stage or level of training.						F	F													
			Provision for scheduling of advanced stages (different levels) and refresher training according to individual's rate and level of improvement.													M	F	M	F			M	M

APPENDIX B

CALCULATION OF COST FACTORS

CALCULATION OF COST FACTORS

1. The generalized set of cost factors for training media can be grouped into categories of acquisition and operation and maintenance. The acquisition cost relationship given in equation form is as follows:

$C_{ACQI} = C_{HD} + C_{MOD} + C_{TD} + C_{LS} + C_{FACA} + C_{PSEA} + C_{GFE} + C_{MTSA} + C_{OTHA}$ where:

C_{ACQI} = Cost of acquisition of a training medium within a training system.

C_{HD} = Cost of hardware, excluding contract modifications and logistic support items.

C_{MOD} = Cost of contractor developed and installed modifications during the acquisition phase.

C_{TD} = Cost of all technical data and information to be supplied under the contract.

C_{LS} = Cost of all logistic support items to be provided under the terms of the contract, excluding parts and support equipment.

C_{FACA} = Facility preparation costs.

C_{PSEA} = Cost of parts and support equipment.

C_{GFE} = Total cost of Government Furnished Equipment supplied by the Government to be used as an integral part or in conjunction with the training medium.

C_{MTSA} = Cost of Government management and technical services required to manage the project during the acquisition phase.

C_{OTHA} = Other costs not previously defined.

2. The relationship of cost categories for operation and maintenance is as follows:

$C_{OMNI} = C_{PSEO} + C_{PRS} + C_{FM} + C_{OMTG} + C_{FAOV} + C_{MTSO} + C_{OTHO}$ where:

C_{OMNI} = Annual operation and maintenance cost of the training medium.

C_{PSEO} = Cost of replacement and replenishment of spares, repair parts and support equipment during the operational phase.

C_{PRS} = Direct and indirect personnel costs required for instruction, operation and support, excluding the trainee costs.

C_{FM} = Cost of field configuration and non-configuration modifications, excluding the cost of Government personnel.

C_{OMTG} = Cost of training and retraining operators and maintenance personnel required to support the training medium.

C_{FAOV} = Variable facility costs associated with the training medium such as electrical power or fuel.

C_{FAOF} = Fixed facility costs such as janitorial services.

C_{MTSO} = Cost of Government management and technical services required during the operational phase.

C_{OTHO} = Operation and maintenance costs associated with the training medium, but not defined elsewhere. Cost for re-installation, storage, documentation revision, and travel would be included in this category.

3. Cost factors for training devices are developed through cost estimating techniques, most often the element estimate method. Cost factors for operational equipment are projected utilizing existing data such as found in OPNAV-90P-02, Navy Program Factors. The cost factors are entered into the cost model in the form shown in Table 6. The treatment of the factors is shown in Figures 3 and 4.

4. Three of the cost factors: C_{PSEO}, C_{PRS}, and C_{FAOV} are functions of utilization time. The cost model considers an estimated cost for each factor at full (100%) utilization and linearizes the factor for all other values. Linearizing in this manner does introduce an error, but for estimating purposes at this time, the error is tolerable.

a. C_{PSEO}, the cost of spares, repair parts and support equipment in the operational phase, is also a function of the maintenance concept and the reliability of the system. Since operation of the system is assumed to be in the constant failure rate region of the life cycle, the linear approximation is valid.

b. C_{PRS}, the cost of personnel to operate and maintain training media, varies with utilization in a "stairstep" manner. Increased utilization requires changes in manning levels that are determined through a staffing criteria analysis. Linearization of costs will introduce some error, but of little significance.

c. C_{FAOV}, the variable portion of facilities costs, is a linear function of utilization, assuming that utilization is a ratio of "power-on" time. This factor, as applied to electrical power for training devices, is analogous to the fuel consumption factor as applied to operational training aircraft.

d. Special Considerations

(1) Care must be exercised in the development of cost factors by making valid assumptions in the estimating process. The accuracy of the cost model output is determined by the estimate precision of the individual cost factors. The prediction of cost factor values for training devices is made by specialists in each of their fields representing acquisition and logistic support disciplines. Sufficient expertise is available at the Naval Training Equipment Center to estimate cost factor values on training media to a relatively high degree of confidence. However, when alternative training system options include operational equipment, such as training aircraft, estimating must be based upon cost data developed outside NAVTRAEQUIPCEN. The cost data for operational equipment consists of composite factors without breakdown or detailed rationale. Navy Program Factors, promulgated by CNO (OP-90), is the usual source of system operation costs. It is imperative that the selection of operational cost factors for predicting future costs be done in a judicious and consistent manner.

(2) The life cycle cost model, in its present form, does not treat costs by required funding categories. Funds are not specifically identified as O&M,N, OPN, PAMN, etc. Rather, the composite of all funding required for the life cycle of training media is considered in the model.

(3) There exists today within the Naval training device community a variation of operating procedures that may not be predictable during the concept formulation phase. For instance, some activities require that training devices be activated twenty-four hours per day

even if the actual training utilization is eight hours or less. The differential between utilization time and "power-on" time is significant in projecting variable operation and maintenance costs. Unfortunately, it is not possible to predict this type of occurrence and, consequently, the actual life cycle costs will differ from the estimated values.

(4) In this report, the end-of-year convention was used which assumes that cash flows occurring throughout a year were concentrated at the year end. This convention is not completely harmonious with Secretary of the Navy Instruction 7000.14, wherein the discounting tables presented reflect the continuous compounding of interest. Since neither convention is a completely accurate reflection of the "real world" situation, the end-of-year convention was adopted because of the convenience of being able to use standard interest formulas and tables and the greater acceptance by most people of periodic compounding as opposed to continuous compounding. In most cases, the outcome decisions of the economic analysis will be the same regardless of the convention used. The objective of the analysis is to compare alternative training systems where "relative" as opposed to "absolute" costs are of prime concern.

APPENDIX C

LINEAR PROGRAM SAMPLE OUTPUT FOR TA-4 AIRCRAFT TRAINING SYSTEM

LINEAR PROGRAM SAMPLE OUTPUT FOR TA-4 AIRCRAFT TRAINING SYSTEM

```
LINEAR PROGRAMMING PROBLEM    9

CONSTRAINTS ARE:
C(  1)                    1.0000*X(  1)
                  >        7.9000

C(  2)                    1.0000*X(  1)
                           .5000*X(  2)
                  >        3.9000

C(  3)                    1.0000*X(  3)
                  >       18.0000



MINIMIZE OBJECTIVE FUNCTION:
                   972.3999*X(  1)
                   314.3000*X(  2)
                    50.9000*X(  3)

SOLUTION OPTIMAL AFTER  4 ITERATIONS

OBJECTIVE FUNCTION VALUE = 9855.35


VARIABLE     STATUS     VALUE    DELTA x COEFFICIENT
X(  1)       BASE       7.900          .0000
X(  2)       BASE       4.000          .0000
X(  3)       BASE       18.00          .0000
S(  1)                  .0000         -343.8
S(  2)                  .0000         -628.6
S(  3)                  .0000         -50.90

CONSTRAINT STATUS      DELTA OBJECTIVE FUNCTION     DECREASE       INCREASE
C(  1)     BIND               -343.8                 7.900       2.000
C(  2)     BIND               -628.6                 2.000           OPEN
C(  3)     BIND               -50.90                 18.00           OPEN
```

DESCRIPTION OF LINEAR PROGRAM SAMPLE OUTPUT

General

The linear program sample output shown in this Appendix provides optimization information for the tactics stage of TA-4 training. The constraint equations C(1), C(2), and C(3) provide allowable media substitution ratios and time constraints. The objective function, which is to be minimized in this example, introduces the dimension of media cost per utilization hour. The computer uses the simplex method of solution to provide the minimum objective function within the above constraints and provides information on the number of iterations required for optimization. The time in each medium is given for the minimum cost case and the delta objective function provides information on costs associated with changes to the optimum mix.

Computer Input

The computer input information consists of constraint equations and media cost data per utilization hour for a given level of utilization. The three constraint equations, represented as C(1), C(2), and C(3) are shown below:

C(1) $X_1 \geq 7.9$

C(2) $X_1 + 0.5X_2 \geq 9.9$

C(3) $X_3 \geq 18.0$

X_1 represents hours in medium 1 (aircraft + instructor)

X_2 represents hours in medium 2 (simulator with wide angle visual)

X_3 represents hours in medium 3 (tutor)

The constraint equations are used in conjunction with media cost information. For this example, the cost per utilization hour of each media considered is:

Medium 1 (aircraft + instructor) = $972.40
Medium 2 (simulator with wide angle visual) = $314.30
Medium 3 (tutor) = $50.90

Computer Output

Using the simplex method of solution, the computer provides information on the number of hours assigned to each medium for the minimum cost mix. It also records the number of iterations required for optimal solution. In this example, four iterations were required for optimal solution and the cost (minimum) is given as the objective function value ($9855.35). This value is the summation of the costs associated with each medium used in the stage of training and is shown below:

Medium 1   7.9 hours x $972.40 = $7681.95
Medium 2   4.0 hours x $314.30 = $1257.20
Medium 3   18.0 hours x $50.90 = $ 916.20
Total Cost = $9855.35

In addition to optimal mix (minimum cost) information, a delta objective function is provided which shows the allowable variation of each constraint limit within the solution range. The cost per hour to be subtracted from or added to the objective function value is also given. As an example, if the C(3) constraint equation limit is reduced two units, which is in the allowable range of 18 unit decrease to an unlimited increase, the equation would become:

$$X_3 \geq 16.0$$

This would reduce total cost by:

2 hours x $50.90 = $101.80

The resulting objective function would become:

$9855.35 - $101.80 = $9753.55

Each stage of training was analyzed in the above manner in order to arrive at total system optimization.

APPENDIX D

LIFE CYCLE COSTS PER UTILIZATION HOUR FOR 17 MEDIA
(COST/UTILIZATION PROGRAM OUTPUT)

LIFE CYCLE COSTS PER UTILIZATION HOUR FOR 17 MEDIA

(COST/UTILIZATION PROGRAM OUTPUT)

```
  MEDIA COST
 MEDIA                                     UTILIZATION

             .05        .10        .15        .20        .25        .30        .35        .40        .45        .50
   1     .252166    .147095    .112071    .034559    .084052    .077048    .072044    .068292    .065373    .063032
   2     .143750    .093750    .077083    .068750    .063750    .060417    .058036    .056250    .054861    .053750
   3     .176551    .092085    .063929    .049852    .041405    .035774    .031752    .028736    .026389    .024512
   4     .123431    .063412    .043406    .033402    .027401    .023399    .020541    .018398    .016730    .015397
   5     .457913    .234195    .159622    .122336    .099964    .085049    .074396    .066406    .060191    .055220
   6    1.536235    .774933    .521166    .394282    .318152    .267398    .231146    .203956    .182809    .165891
   7    1.920726    .970929    .654409    .496119    .401145    .337830    .292604    .258685    .232303    .211198
   8    4.016294   2.022941   1.358467   1.026262    .826926    .694036    .539114    .527923    .472552    .425255
   9    6.329325   3.312356   2.306699   1.803869   1.502172   1.301042   1.157375   1.049627    .965823    .898776
  10.   7.014224   3.740960   2.676536   2.134324   1.806997   1.592113   1.437196   1.321009   1.230640   1.158344
  11    6.515964   3.658363   2.572501   2.029567   1.703807   1.486635   1.331511   1.215169   1.124680   1.052288
  12   12.858550   9.036963   7.776440   7.136174   6.752017   6.495912   6.312979   6.175765   6.069074   5.983701
  13    4.146161   2.088229   1.402251   1.059264    .853470    .716275    .618278    .544781    .487616    .441384
  14   14.043771   7.530577   5.358346   4.272980   3.621461   3.187115   2.876867   2.644184   2.463206   2.313422
  15   13.630389   7.269038   5.148589   4.088364   3.452230   3.028140   2.725219   2.498030   2.321325   2.179961
  16    8.445801   4.516749   3.207065   2.552219   2.159314   1.897377   1.710279   1.569958   1.460816   1.373503
  17   14.219711   7.500627   5.260931   4.141082   3.469173   3.021235   2.701277   2.461312   2.274670   2.125356

             .55        .60        .65        .70        .75        .80        .85        .90        .95       1.00
   1     .061122    .059536    .058189    .057034    .056033    .055158    .054385    .053698    .053084    .052531
   2     .052841    .052083    .051442    .050893    .050417    .050000    .049632    .049306    .049013    .048750
   3     .022976    .021697    .020614    .019686    .018881    .018177    .017556    .017004    .016510    .016066
   4     .014305    .013396    .012627    .011967    .011395    .010895    .010454    .010062    .009711    .009395
   5     .051152    .047763    .044894    .042436    .040305    .038441    .036796    .035334    .034026    .032848
   6     .152049    .140515    .130754    .122385    .115138    .108794    .103196    .098220    .093769    .089761
   7     .193930    .179540    .167364    .156027    .147682    .139967    .132984    .126776    .121222    .118234
   8     .392012    .361203    .336254    .314349    .295364    .278753    .264096    .251067    .239410    .228919
   9     .843925    .796213    .759534    .726380    .697647    .672505    .650322    .630604    .612960    .597082
  10    1.093195   1.049903   1.008195    .972445    .941461    .914350    .890429    .869166    .850141    .833019
  11     .993060    .943702    .901939    .866141    .835115    .807969    .784016    .762725    .743674    .726529
  12    5.913857   5.855631   5.806399   5.764184   5.727595   5.695582   5.667337   5.642229   5.619763   5.599543
  13     .404467    .373286    .346903    .324282    .304686    .287539    .272407    .258957    .246922    .236091
  14    2.199965   2.101251   2.017722   1.946127   1.884076   1.829783   1.781878   1.739295   1.701154   1.666903
  15    2.064301   1.947916   1.886361   1.816456   1.755872   1.702860   1.656086   1.614509   1.577308   1.543826
  16    1.302066   1.242536   1.192163   1.146986   1.111566   1.078824   1.049934   1.024254   1.001277    .980598
  17    2.003191   1.901386   1.815245   1.741408   1.677417   1.621424   1.572020   1.528104   1.488811   1.453446
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13. ABSTRACT

This report describes the activities performed during a Staff Study on the cost and training effectiveness of proposed training systems.

Development of a Training Effectiveness and Cost Effectiveness Prediction (TECEP) Model was begun. It will eventually contain the following elements: task description and analysis; characteristics of student population; training tasks and training stages; a method for the determination of useful media options; media cost factors; guidelines for substitution and transfer; training program of primary media and allowable substitutions; linear program to optimize for least cost; and a report including economic analysis and recommendations.

An application of the TECEP Model using the TA-4 advanced jet training system was performed to test the feasibility of the Model. Included in the discussion of the application are a training analysis, training media mix options, cost factors for the TA-4 aircraft and training media, and TA-4 training system cost/training effectiveness.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Training Effectiveness						
Cost Effectiveness						
Transfer of Training						
Training System Design						
Fidelity of Simulation						
Training Media Selection						
Training Media Cost Model						
Cost/Utilization Model						
Economic Analysis						
Life Cycle Cost Model						
Training System Optimization						
Training Effectiveness Prediction						
Training Equipment Substitution