Research Note 85-34

A REVIEW OF MODELS FOR COST AND TRAINING EFFECTIVENESS ANALYSIS (CTEA)

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U. S. Army
Research Institute for the Behavioral and Social Sciences

March 1985

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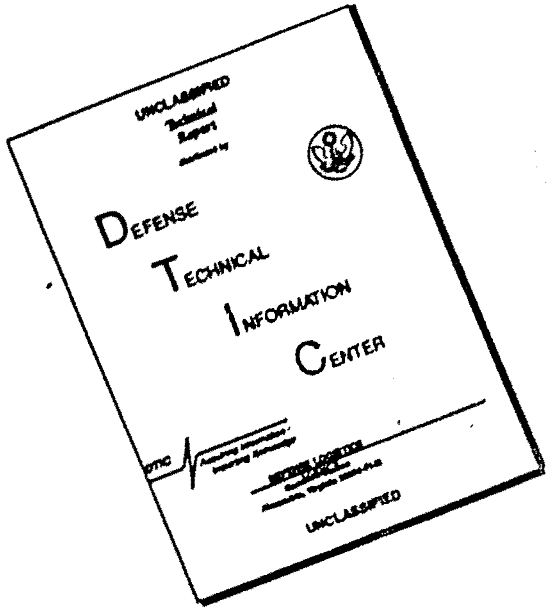

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
Research Note 85-34

2. GOVT ACCESSION NO.
AD-A158041

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
A REVIEW OF MODELS FOR COST AND TRAINING EFFECTIVENESS ANALYSIS (CTEA)

5. TYPE OF REPORT & PERIOD COVERED
Final Report
Mar 80 - Mar 81

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

Melvin Rosen
Doris C. Berger
Richard K. Matlick

8. CONTRACT OR GRANT NUMBER(s)
MDA 903-80-R-0345

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Litton Mellonics Systems Development Division
Washington Scientific Support Office
1725 Jefferson Davis Hwy. #508, Arlington, VA 22202

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
63743A, 2Q263743A794, 3350 53B

11. CONTROLLING OFFICE NAME AND ADDRESS
U.S. Army Research Institute for the Behavioral and Social Sciences, Fort Benning Field Unit
P. O. Box 2086, Fort Benning, GA 31905

12. REPORT DATE
March 1985

13. NUMBER OF PAGES
192

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

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

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

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Cost and Training Effectiveness Analysis (CTEA)
Training Evaluation
Training Effectiveness
Training Models
Initial Screening Training Effectiveness Analysis (ISTEA)

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

This research attempted to identify current models for CTEA which might be generalized to all Army systems and non-systems training programs, procedures and devices. This attempt was not completely successful. However, the extensive literature review is reported for use by other researchers and interested parties. Also reported is a systematic approach to defining which of several existing CTEA "sub-models" should be used under differing conditions of analysis

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Item 19 continued

Training Subsystem Effectiveness Analysis (TSEA)
Training Effectiveness Analysis (TEA)
Training Developments Study (TDS)
Instructional Systems Development (ISD)
Training in the LCSMM
Training Program Prediction
Training Alternatives
Training Extension Course (TEC)

Item 20 continued

needs as specified by the user or analytic group involved. The authors have also developed more detailed functional steps for performance of some of the "sub-model" analyses.

A REVIEW OF MODELS FOR COST AND TRAINING EFFECTIVENESS ANALYSIS (CTEA)

EXECUTIVE SUMMARY

Requirement:

No methodology currently exists for Cost and Training Effectiveness Analysis (CTEA) that:

- Is generalizable to all Army systems and nonsystems
- Goes beyond the acquisition phase of systems to include the analysis of fielded systems.

This project was to identify how these needs would be met through extension, development, or refinement of current methods.

Procedure:

A previous Litton literature search was refined and extended--especially to include studies conducted to determine cost and effectiveness of Training Extension Course (TEC). Since it was determined that there existed no model that could be modified to meet the research objectives, a systematic approach to Training Effectiveness Analysis (TEA) for multiple purposes was developed, based on TRADOC Regulation 350-4. This approach considers application of the following submodels:

- CTEA for Developing Systems. This submodel was developed by Litton in previous research for the Army Research Institute (ARI) Field Unit at Fort Bliss, Texas (Matlick et al., 1980a).
- Instructional System Development (ISD). This submodel is covered fully in TRADOC Pamphlet 350-30.
- Training Evaluation for Nonsystem Training. This submodel was developed in the current research effort.

- Initial Screening Training Effectiveness Analysis (ISTEA) for Fielded Systems. This submodel was developed in the current effort based on TRADOC Regulation 350-4.
- Training Subsystem Effectiveness Analysis (TSEA) for Fielded Systems. This submodel was developed in the current effort based on TRADOC Regulation 350-4.
- Training Developments Study (TDS). This submodel was developed in the current effort based on TRADOC Regulation 350-4.

Findings:

No current model or methodology lends itself to CTEA for developing and fielded systems, and to systems and nonsystems training. Therefore, a systematic approach to TEA was developed based on a family of submodels. Methods are available for accomplishing the processes embedded in some of these submodels (e.g., see Matlick et al., 1980a, for methods recommended for CTEA for developing systems). For other submodels, the required processes have been identified, but the development required of the specific methods was not within the scope of the current project.

Utilization of findings:

These findings, especially the systematic approach to identifying the appropriate CTEA model for a given problem, will be useful to training developers and researchers in this area. Detailed methods for performing some of the new submodels developed in this effort await their application, and subsequent codification by analysts and researchers.

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SECTION 1

INTRODUCTION

At least fifteen years ago*, the Army recognized that the fielding of Army systems without due consideration to the impact of the cost and effectiveness of training subsystems was neither economical nor efficient. The Army's Life Cycle System Management Model (LCSMM) (DA Pamphlet 11-25) defines the process by which Army materiel systems are acquired. Although it was designed to ensure consideration of all aspects of the system (training subsystem, personnel subsystem, logistics subsystem), the emphasis has remained on the hardware subsystem. Nevertheless, there continues to be a need for data on the cost and training effectiveness of both developing systems and fielded systems so that decision-makers can make rational decisions concerning competing developing systems, or on how to ameliorate excessive cost of or ineffective training on fielded systems.

The Army Research Institute (ARI) Field Unit at Fort Benning, Georgia sought to develop a CTEA methodology that:

- Could be generalized to all training for Army systems and nonsystems,
- Would extend and refine previous research in the CTEA area, and
- Go beyond the acquisition phase of systems to include the analysis of fielded systems.

This research effort builds on previous research for the ARI Field Unit at Fort Bliss, Texas. The former objective was to provide Army analysts with a performance guide for CTEA at each stage of the acquisition process (LCSMM)

*The first version of DA Pamphlet 11-25, Life Cycle System Management Model for Army Systems was published in October 1968, but the problem was being considered for several years prior to this.

of a developing system (Matlick et al., 1980a, 1980b). For example, four Cost and Operational Effectiveness Analyses (COEA) are conducted during the LCSMM. CTEA support COEA by providing assessments of alternative ways to train and achieve the desired operational effectiveness of the system as well as providing relevant cost data. Thus, at least four CTEA are required to support these COEA. Additional CTEA are needed to support training development decisions. Depending upon the data situation, the analyst needs a different strategy to perform each CTEA.

To define some terms, system training and system device indicate that the training or device is to be used exclusively for one hardware-oriented system. If the device or training is to be used in conjunction with two or more systems or for general military training, then, it is called nonsystem (ATSC, Training Device Requirements Document Guide, 1979). Thus, training in military courtesy is nonsystem training. The Beseler CUE/SEE to be used with Training Extension Course (TEC) tapes is an audio/visual medium which constitutes a nonsystem training device.

Although CTEA has been used most commonly in a generic sense to encompass all such analyses done for developing or fielded systems, and for system or nonsystem training, TRADOC Regulation 350-4 (1979), sets forth narrower definitions. In the TRADOC Regulation 350-4, Training Effectiveness Analyses (TEA) system schema, the following terms are used as indicated:

- Training Effectiveness Analysis (TEA) - overall rubric.
- Cost and Training Effectiveness Analysis (CTEA) - conducted for developing systems in the acquisition phase.
- Initial Screening Training Effectiveness Analysis (ISTEA) - conducted for fielded systems to determine if there is a performance gap. The

ISTEA May have a secondary function of providing support/input to a CTEA (on a developing system).

- Training Subsystem Effectiveness Analysis (TSEA) - conducted for fielded systems to determine if an existing performance gap is due in whole or in part to the training subsystem.
- Training Developments Study (TDS) - conducted to develop a fix for a training subsystem deficiency or develop a more cost-effective way to train.
- Total System Evaluation (TSE) - conducted to arrive at cost-effective ways to eliminate performance gaps not caused by the training subsystem. Since the training subsystem is our primary concern here, and since it has been eliminated as a cause for system deficiency, we will not concern ourselves further with the TSE. Suffice it to say that the TSE goes on to look in detail at the personnel subsystem, the hardware subsystem, and the logistics support subsystem.

Thus, to place these terms in perspective, we might say that: A CTEA (generic) may be a CTEA (TRADOC Regulation 350-4), an ISTEA, a TSEA, or a TDS, or a combination of ISTEA, TSEA, and TDS.

Within the research and training development communities, the term Weapon System Training Effectiveness Analysis (WSTEA) also has been in general use with respect to fielded systems. In the context of TRADOC Regulation 350-4, the WSTEA was generally a combination of ISTEA, TSEA, and TDS.

With respect to systems, most CTEA (generic) includes CTEA (TRADOC Regulation 350-4), ISTEA, TSEA, and TDS. The previous research developed the model for CTEA (TRADOC Regulation 350-4). Our objective in this research was to obtain or develop a generic CTEA model for systems and nonsystems, and developing and fielded systems. Once the general model was developed, the appropriate submodels had to be developed. These developments and the resulting models are described in the final section of this report. The second section summarizes the literature on cost and training effectiveness analysis. Appendix A is a 31-item bibliography with abstracts of selected related literature, Appendix B is a full 124-item bibliography of CTEA-related literature, and Appendix C is a listing of abbreviations and acronyms found in the CTEA literature.

SECTION 2

LITERATURE REVIEW

2.1 Purpose

This review of current literature on Cost and Training Effectiveness (CTEA) methods was undertaken to determine the state of the art of such methods. The review was then to form the basis for deriving or developing a generic method or set of methods for CTEA to apply to a broader set of training programs, systems or devices - including development efforts for both developing and fielded, systems and nonsystems-related, training systems.

2.2 Types of Literature Reviewed

Three areas of literature were identified as a particular concern. These were generic CTEA, CTEA TDS for major training devices, and the original focus--CTEA for TEC lessons. Therefore, we examined four general categories of relevant literature:

- Department of Defense/Department of Army directives and regulations,
- CTEA methods/methodologies, and
- Reports documenting CTEA.

The review builds on the literature reviews of Matlick et al. (1980a) and Sassone (1978). The Life Cycle System Management Model, and some of the prescriptive, predictive, and cost models reviewed in the former are reviewed also herein. These documents have been re-examined to discover their treatment of training media in general and devices and the Training Extension Courses

(TEC) in particular. This reexamination, however, constitutes only a small portion of the following literature analysis since the focus of Matlick et al. (1980a) was specifically on CTEA methods for developing systems. Most of the Sassone (1978) review focused on literature germane to construction of a cost-effectiveness model for the training program component (e.g., TEC). This present review has encompassed all literature available on TEC.

Applicable literature identified in computerized searches of National Technical Information Services (NTIS), Defense Technical Information Center (DTIC), Educational Research Information Center (ERIC), and other library holdings have been examined. A summary of the findings in the four areas follows.

2.3 Army Regulations and Guidance

2.3.1 Introduction. In order to understand the context in which CTEA takes place, an understanding of basic Army and Department of Defense directives, regulations, and guidance is required. It is from this literature that the requirement for formal CTEA and other effectiveness assessments are identified. This literature also provides a set of basic definitions of terms without which a study of the plethora of CTEA documents would be unintelligible.

2.3.2 The Life Cycle System Management Model. Evaluation of the cost and effectiveness of a training system is required at several points in the LCSMM of a major developing operational system. Additionally, a training device requires evaluation at additional points in its own developmental cycle; in some cases a device is evaluated at the same time as the operational system.

The process through which Army materiel systems are acquired and maintained is described in DA Pamphlet 11-25, Life Cycle System Management Model (LCSMM), expressed in a 119-event flow chart (Department of the Army, 1975). LCSMM outlines procedures for the development, acquisition, and management of Army systems from concept investigation through ultimate disposal of obsolete systems. It covers coordination of combat development, research and development, production and logistic support, training and personnel requirements, and actions required to develop and maintain the system.

Training considerations are integrated into the LCSMM through the Integrated Personnel Support (IPS) system (Department of the Army, 1978). The goal of IPS is to ensure that personnel-related issues are planned, developed, acquired, tested, and deployed in conjunction with the materiel acquisition process. Such issues include the number and characteristics of personnel required to operate, support, and maintain the system, their training, interface with hardware, human resources development, and other personnel factors.

Matlick et al. (1980a) have identified the locations for CTEA and CTEA updates in the system acquisition process (Figure 2-1). The conduct of CTEA-type analyses after a system becomes operational is defined less clearly. The LCSMM events related to CTEA and the issues they must resolve are shown in Table 2-1*.

The process is relevant to training devices from two standpoints. First, all major devices and simulators are subject to the same regulations and directives as any other Army hardware system in regard to procedures for development, acquisition, and management. Therefore, they follow as much of

*For a detailed description of all LCSMM events and their implications for CTEA, see Matlick et al., Cost and Training Effectiveness in the Army Life Cycle Systems Management Model, pp. II-1 - II-15.

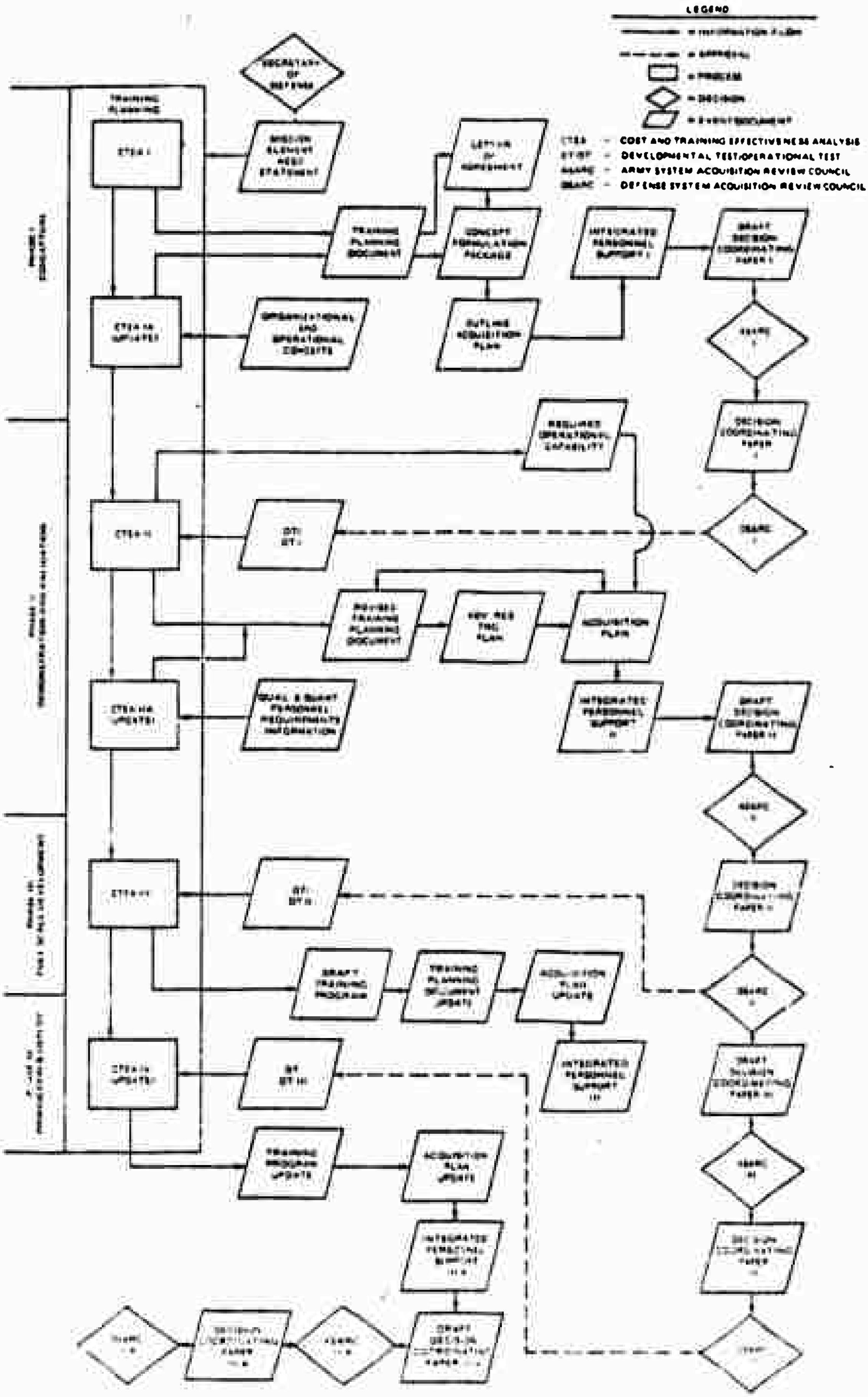

Figure 2-1 CTEA in the System Acquisition Process
SOURCE: Matlick et al., 1980, p. II-2

LCSMM PHASE	CTEA	PRIMARY LCSMM EVENTS YIELDING DATA TO CTEA	ISSUES REQUIRING RESOLUTION
CONCEPTUAL	I	• MENS • INITIATION OF TRAINING PLANNING • INITIATION OF LOGISTICS SUPPORT PLANNING	• TRAINABILITY OF BASIC CONCEPT • COST OF TRAINING • TRAINING PROGRAM ELEMENTS TO BE INCLUDED OR STUDIED
	I A (update)	• LOA • ORGANIZATIONAL AND OPERATIONAL CONCEPTS	• TRAINABILITY OF ALTERNATIVE CONCEPTS • RELATIVE COST EFFECTIVENESS OF TRAINING PROGRAMS OF ALTERNATIVE CONCEPTS
DEMONSTRATION AND VALIDATION	II	• OAP • DT/OT I	• TRAINABILITY • NECESSARY REVISIONS OF TRAINING PROGRAMS • RELATIVE COST EFFECTIVENESS
	II A (update)	• PQQPRI • DCP(IPS)	• TRAINABILITY • TDR • RELATIVE COST EFFECTIVENESS OF REVISED TRAINING PROGRAMS
FULL-SCALE ENGINEERING DEVELOPMENT	III	• NET PLAN • AP • DT/OT II	• PERFORMANCE VERSUS STANDARDS • PERFORMANCE VERSUS HARDWARE AND TRAINING PROGRAM DESIGN, PERSONNEL SELECTION, ETC.
PRODUCTION AND DEPLOYMENT	IV (update)	• TRAINING PLAN UPDATE • DRAFT TRAINING PROGRAM • AP • DT/OT III	• COST EFFECTIVESS OF REVISED TRAINING PROGRAM

Table 2-1 CTEA in the LCSMM
SOURCE: Matlick et al., 1980, p. II-41

the LCSMM (DA Pam. No. 11-25) as each set of unique conditions allows. Second, the LCSSM for a major system controls and influences the subordinate development, acquisition, testing, and operation of all the devices related to its training systems. The scheduling and milestones of the major end-item determine those required for the training devices, sometimes creating serious compression of their design and development.

2.3.3 The Instructional System Development (ISD) Methodology. The Army and all the other services prescribe a similar sequence of procedures for the development of training--the Instructional System Development (ISD) Model. The procedures are described in Interservice Procedures for Instructional Systems Development, TRADOC Pamphlet 350-30 (1975). Training media (devices, simulators, and TEC Lessons) are only a part, albeit an important and expensive part, of a complete system designed to train a larger set of related tasks required by an operational systems, a MOS, or a team.

The ISD procedures constitute a systems approach to training development and as such offer a repetitive process of analysis, design, verification and revision. Fundamental to ISD are rigorous derivations of training requirements for job requirements, selection of instructional strategies to maximize training cost effectiveness, and continual testing and revision of the training during development until training objectives are met. Like the LCSMM, the complete, rigorous application of ISD presents problems when its use is attempted in a real world environment. The ISD process takes place in five phases: (1) Analyze, (2) Design, (3) Develop, (4) Implement, and (5) Control.

Training media should be dealt with in the general ISD context. A brief description of the five ISD phases follows.

2.3.3.1 Phase I - Analyze. During Phase I, emphasis is on the job to be performed. The job performance is analyzed in as a great detail as possible; a complete task list is compiled; tasks that require instruction are selected; a job performance measure is specified for each task selected for instruction; existing analogous training is analyzed; and the most suitable instructional setting is proposed for each task selected for instruction. Good research at this stage is vital to device specification and development because device design depends on complete task description. Existence of job performance measures makes possible assessment of training system and device effectiveness.

It is in the analysis of existing courses and prediction of settings that use of devices for certain tasks or groups of tasks may first be recognized.

2.3.3.2 Phase II - Design. Phase II is concerned with designing instruction based on the tasks, sub-tasks, performance measures, setting selection and other data acquired during the analysis phase. The first step is to convert each task selected for training into a terminal learning objective. Second, test items are designed to measure degree of mastery of the learning objective. Third, research is conducted to determine the degree of skill or knowledge that may be expected before training. Finally, the tasks are sequenced into a logical, coherent, structured instructional program.

If this step in ISD has been carried out, it is of great value in device development since it provides empirical criteria that can be used to measure trainees who are trained to tasks on a simulator or device.

2.3.3.3 Phase III - Develop. There are five steps in the ISD development phase. First, the training developers classify the learning objectives by learning category. This enables them to identify apropriate learning guidelines. Next, they apply a media selection process to determine the instructional package and presentation. The media selection process should take into consideration such factors as learning category and guidelines, media characteristics, training setting criteria and costs. Other steps include analysis of existing analogous training packages, development of new materials and media as required, and field testing and revision of instructional material. The TEC prototypes are developed as part of this package.

It is in ISD Phase III that a need for a device may be identified or verified. In the media selection process, analysts consider devices and simulators and, if found appropriate, effective training media for the tasks under consideration will include them in alternative programs subject to cost and training effectiveness analysis.

2.3.3.4 Phase IV - Implement. In the implementation phase, the training delivery personnel take over the newly-designed program and put it into use. Classes are scheduled, space made available, staff trained, materials and media acquired, and students assigned. The appropriate agency conducts instruction and documents need for improvement for each succeeding training media, and the trainers make an assessment of strengths and weaknesses along with the other components of the instructional package. TEC prototype packages are validated.

2.3.3.5 Phase V - Control. Phase V is the ongoing, continued evaluation and revision of the training program. It is the bridge that closes the loop back to other phases of the system. Throughout the life of a training system, data on instructional effectiveness and costs, and on-the-job performance in the field may be collected and analyzed. When possible, outside evaluation teams will make such assessments. These analyses serve as a quality control of instruction and generate empirical data required to justify system revisions.

As in Phase IV, the devices in use are subject to the same scrutiny as the program. The continuous data gathering on and evaluation of the device serves as a basis to refine and improve it, cost it accurately, phase it out, and provides a data base for design and development of new devices.

2.3.3.6 The LCSMM and the ISD. The ISD process defines training acquisition events and activities. However, these events and activities occur and are dealt with within the context of the overall system acquisition process governed in the Army by the LCSMM. The LCSMM is applicable to acquisition initiatives directed toward improving fielded, operational systems, processing developmental systems, and procuring new systems. A system may be a new or existing training system. It may be, and is usually thought of as being, a major weapon or hardware system. For such systems, a complete instructional system must be developed.

Analysis by CORADCOM (1978) has structured training events and activities in the context of the LCSMM as has TRADOC in TRADOC Regulation 600-4 (1978). The two processes, LCSMM and ISD, are compatible although not congruent. ISD relies on accurate task analysis and a great deal of empirical data to achieve maximum utility. Therefore, it is better suited to design and revision of training for jobs that already exist. When IDS is used within the context of the LCSMM of a new hardware system, real-world data such as well-defined task lists and performance measures do not exist to guide the ISD. However, the general sequence of events of both models applies to training systems acquisition. This special acquisition process is next discussed.

2.3.4 Training Acquisition Handbook. DARCOM and TRADOC have provided a consolidated set of information and guidelines covering training requirements within the acquisition process in a jointly prepared Training Acquisition Handbook (CORADCOM, 1980). This handbook reviews the ISD process, the LCSMM, and training acquisition in the LCSMM context. TEC lesson* as well as training devices are identified as part of the media selection process. The development of TEC, part of the extension training material, is keyed to the technical manuals. This is a subordinate step in the Skill Performance Aids development process (formerly termed Integrated Technical Documentation and Training or ITDT). The handbook advises that a set of material will be developed for each duty position. Table 2-2 shows the contents of a typical package. The handbook also states that the lesson formats are modeled on the TEC format that provides for three instructional media formats: (1) audio/visual, (2) written, and (3) audio. Use of formats other than written must be justified by a media analysis. A general model of the Skill Performance Aids package development is shown in Figure 2-2.

Training device acquisition is considered of major importance. The handbook treats it in a separate major section, Chapter Six, Training Device Acquisition. A review of regulations and guidelines related to devices will be discussed later in this report.

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*Unless otherwise identified, TEC lesson will be applied to those audio/visual extension course lessons provided on 8mm film and viewed on the Beseler CUE/SEE.

Table 2-2 Typical Skill Performance Aids Package Contents

Documentation (TMs)

- Maintenance Manuals (New Look format)*

  TM 9-xxx-xxx-20: Organizational Maintenance
  TM 9-xxx-xxx-30: Direct Support Maintenance
  TM 9-xxx-xxx-40: General Support Maintenance

- Operator Manual (New Look format)*

  TM 9-xxx-xxx-10: Operator's Manual

Training (ETM)

- Training Manager's Guide (TMG)

- Student Guide (SG)

- Lesson Administrative Instructions (LAI)

- Student Lesson Sheet (SLS)

- Lesson Content Materiel (Media Options)

  Audio/Visual
  Written
  Audio
  Computer Mediated (CAI, CMI, etc.)
  Training Devices and Simulators

*Characterized by highly illustrated, simple to read, step-by-step task performance instructions organized for use by both entry-level and experienced personnel. (Source: CORADCOM, 1978, p. 4-3)

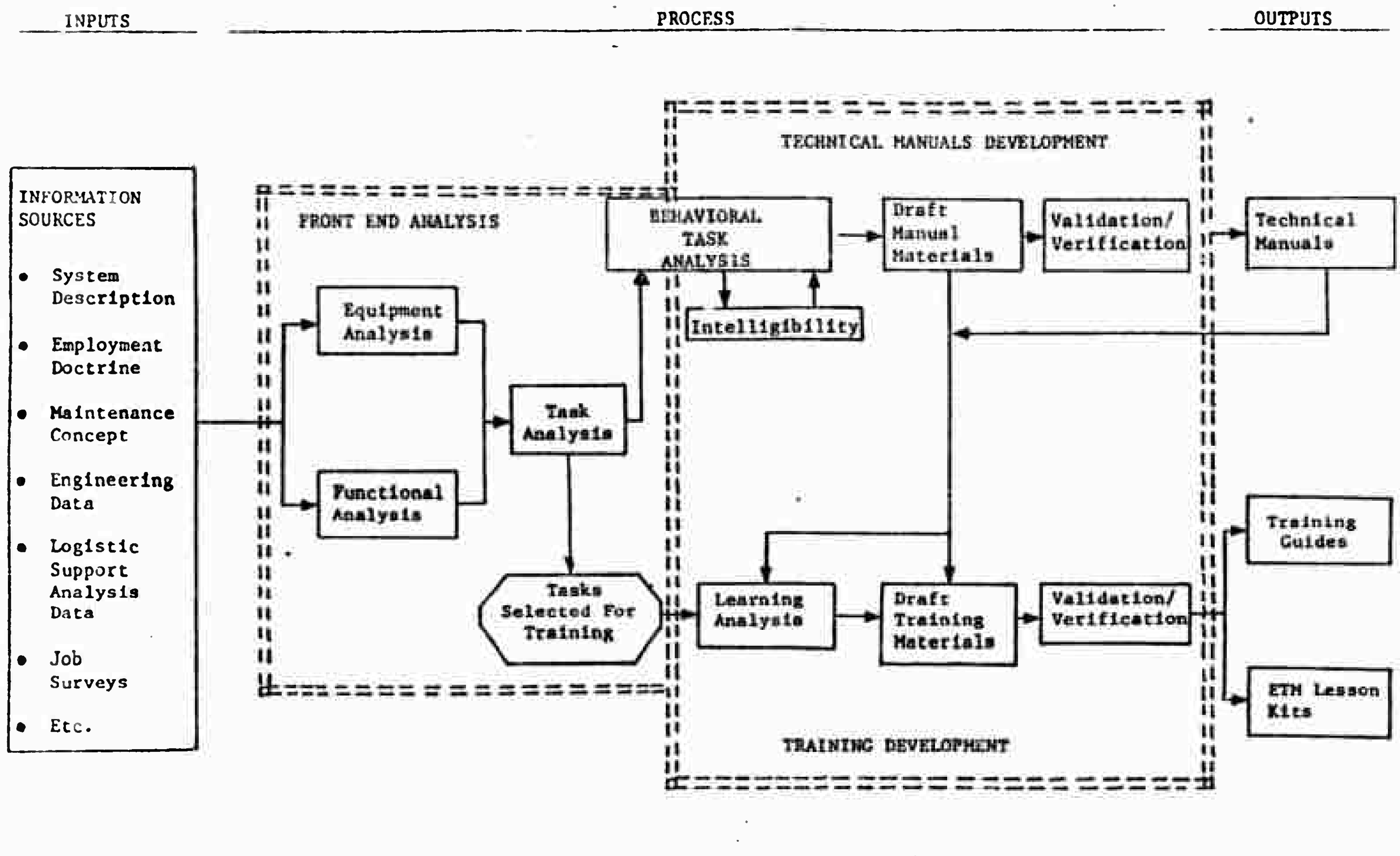


Figure 2-2 Skills Performance Aids Development Process
SOURCE: CORADCOM, 1978, pp. 4-6

2.3.5 TRADOC Guidance for Training Effectiveness Assessment

2.3.5.1 TRADOC Regulation 350-4. TRADOC provides guidance for several types of training effectiveness assessment in two recent publications. The first, TRADOC Regulation 350-4, Training: The TRADOC Training Effectiveness Analysis (TEA) System (May 1979) prescribes policies, procedures, and responsibilities governing the operation of the TRADOC TEA System. This regulation identifies and describes five types of TEA as shown in Table 2-3. The authors state that if valid evidence of a significant performance gap exists, a TSEA should be conducted in lieu of an ISTEA. They note the similarity between a CTEA and a TDS, remarking that they are procedurally similar and heavily cost (economic) analysis oriented. The TEA system flow chart, depicting the relation of TEA to system life cycle, is shown in Figure 2-3.

The regulation delegates TEA authority and defines their roles and responsibilities among several agencies. The pertinent information unique to CTEA is shown in Table 2-4.

Special mention is made of TRASANA's role in developing a TEA handbook. This is envisioned as an evolutionary document, initially concentrating on concept and methodology with the ultimate goal of providing a how to guidebook.

2.3.5.2 TRASANA's TEA Handbook. The guidebook referred to in the preceding paragraph is now available in draft form--TRADOC Training Effectiveness Analysis Handbook, TRASANA (1980). This handbook is a procedural guide for persons charged with conduct of TEA. The methodology for conduct of CTEA (from preliminary to update to final) is shown in Figure 2-4. The text describes the method step-by-step telling the analyst what to do and in some cases, how to do it, and suggesting data sources.

Table 2-3 Types of TEA Described in TRADOC Regulation 350-4

Type	Description
1. Cost and Training Effectiveness Analysis (CTEA)	Conducted during the acquisition process in order to: Insure that Training Development (TD) processes (ISD Phases I, II, and III) are initiated early in the life cycle of hardware systems and are accomplished both in parallel and coordination with Combat Development (CD) processes during the acquisition cycle. Optimize soldier hardware subsystem interface. Insure that the appropriate level of scientific methods are used in the development of the training subsystem. Insure that all feasible training subsystem alternatives are considered. Optimize soldier training subsystem interface. Recommend the preferred training alternative for the preferred hardware system based on cost and training effectiveness. Provide decision-makers with more precise information at critical points in the acquisition process concerning the Total System comprised of the training, hardware, and other subsystems (TRADOC Pamphlet 71-8).
2. Initial Screening Training Effectiveness Analysis (ISTEA)	Conducted after a system has been fielded in order to: Determine if actual effectiveness (E_A) and design effectiveness (E_D) are essentially equal or if a significant performance gap exists.

Table 2-3 Types of TEA Described in TRADOC Regulation 350-4

	Determine if a cause and effect relationship exists between demonstrated soldier proficiency and attitudes and trainer proficiency and attitudes.
	Examine aspects of the training environment which are most likely related to the E_A/E_D relationship.
3. Training Subsystem Effectiveness	Conducted after a system has been fielded in order to:
	Determine if existing significant performance gap is caused, all or in part, by the training subsystem.
	Examine the training subsystem in detail.
	Relate soldier, trainer, training environment, training subsystem and hardware subsystem factors/variables to obtain high resolution of problem areas.
	Examine, by excursion, related subsystems (personnel and logistical support subsystems) that may be contributing agents to a performance gap.
	Identify potential solutions to training subsystem problems.
4. Training Developments Study (TDS)	Usually conducted after a system has been fielded but also is used preliminary to the conduct of CTEA for developing system training devices and nonsystem training devices which are under separate Training Device Letter Requirement (TDLR). The TDS is designed to:
	Find the most cost-effective way to fix training subsystems found deficient during the conduct of a TSEA.
	Find the most cost-effective way to change training subsystems which are not deficient but considered too costly or in need of revision.

Table 2-3 Types of TEA Described in TRADOC Regulation 350-4

5. Total System Evaluation (TSE)	TSE, as it applies herein, is derived from TRADOC Pamphlet 71-8. It includes the training subsystem, hardware subsystem, personnel support subsystems and logical support subsystem. TSE are conducted on fielded systems when it is determined that an existing performance gap is not caused entirely by the training subsystem. A TSE is performed to identify the problem area(s) causing such gaps. The emphasis of a TSE includes, but is not necessarily limited to, the personnel and logistical support subsystem.

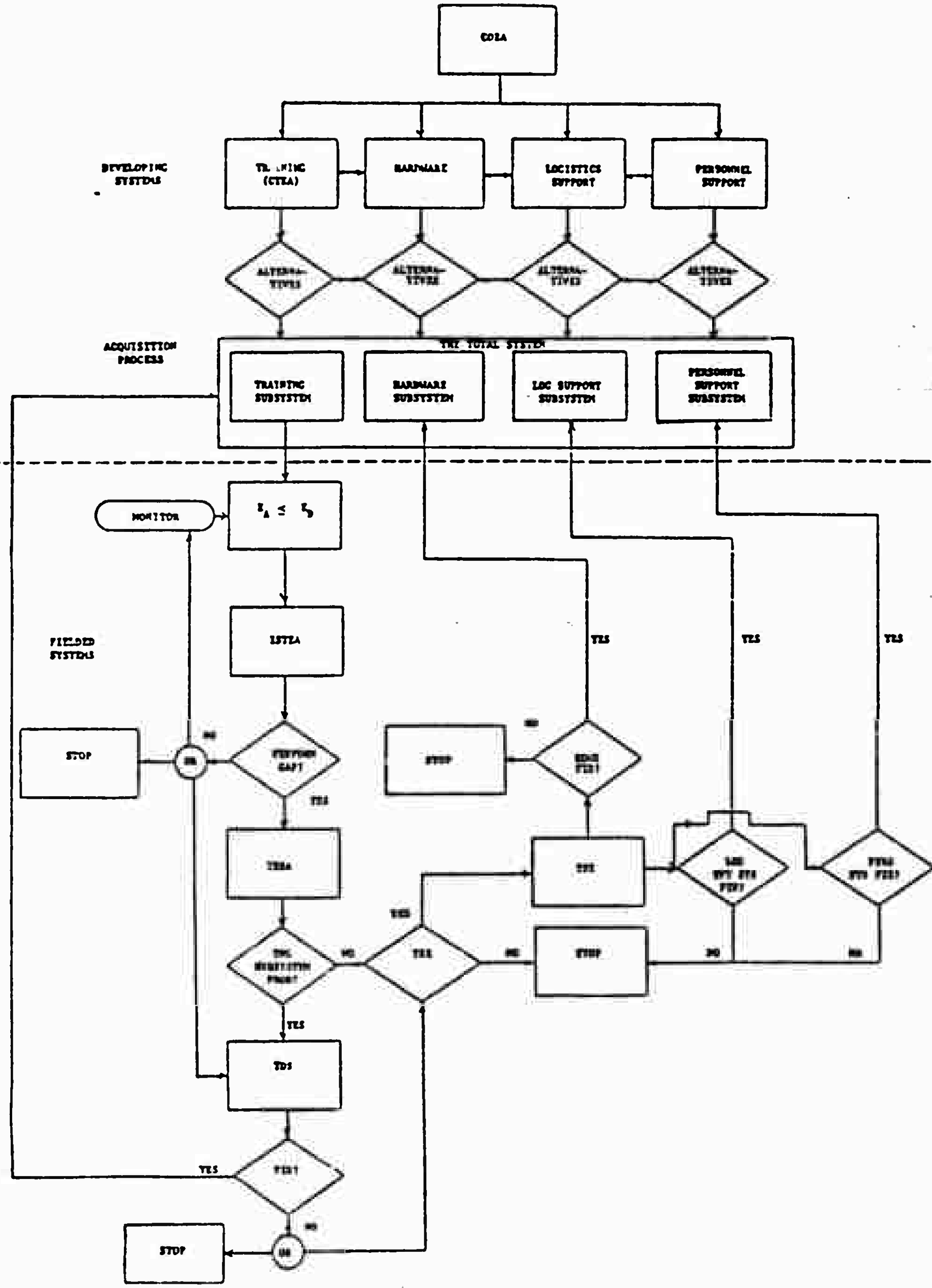


Figure 2-3. TRADOC TEA System Flow Chart

Source: TRADOC Regulation 350-4, p. 7.

Table 2-4 CTEA Roles and Responsibilities as Assigned by TRADOC

Agency	Responsibility
HQ TRADOC	Provides policy, direction, program review, and study approval.
Deputy Chief of Staff for Training (DCST)	Directs the TRADOC TEA System.
Deputy Chief of Staff for Combat Developments (DCSCD)	In coordination with the TRADOC DCST, insures OMA and RDT&E funds for the CTEA portion of the COEA are included in the programming of funds (DD Form 1498) for COEA and other related combat development studies (TRADOC Regulation 11-8). Functions as HQ TRADOC point of contact for TRASANA in CTEA matters as they pertain to the overall COEA effort. In support of the CTEA effort, provides a coordination link which facilitates TRASANA's entry into the TSM, HQ DARCOM and PM loop.
U.S. Army Training Support Center (ATSC)	Serves as the TRADOC DCST point of contact (POC) for proponents in matters relating to CTEA study directives for developing systems and nonsystem training devices.
TRADOC Systems Analysis Agency (TRASANA)	Responsible for the TRADOC TEA Handbook which explains the how to procedure and methodologies for each type TEA. Conducts independent TEA efforts as directed by HQ TRADOC.
Proponent Service Schools	Serve as TEA study proponent.

C T E A

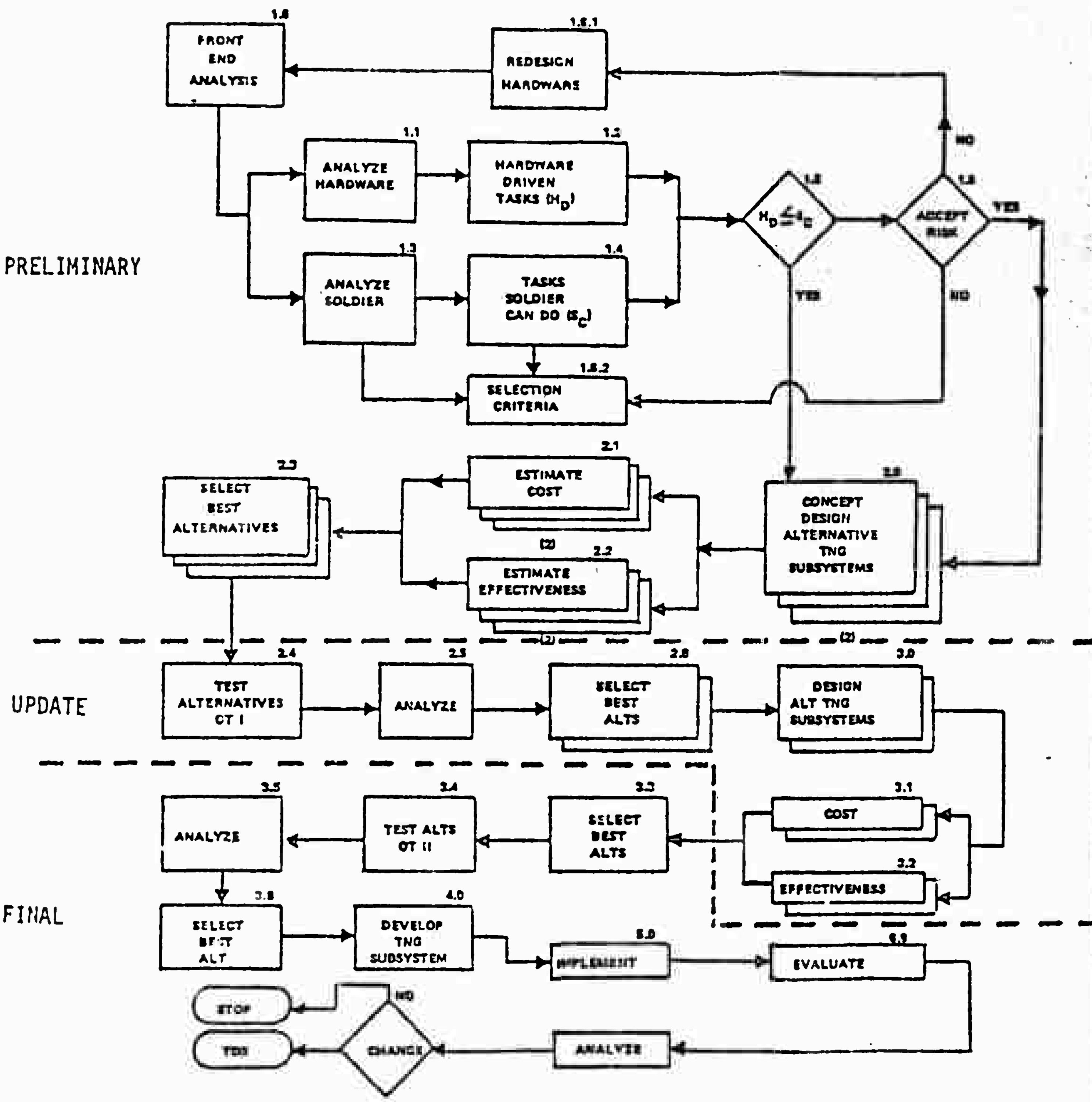


Figure 2-4. CTEA Flowchart

Source: Department of Army, TRASANA, 1980, Draft, p. 2-8.

2.3.6 <u>The Training Device Acquisition Process</u>. The Training Acquisition Handbook (U.S. Department of Army, CORADOM, 1980) defines training devices as panel displays, simulators, part-task trainers and full crew trainers. They are distinguished from training aids (descriptive charts, graphics, and audio/visual material) and training equipment (operational equipment dedicated to training). Major training devices and simulators are recommended for use primarily when critical subject matter is too complex for verbal, symbolic, or simple pictorial presentation or when it requires extensive hands-on practice to develop the requisite level of skill. Categories of devices include teaching machines, models and mockups, hardware simulator-trainers, and actual objects (component, assembly, unit or system). Training devices that use the actual equipment induced to act and react as it would in an operational environment are called simulators (Montemerlo, 1977).

PM TRADE (1979) classifies training devices by their intended use. If the device is to be used exclusively for one system, it is called a "system" device. If it is designed for use in two or more systems or for general military training, it is called a "nonsystem" device. A further classification results when the system itself is evaluated -- is it fielded or developmental? The four categories are shown in Table 2-5.

Table 2-5. Categories of Training Devices and Weapon/Operational Systems

		WEAPON/OPERATIONAL SYSTEM	
		FIELDED	DEVELOPMENTAL
TRAINING DEVICE	NONSYSTEM	NONSYSTEM FIELDED	NONSYSTEM DEVELOPMENT
	SYSTEM	SYSTEM FIELDED	SYSTEM DEVELOPMENT

SOURCE: PM TRADE, 1979, p. 42.

Futhermore, a complex simulation trainer may have several identical modules for group training or several different modules for simultaneous team training.

The unique training device acquisition process begins after the development of initial training system concepts (if the device is part of a developing system) or after a need is identified for a new type device or simulator and validated by PM TRADE or TRADOC. This process has been modeled by CORADCOM (1980) in relation to the Life Cycle System Mangement Model (LCSMM) of the operational equipment for which its training is designed; (Figure 2-5) and PM TRADE (1979) in greater detail and applicable to all types of devices.

First, the device enters a period of concept formulation. Developers will consider: (1) tasks to be trained, (2) trainee characteristics, (3) alternative hardware configurations, (4) analogous and new simulation technology, (5) degree of fidelity required, and (6) costs. Usually several alternative device concepts will be developed. As work in this concept formulation period progresses, the designated developers assisted by manufacturers, trainers, users, behavioral scientists and other subject matter experts will produce one or more concepts for cost-effective devices. The proposed devices may be theoretical designs or existing devices. They will be assessed by a preliminary type of cost and training effectiveness analysis (CTEA). U.S. Army Training Support Center's (ATSC) Guide to Training Effectiveness Analysis for Training Devices (1980) defines this CTEA-type study as a Training Development Study (TDS) and requires that a formal study be made and a report written for all devices with medium/high development risk during the concept phase. Based on the TDS, the designated developers, ATSC and PM TRADE, will decide whether to proceed with development of a new device or purchase of

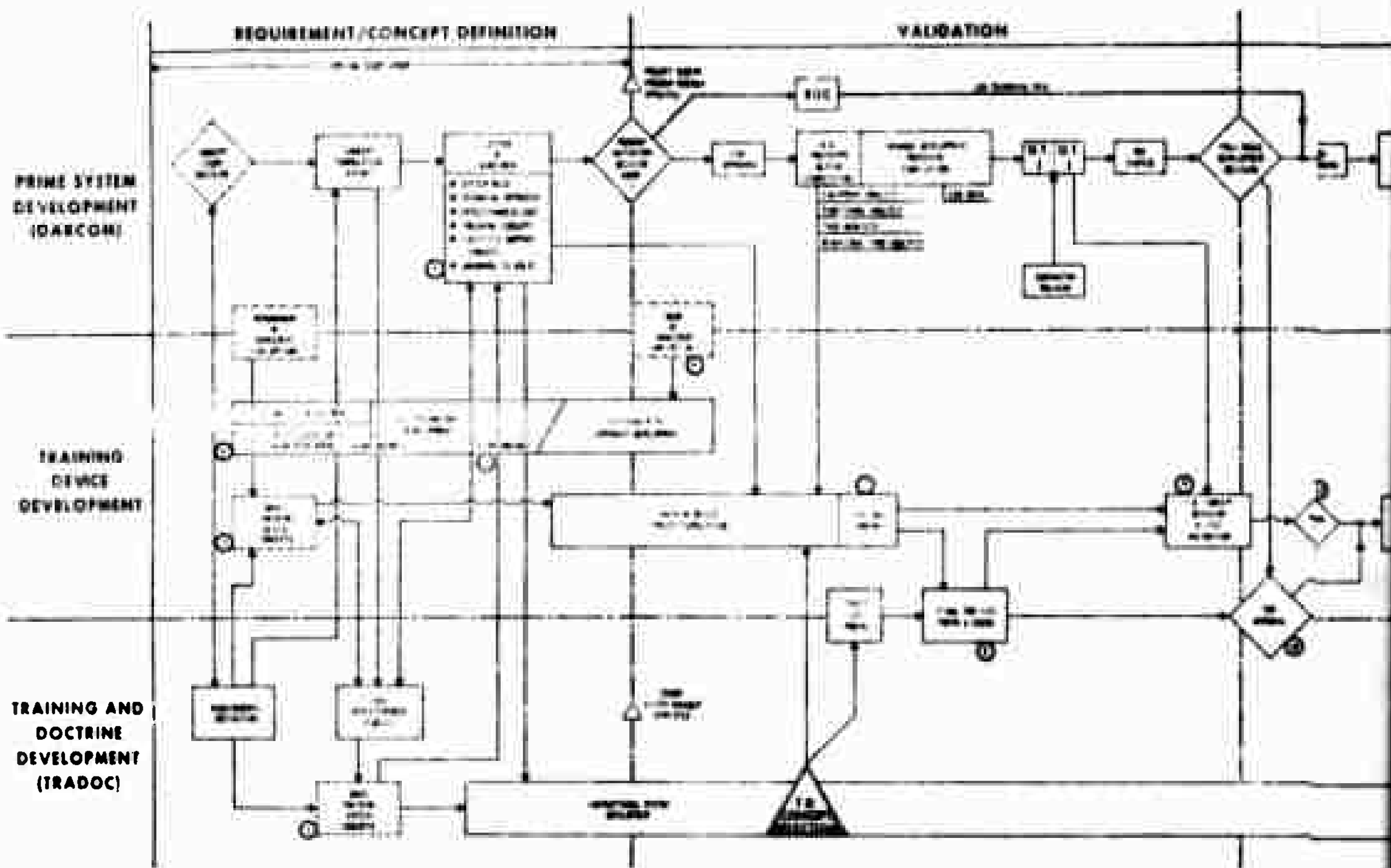
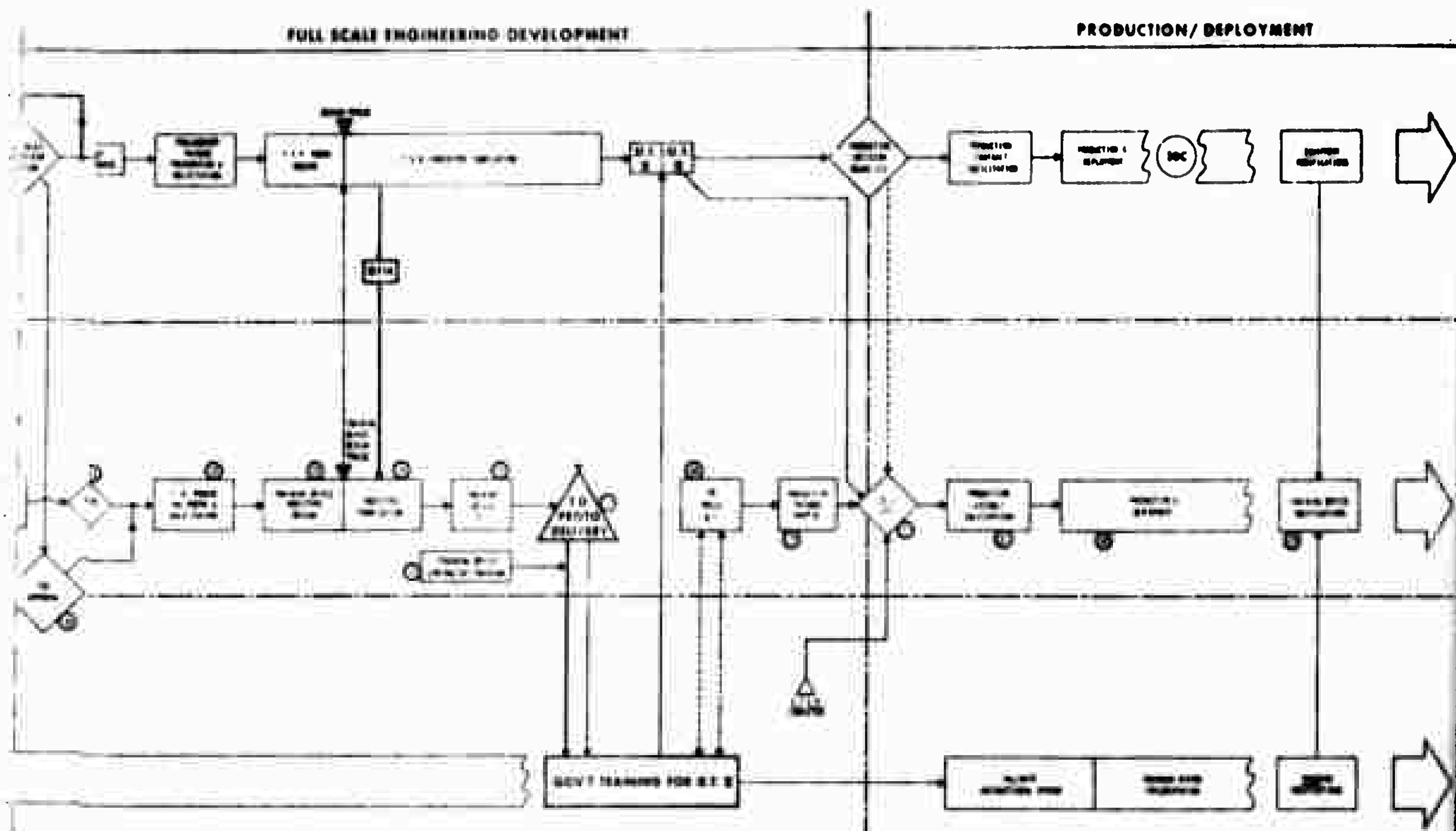


Figure 2.5 Training Device Acquisition Schedule

1 of 2


FULL SCALE ENGINEERING DEVELOPMENT
PRODUCTION/ DEPLOYMENT
GOV'T TRAINING FOR DT II

2/E 2-22

commercially available equipment. If an existing, inexpensive, low risk device exists, the decision probably will be to procure it by issuing a Commercially Available/Fabricated Training Device Requirement (CAFTDR) document. This initiates procurement along the desired time schedule for use. No further development processes are required.

If there is clear-cut evidence to support device specifications and cost and developmental risks are relatively low, a training device acquisition may proceed following preparation of a Training Device Requirement Document (TDR) or Training Device Letter Requirement (TDLR). A preliminary TDS with cost estimates and potential effectiveness assessment accompanies the TDR/TDLR. Following Department of Army approval, DARCOM will fund the device acquisition.

If the preliminary TDS indicates medium to high developmental risk, high cost, unclear choice among alternatives or other substantial unresolved issues, the conceptual phase closes with the preparation of a Training Device Letter of Agreement (TDLOA). A working document, the TDLOA states the issues to be considered in order to validate the device concept before development can take place.

An update TDS is undertaken during the validation phase. It will compare the alternative device concepts or if there is only one concept, it will be compared to a baseline of training without the device. The working group conducting the TDS will evaluate (1) how well critical tasks are taught, (2) the potential for transfer of training to the actual equipment, (3) occurrence of negative training or difficulties in use, and (4) any evidence of poor design of equipment, training program or device. With update of costs included, this update TDS will be annexed to a formal TDR. If the TDR is approved, the device enters the Full Scale Engineering Development (FSED) phase.

During the FSED of the device, the TDR is converted to design specifications and procurement documents, a contractor is selected, and a prototype device is produced. If the device is developed in conjunction with a major system, its design freezes with that of the prime system. Additionally, the prototype must be ready for testing at the time of the prime system OT II (AR 1000-1978). During this phase, the final TDS is made. It includes data from the OT II and addresses the same issues as the previous TDS. At this time, the analysts are able to make the assessment based on empirical measures of effectiveness rather than predictive analytical measures. They are able now to make reliable cost effectiveness determinations. If no adverse or unresolved issues remain, a training device development acceptance in-process review (DEVA IPR) is held. This is the final in-process review; it determines whether full-scale production should take place. If the DEVA IPR is favorable, the device advances to the next phase. This phase is production and deployment. The device is now part of the Army inventory.

Major generic or nonsystem devices and simulators (those at high developmental risk, costing over $3 million and initiated by a TDLOA) follow the general Army LCSMM. CTEA may be necessary only if a training system must be designed to manage the simulator or device and/or a unique training system set up to train personnel to teach, operate, and maintain it. The required COEA of the LCSMM, since they measure cost and effectiveness (in this case training effectiveness), serve both as COEA and CTEA.

When the training device or simulator does not undergo the formal CTEA or COEA process, the training developers usually conduct training developmental studies (TDS) as input to requirements documents for low risk, less expensive devices or as input to training system CTEA and operational system

COEA. A TDS is required (ATSC, 1980; TRADOC Circular 350-4, 1979) before each device development decision point. Each of these TDS requires an assessment of potential device training effectiveness as well as a determination of non-quantifiable benefits and costs. The ATSC Guide (TRADOC, 1980) requires that most TDS predict effectiveness of proposed devices by comparing them with the present methods of training similar tasks. Table 2-6 displays the requirements for conduct of TDS.

Table 2-6 Decision Points Requiring TDS Time-Phased

TDS Type	Life Cycle Phase	Decision/Document Requiring TDS Input
Preliminary	Conceptual	TDLOA (full LCSMM)
	Validation	TDR/TDLR (partial LCSMM)
Update of Preliminary (follows DT I/OT I)	Validation	TDR/TDLR (full LCSMM)
Final (follows DT II/ OT II)	Full Scale Development	DEVA IPR

2.4 Current CTEA Methods and Methodologies*

The major guidance for evaluating training effectiveness is contained in the literature discussed in the preceeding section and such documents as TRADOC Circular 70-1, Training Device Development (1979); TRADOC Regulation 11-8, Cost and Operational Effectiveness Analysis in Materiel Acquistion

*For a complete review of these methods, see Matlick et al., 1980a. Example of their application may be found in Matlick et al., 1980b.

Process; and TRADOC Pamphlet 71-10, Cost and Training Effectiveness Analysis. In addition, a number of CTEA methodologies currently exist, the result of a great deal of research in all the services. They may be categorized as primarily prescriptive--they prescribe suitable training programs analytically where none exist; predictive--they predict the effectiveness of training programs or training program elements analytically; or empirical--they evaluate training programs or program elements using real-world performance data. Usually these methods treat effectiveness and cost as separate modules, combining them in C/E ratios as a final step. Representative models and methods will be discussed in the following paragraphs of this section.

2.4.1 Prescriptive Methods. The first set of methods might be termed prescriptive. They prescribe a training program (or program elements such as media, context, devices) based on task characteristics, earlier analogous systems or other means.

2.4.1.1 Training Effectiveness, Cost Effectiveness Prediction (TECEP). One of the most widely used analytical methods is TECEP, a manual method developed by Braby and his associates and reported in A Technique for Choosing Cost-Effective Instructional Delivery Systems, TAEG Report No. 16 (1975). The Army and Navy ISD use TECEP, and it is also the recommended method in the manual sponsored by PM TRADE (1979). TECEP is designed for use during the conceptual phase for training program development.

The TECEP technique begins with a list of training objectives, classifies those objectives according to the type of learning algorithm required, selects alternative media systems to support those algorithms, estimates the cost of each alternative delivery system, and identifies a cost-effective instructional delivery system. The technique is simple though its developers caution that it is intended for use by experienced training system designers.

TECEP is applied to select instructional delivery systems from training objectives within ISD. Each training objective is matched with one of twelve learning algorithms, accomplished by comparing a task to the various algorithms in terms of action verbs, behavioral attributes, and examples of objectives (Figure 2-6). Once tasks and objectives have been classified and grouped according to the learning algorithms, a table is used to select delivery systems for each group of tasks and objectives. Alternative systems then are analyzed for cost-effectiveness comparisons.

2.4.1.2 Training Efficiency Estimation Model. An Army model based in part on TECEP is the Training Efficiency Estimation Model (TEEM) of Jorgensen and Hoffer (1978), a major portion of which concerns selection of media. This is a potentially highly useful model, since it is also a predictive model of effectiveness, efficiency, and cost-effectiveness.

The measure, the efficiency ratio, represents a value composed of the efficiency score of an estimated program with real world constraints divided by the efficiency score of an idealized program with no constraints. Outputs of this method include a cost-analyzed training program. Input requirements are task list plus sufficient knowledge of the weapon system to permit inferences about the nature of stimuli, responses, and feedback.

The selection of media (training devices and materials) is accomplished by the TEEM computer program in which training devices and materials have been described using the same variables used to describe the tasks. Media with the highest number of matches with tasks become candidates for selection.

The media selection procedure results in stimulus, response, and feedback media for each task. Since an array of media is not supportable in the real

	Characteristics of Training Objectives That Can Be Achieved with Specific Algorithms.		
Names of Learning Algorithms	Action Verb	Behavioral Attributes	Examples
9. Recalling Procedures, Positioning Movement	Activate Adjust Align Assemble Calibrate Disassemble Inspect Operate Service	1. Concerns the chaining or sequencing of events. 2. Includes both the cognitive and motor aspects of equipment setup and operating procedures. 3. Procedural checklists are used frequently as job aids.	1. Recalling equipment assembly and disassembly procedures. 2. Recalling the operation and checkout procedures for a piece of equipment (cockpit checklists). 3. Following equipment turn-on procedures emphasis on motor behavior.

Figure 2-6 Sample of Matching Training Objective Characteristics With a Type of Learning Algorithm (from TAEG Report No. 16). Source: Matlick et al., 1980b, p. III-13.

world, the media set for each functional group of tasks is reduced to a supportable number derived from the matches between task descriptions and media descriptions. The ideal, unconstrained training program establishes the base case against which reduced media sets are compared. By definition, the efficiency of the unconstrained media set is 1.0. All reduced media sets have an efficiency of less than 1.0.

The TEEM computer program eliminates the medium with the lowest number of matches across all tasks from the media set in each matrix (that is, the medium least useful for stimulus presentation, receiving responses, and providing feedback). Iteration of the procedure measures the fit of all tasks with all functions and this measure divided by the measure of the ideal, unconstrained case expresses the efficiency of the reduced media set. The medium in each matrix with the lowest number of matches across all tasks is removed from consideration, and the efficiency of the further reduced media set is calculated. Iterations of the procedure continue until all media have been removed.

Efficiency ratios are plotted against the number of the iteration. This plot shows the iteration where the efficiency begins to drop off steeply and the analyst uses it to select a media set that provides the lowest acceptable efficiency.

Cost are determined by describing media and methods in terms of 37 cost variables, and the cost data are analyzed by the computer program (a variation of the TECEP cost model). Outputs are program costs.

Once costs have been obtained, a decision metric, a cost-effeciency ratio is obtained by dividing the cost by the efficiency value. The analyst chooses alternative methods, calculates their efficiency values and costs, and obtains their cost-effeciency ratios. The analyst could recommend the method with the lowest cost-efficiency ratio (the lowest cost for at least an acceptable efficiency), or might recommend a method with a slightly higher cost-efficiency ratio to obtain a large increase in efficiency at a higher cost.

2.4.1.3 Training Consonance Analysis (TCA). TCA, a modification of TEEM, is another method for estimation of effectiveness. Developed by Hawley and Thomason (1978), the TCA technique compares training alternatives on the basis of task descriptions and the methods and media employed to train the tasks. Unlike TEEM, TCA uses the descriptions to indicate how close the media/method combinations come to the task description; that is, TCA yields an indication of the consonance of the task requirements and the proposed training programs. Hawley and Thomason further modified TEEM by adding the diagnostic concepts training deficiency, training excess, and training redundancy. The definitions of these diagnostics are:

- Training deficiency: A variable in the task description does not occur in the training description.
- Training excess: A variable in the training description does not occur in the task description.
- Training redundancy: A variable in the training description is redundant. This occurs only if two or more training media and/or methodologies are combined in the training description. The variables common to two or more media/methodologies are redundant.

These factors explain the differences in the efficiencies of alternative training programs. The smaller the number of excesses and redundancies, the more efficient a training program is in media and methods.

Training consonance ratios and diagnostics provide a basis for recommendation of a training program and for improving the program. TCA is applicable to estimating alternative devices effectiveness or comparing a training system with a device to a baseline without it. TCA is a computerized model and accommodates a large number of tasks.

2.4.1.4 Training Developers Decision Aid (TDDA). Pieper et al.'s Training Developers Decision Aid, based on TECEP and TEEM, has both manual and computerized forms. It has not been applied widely.

The four functional elements of TDDA are: (1) task description, (2) training prescription, (3) training hierarchy and sequence, and (4) training cost. Tasks are described using specific action verbs and the piece of equipment used. Training is prescribed as to: learning algorithms, stimulus media, response acceptance mechanisms, method of instruction, and learning setting. Training hierarchy is the result of assigning tasks to resident training, on-the-job training or no training, while sequence is the specification of the order in which tasks are to be trained. Relative costs of feasible training alternatives are established through a cost-rating technique.

2.4.1.5 Systems Approach to Training. One of the most rigorous models was developed by Sugarman et al. (1975)--the B-1 Systems Approach to Training (SAT) developed a training program for the air crew of the B-1 strategic bomber. It applied the techniques of systems analysis to instructional system development to assure that the entire training system would be considered within an orderly and complete process. ISD application is rarely as rigorous as in the B-1 SAT study.

B-1 SAT identified training device requirements as part of method and media selection. Guidance for the program prediction and identification of training device requirements was taken from the Navy's Training Effectiveness, Cost Effectiveness Prediction Technique (TECEP) (Braby, Henry, and Morris, 1975), modified to reflect the special requirements of the B-1 SAT.

Media/method selection is an aspect of the structuring and scheduling of courses, tracks, and instructional blocks. The tool employed to this end is the Training Resources Analytic Model, a set of computer programs that examine proposed training system of resources, schedules, and costs.

2.4.1.6 Coordinated Human Resources Technology. In another computerized model, the Advanced Systems Division of the Air Force Human Resources Laboratory (Goclowski et al., 1978a, b, c) combined five technologies in the weapon system acquisition process: (1) Maintenance Manpower Modeling (MMM), (2) ISD, (3) Job Guide Development, (4) System Ownership Costing, and (5) Human Resources in design trade-offs. All five are applied individually during the material acquisition process and have data requirements in common. Therefore, one objective was to integrate and apply the technologies to form a Coordinated Human Resources Technology (CHRT).

Instructional Systems Development (ISD) within CHRT differs from ISD in other contexts; it is coordinated with other human resource technologies and draws its data from a base common to these technologies. It results in training concepts during the concept phase of system acquisition, a training plan during the validation phase, and a fully developed training program during the full scale development phase.

Job Guide Development (JGD) results in products that may substitute for or reduce the need for training. JGD at present appears to be concerned with maintenance tasks, although guides for operational tasks are consistent with the JGD concept.

Impact analysis, the final CHRT activity, is the investigation of the impacts on human resource costs of a variety of system alternatives. CHRT assigns human resources and other systems ownership costs to system design, maintenance, operations, and support alternatives, so that these costs may be considered fully during the early and critical acquisition decisions.

2.4.1.7 Training Requirements Analysis Model. A third computerized Air Force method is the Digital Avionics Information System: Training Requirements Analysis (Czychry et al., 1978). The Training Requirements Analysis Model (TRAMOD) is one of a group of computerized analytical models that make up a life cycle cost model. It is a computerized means for training design, and makes design decisions rather than simply revealing the impacts of decisions already made. TRAMOD selects from an input list the tasks to be trained. It generates a training plan consisting of: a place of training (school or OJT), methods of instruction (simulation, performance, lecture, etc.), and media (simulator, mockup, etc.) Finally, it determines possible schedules. Task input includes values for a number of parameters: (1) criticality, (2) learning difficulty, (3) frequency, (4) psychomotor level, (5) cognitive level, and (6) estimated time required to accomplish training. In the early stages of design of new equipment, data values are obtained from comparable operational equipment.

TRAMOD considers cost but not effectiveness. Given adequate task data, it would appear to be a valuable CTEA method for comparing training alternatives resulting from various constraints (limits on training time, equipment shortages, etc.)

The device-relevant portion of this model is in the module that assigns methods and media. TRAMOD generates a method and medium for each task using standard Air Force ISD media selection. A sample is shown in Figure 2-7. Methods and media are generated for technical training school or on-the-job training contexts.

Figure 2-7 Sample of Air Force ISD Media Selection Matrix

Taxonomic Description	Learning Training Objective	Method/Media
Psychomotor 1 (Imitation) Cognitive 1 (Comprehensive)	Identifications	TTS: Discussion/Transparencies OJT: Informal Lecture/ Transparencies
Psychomotor 2 (Manipulation) Psychomoter 3 (Precision)	Learning Perceptual Discrimination	TTS: Simulation/Training Film OJT: Demonstration/Training Film
Psychomotor 4 (Articulation) Cognitive 2 (Application)	Understanding Principles	TTS: Simulation/Simulator OJT: Performance/Mockups
Cognitive 3 (Analysis) Cognitive 4 (Synthesis)	Learning Procedural Sequence	TTS: Performance/Simulator OJT: Performance/Training Film
Cognitive 5 (Evaluation)	Making Decisions	TTS: Simulation/Simulator OJT: Performance/Training Film
Psychomotor 5 (Naturalization)	Performing Skilled	TTS: Peformance/Simulator OJT: Performance/On-Equipment

Source: Parker and Downs, 1961, p. 35.

2.4.1.8 Summary of Prescriptive Models. Models such as TECEP, TEEM, etc. are typical of the models that prescribe elements of a training system to train a set of well-defined tasks. ISD appears to be the most frequently employed, perhaps because it is so general. TECEP is more specific to the problem of training prescription and also is used widely. TECEP is used as originally designed and as a part of other models such as TEEM and the many spin-offs from TEEM. The refinements of TEEM (TCA, TDDA, ATM) are too new to have been applied. The remaining models, such as the B-1 SAT, have been applied to one or more systems or subsystems in the Navy or Air Force. A recent review of ISD methodologies by Vineberg and Joyner (1979) states that current procedures for selecting media appear adequate if instructional activities have been specified in sufficient detail. Conversely, Fink and Carswell (1980) identified technological gaps in personnel and training and they conclude that media selection techniques in general need considerable improvement. Addressing training devices in particular, they find that methods are lacking that could help decide whether devices are needed at all and for deciding the strategy for using them. Fink and Carswell also state that, "the relationship between stages of learning and training devices requirements has not been fully explored." A review of media selection methods as they pertain to device is yet to be undertaken.

2.4.2 Predictive Models. When a training program or alternative programs have been designed, the concepts must be evaluated to predict their training effectiveness for use in a CTEA. Of the models/methods discussed above, TEEM and TCA predict effectiveness as well as prescribe an effective system. Some other methods are more specific, especially those designed to predict device effectiveness.

2.4.2.1 TRAINVICE I*. Wheaton and his associates have produced the most substantive original body of work in development of a systematic approach to analysis and evaluation of alternative device concepts. Their procedure for this is the TRAINVICE I model. TRAINVICE I can evaluate either existing or theoretical devices and allow comparison of either type or a mixture. The model compares the alternatives by relative training effectiveness and cost effectiveness. The result is a device effectiveness score for each alternative. Five separate analyses are required. These are:

- Task commonality analysis,
- Physical similarity analysis,
- Functional similarity analysis,
- Learning deficit analysis, and
- Training technique assessment.

The basic model is shown in Figure 2-8. This model has been used widely. PM TRADE (1979) includes it in their Training Device Requirements Documents Guide.

Wheaton et al. validated the model in two field studies (August 1976a, b). As further application and use occurred, modifications to TRAINVICE have been proposed.

2.4.2.2 TRAINVICE II. Narva (1979) developed a rationale for a revised TRAINVICE based on experience gained through utilization of the original. The revised TRAINVICE is shown in Figure 2-9. The analyst first assesses the skills trained on the device, whether all requisite coverage occurs, how well they fit the training objectives, and why they are included. Next, the physical and functional characteristics are considered.

*Originally TRAINVICE, known as TRAINVICE I since the development of Narva's TRAINVICE II (1979).

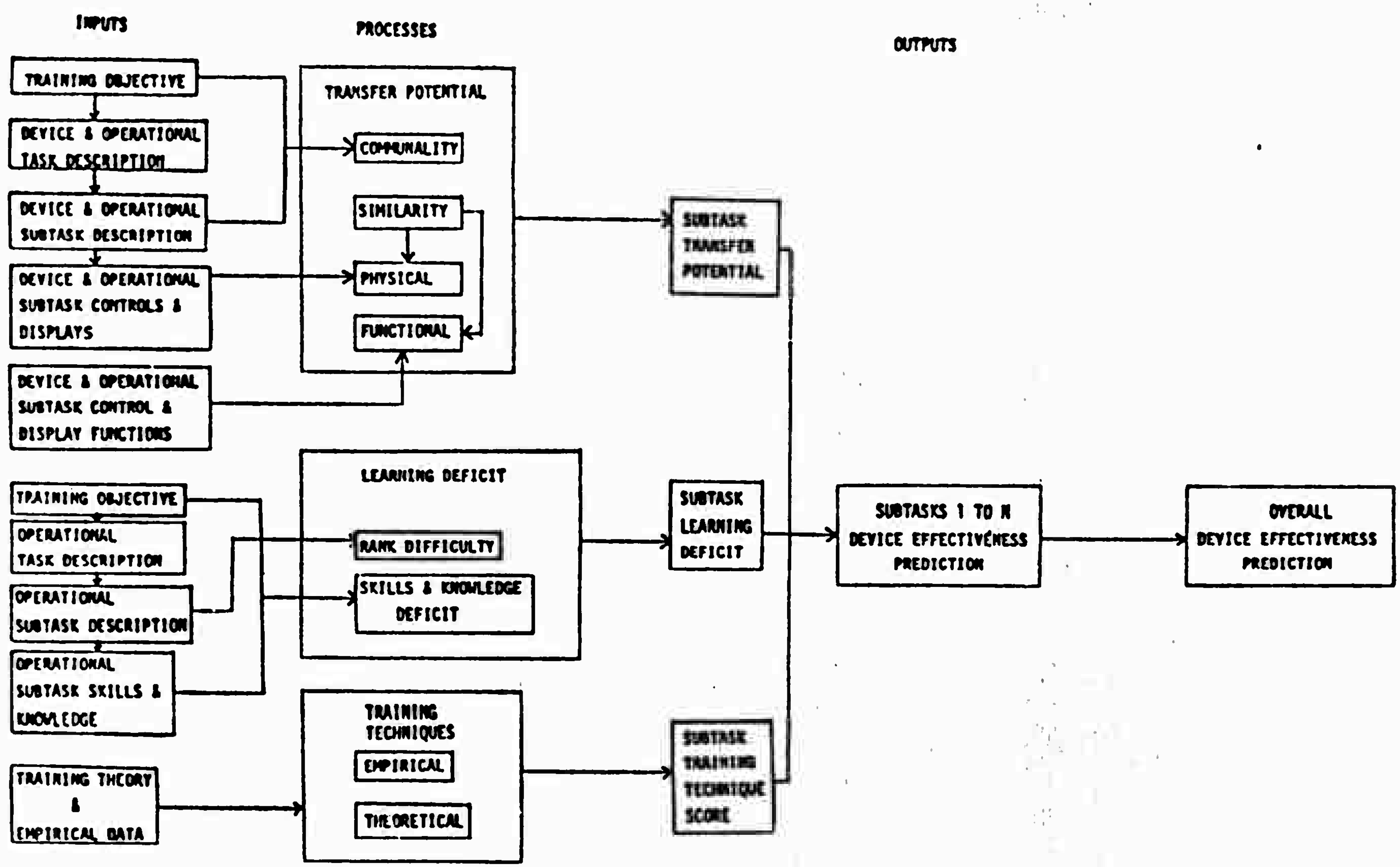


Figure 2-8. The TRAINVICE Model (From Wheaton, et al., 1976b)

Source: Narva, 1979, p. 4.

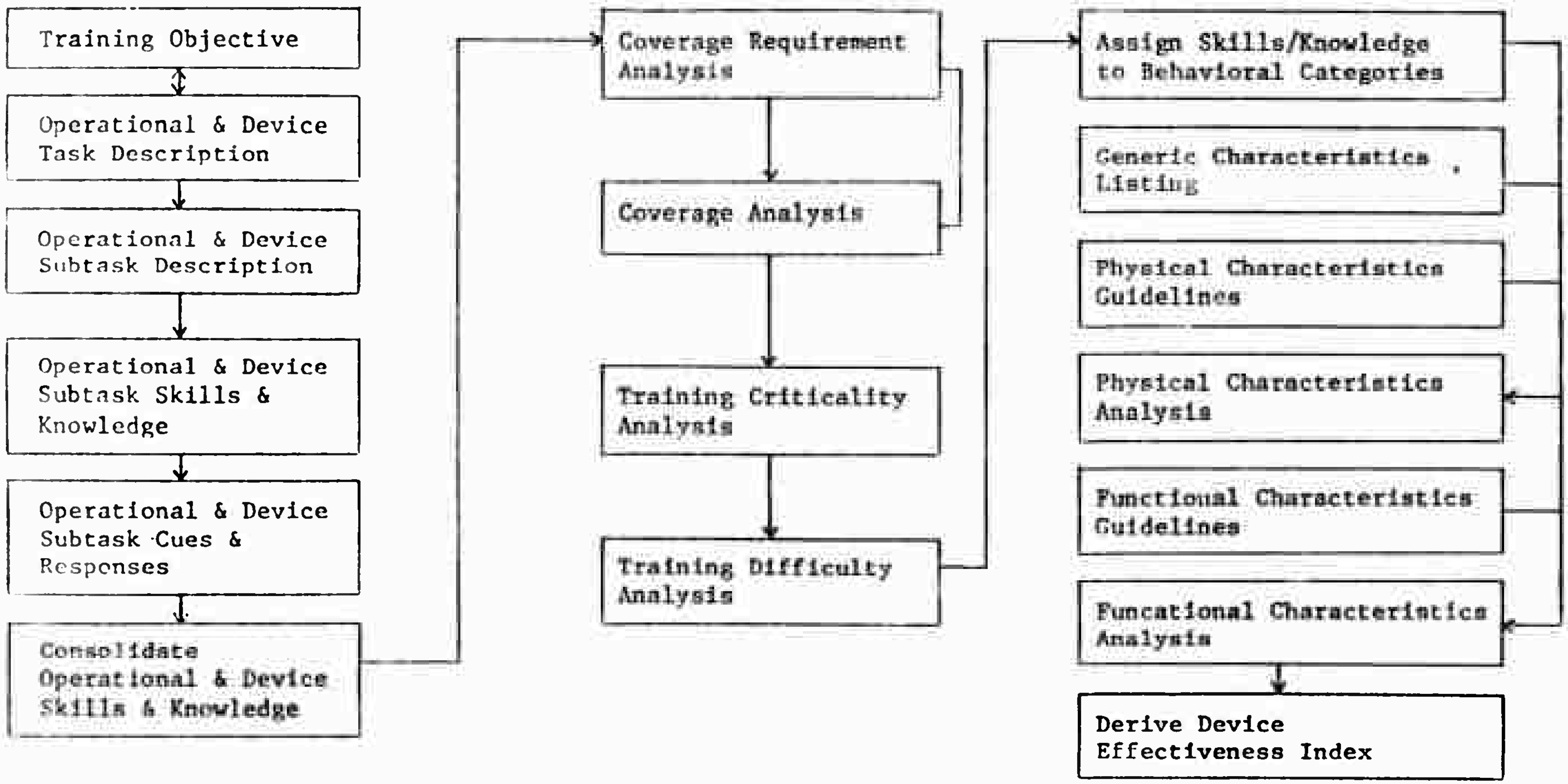


Figure 2-9. The Revised TRAINVICE Model, Narva (1979)

Source: Narva, 1979, p. 6.

These characteristics are used to rate the adequacy of devices to meet ISD/Braby et al. requirements and guidelines. Each skill under consideration is placed into an appropriate behavioral category, and the ISD/Braby matrices discussed earlier are applied. When the entire model has been applied, the result is the derivation of an index of predicted training device effectiveness. The formula for calculating the index follows a procedure discussed by Gagne et al. (1948). The index of the original TRAINVICE was based also on this work. Both indices rate devices overall between 0 and 1, with 1 attained if the device were to follow all guidelines perfectly.

Josefowitz and Kochevar (1980) have extended TRAINVICE to generic trainers. Their effectiveness index is a function of difficulty and criticality score and requires at least two devices since maximum attainable score rather than perfect fit is the yardstick.

2.4.2.3 Analogous Task Method. Two recent methods prescribe training media and predict or estimate their effectiveness by comparing them to similar existing systems. These are the Litton Mellonics' Analogous Task Method (ATM) and the Training Requirements Analysis (TRA) methodology of the Navy's Military Manpower versus Hardware Procurement (HARDMAN) methodology.

The Litton Mellonics ATM (Matlick et al., 1980a, b) begins with a proposed list of tasks for the developing system. Next, tasks of fielded systems that are analogous to the target tasks are identified. The empirical effectiveness data of the analogous tasks (e.g., percent trainees trained to meet criterion, average length of time required to train to meet criterion, scores on performance tests) become the estimates of the effectiveness of the new program to train the matching tasks. ATM also will prescribe and predict complete programs.

2.4.2.4 Training Requirements Analysis (TRA). The TRA (Vaughan, 1979) predicts effectiveness in a way similar to ATM. First, an estimated training system is designed by a skilled training developer. A procedure similar to ISD, but resulting in less detailed products, is used. Simulators and devices are a principal item considered in media selection. This estimated system is called the baseline, and its effectiveness is predicted subjectively.

Second, a reference training system is selected. Its function is to serve as a data source for the baseline through extrapolation. The reference training system may be an existing similar system, portions of an existing similar system, or related training system data gleaned from the literature. Data to be acquired from the reference systems are specific (e.g., executed student performance by task). TRA assesses probability of success with a variation of a technique known as fault-tree analysis. This technique provides an indication of the most likely points of failure which could occur in any system. The analyst performs a step-by-step description of the various combinations of occurrences within the system design which could result in failure. A further benefit of the technique is that it depicts the probable failure event sequence which can lead to failure of a key learning outcome.

On completion of the fault-tree analysis, formulas are used to determine the strategic paths leading to the desired events. Through a summation process, the probability of success of a given design may be predicted. The overall value of this technique is that it indicates the weakest point in the design as well as the comparative success probabilities of alternative designs.

2.4.3 Empirical Methods. Empirical measures of training effectiveness, along with methods and models of effectiveness analysis that require reliable real-world data, are used to assess and compare device and simulator effectiveness after they exist as manufactured hardware. This may be in the form of prototypes, initial production run equipment, or equipment that has been operational and in the inventory for many years.

The agency with responsibility for testing at this stage is the U.S. Army Operation Test and Evaluation Agency (OTEA). OTEA may specify that a school, user, or contractor will conduct requisite tests under their oversight. The OTEA operational test cycle model is shown in Figure 2-10. Their basic test designing process consists of three elements:

(1) Development of Test Conditions

- Listing influencing factors and conditions,
- Combining related conditions,
- Structuring subtests, and
- Determining number of trials required;

(2) Development of Data Requirement

- Derivation of measures,
- Selection of measures, and
- Statement of measures; and

(3) Development of Analysis Logic

- Required assumptions,
- Comparisons planned,
- Statistical and numerical tools, and
- Non-numerical analysis.

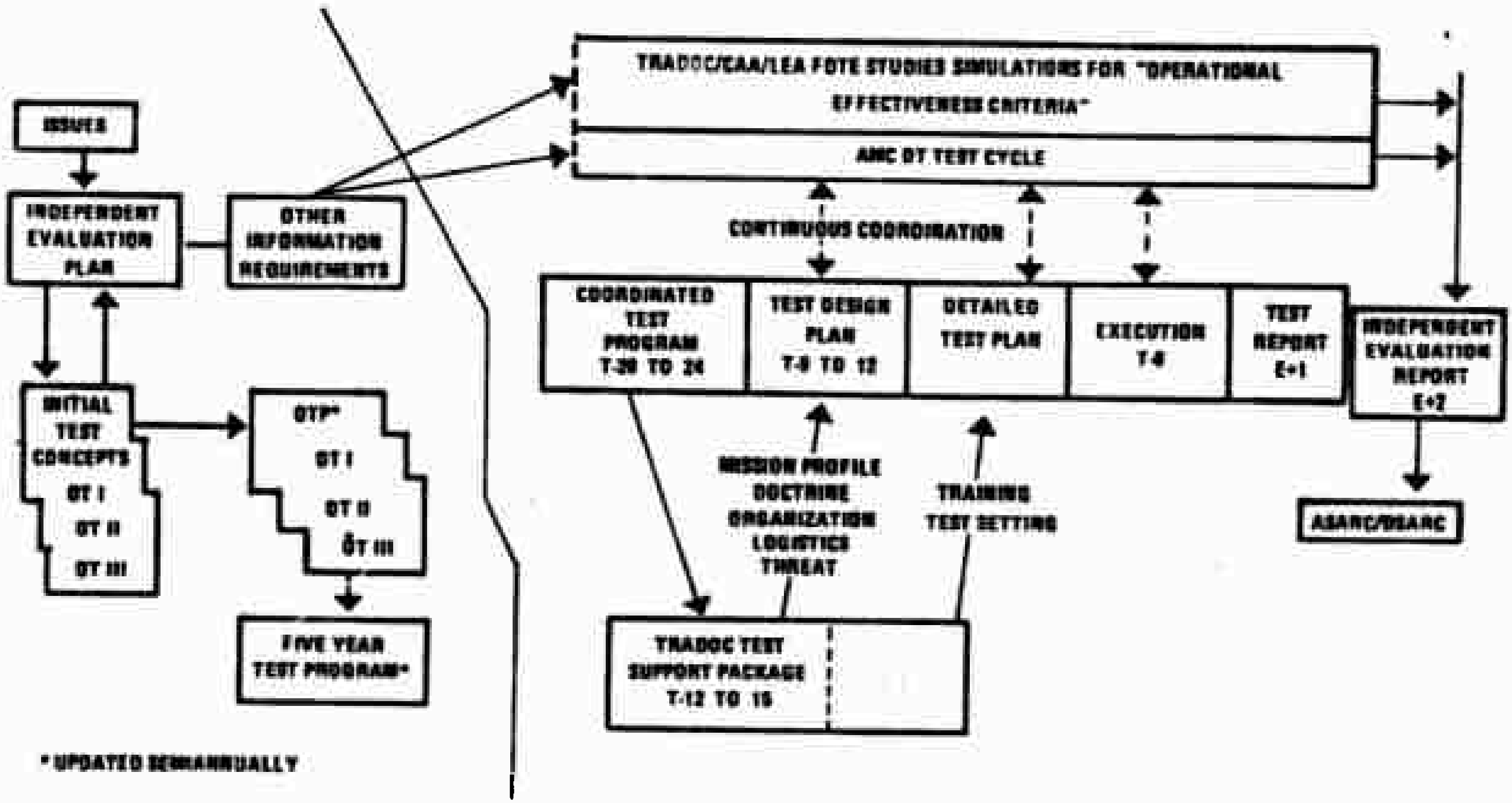


Figure 2-10. Operational Test Cycle Model

Source: OTEA, 1976.

From this design process emerges the test concept, which should be as comprehensive and rigorous as time, manpower, and funds permit. The process is described in Operational Test and Evaluation Methodology Guide (U.S. Army OTEA, 1976).

Finley and Strasel (1978) have defined effectiveness training testing for devices into categories that are useful when looking at training systems as a whole. During the developmental phase there are two types: (1) verification testing and (2) system implementation testing. Verification testing is defined as testing sufficient to demonstrate and verify that the training device as actually developed--hardware--fulfills the training requirement and specification with respect to training effectiveness. They define system implementation testing as testing sufficient to determine how to best integrate the training device into the training program (POI).

Verification testing takes place during the device OT I or II and, if there is a parent system, in conjunction with its OT II. This testing determines if the actual device as hardware is as effective as predicted. By this time, the training developers should have prepared the Programs of Instruction (POI), identified representatives of the target population to serve as trainees, and developed standards and criteria for performance and training effectiveness assessment.

System implementation testing, the second type of test yielding empirical data, takes place after the device is fielded. It is usually performed by the user as Force Development Testing and Experimentation (FDTE) under Army Regulation 71-3, and TRADOC Regulation 71-9. The purpose of system implementation testing is to: (1) determine the optimal use of the device in actual system training, (2) asses whether this is being accomplished, (3) measure the deficiency (if any), (4) cover the reasons for less than planned usage, and (5) suggest measures to achieve optimal use.

During this type test, the test agency should investigate various ways to integrate the device into institutional and unit training considering the primary system requirements as well as other constraints. To be fully effective, system implementation testing requires an evaluation of alternative uses contexts, and sequences. CTEA methods applicable to fielded systems, such as Matlick et al. (1980a) and Sassone (1979) can be used.

Guidance for planning, conducting, and documenting Training Effectiveness Analysis (TEA) studies is found in the TRADOC TEA Handbook (Draft, 1980). The section of Training Developments Studies (TDS) is particularly applicable to devices.

The success of all effectiveness testing rests on well-designed experiments, good criteria that can be measured accurately, and models of conditions.

2.4.4 Litton Mellonics CTEA Methodology. The proliferation of models and methods for CTEA has created a body of work that is extensive and bewildering. Analysts charged with conduct of CTEA now require systematic classification and evaluation of the methods.

Work in this direction has been completed recently for the ARI Field Unit at Fort Bliss, Texas, by Matlick and Associates (1980a, b).

The objective of this research was to provide Army analysts with a performance guide for CTEA at each appropriate stage of the LCSMM. The attainment of this objective required:

- Determination of points in the LCSMM at which CTEA are needed.
- Assessment of the utility of existing methods for CTEA at each point.

- Adaptation of methods to each LCSMM point where CTEA are needed.
- Development of methods for areas that existing ones do not cover or cover inadequately.
- Identification of input information required and available at each point.
- Estimation of the impacts of missing or degraded information on the CTEA.
- Synthesis of a general model for CTEA in the LCSMM.
- Production of a CTEA Production Guide for Army analysts.

Examination of the CTEA analytical requirements and current methods, methodologies and CTEA reports showed that the analysts required the following: (1) a task list, (2) alternative training programs, (3) comparable effectiveness data for each alternative, and (4) cost data for each alternative.

Matlick et al. devised a logical model to guide the analyst in assessing the data situation (Figure 2-11). The model leads the analyst through questions concerning the availability of task lists, training programs (including alternative programs), training effectiveness estimates, cost analyses, cost effectiveness comparisons, and issues to be resolved. Depending upon the data situation, the analyst needs a different set of CTEA processes.

None of the CTEA methods unearthed during the research provided all information required for decisions at any point in the LCSMM. However, detailed examination of the techniques, steps, or processes within the methods (i.e., the elements from which the methods are built) showed that each method contributed to the CTEA job to be performed. Some methods contributed more elements within some data situations than others. For example, informal, expert-judgment methods in current use generate task lists if none are avail-

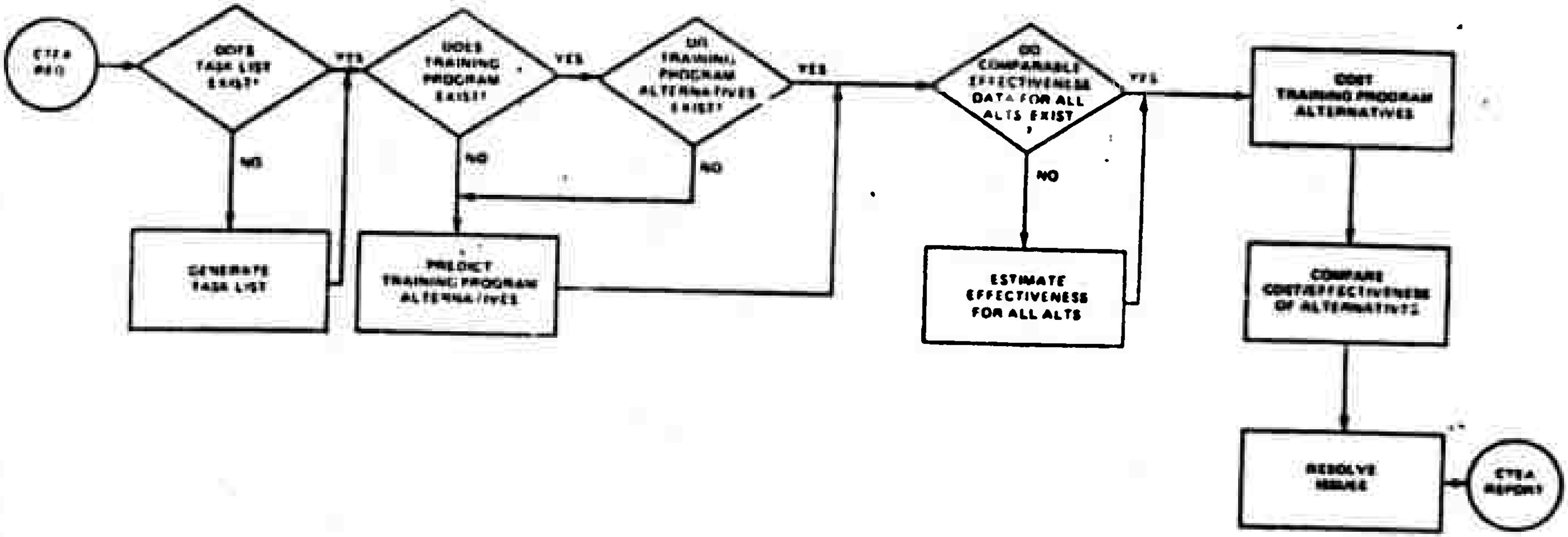


Figure 2-11. General CTEA Model

Source: Matlick et. al. 1980a, P. V-2

able. Formal analytic models for prediction of training programs, however, are superior to the judgmental models if task lists already exist. General methodologies (e.g., TRASANA, 1980) are likely to describe what should be done without telling the analysts how to do it. For example, they are advised to begin with a task list but not where to obtain the information and how to compile the task list if none is available from the tasking organization or manufacturer of the operational system.

Therefore, the Litton research team designed strategies to guide the selection of the processes and to conduct the CTEA. The strategies correspond roughly to the most common input data situations at which the analyst starts the CTEA. These were found to be:

(1) No task list and no training program.

(2) Task list but no training program.

(3) Training program but no alternatives and no effectiveness data.

(4) Training program with effectiveness data but no alternatives.

(5) Alternative training programs but no effectiveness data for all alternatives.

(6) Training program alternatives and effectiveness data for all alternatives.

Extant CTEA methodology contained three weaknesses. First, use of historical data was hampered by inadequate definition of analogous tasks (i.e., tasks in a fielded system functionally and behaviorally similar to tasks in the proposed system). Second, the existing methodology did not thoroughly address the issue of trainability, one of the estimations needed in the LCSMM. Third, the most thorough cost analysis model omitted costs of training in units.

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Methods were devised to fill these methodological gaps. Methods adequate to perform the other required processes already existed in the Army community. Those recommended as process guides are:

- Training Efficiency Estimation Model (TEEM), Jorgensen and Hoffer, 1978.
- Training Consonance Analysis (TCA), Hawley and Thomason, 1978.
- Training Effectiveness, Cost Effectiveness Prediction (TECEP), also known as TAEG No. 16, Braby et al., 1975.
- Army CTEA Methods in current use: (1) DIVAD Gun CTEA, (2) Improved Hawk (HAWK PIP) Training Development, (3) Roland Training Development, (4) Improved TOW Vehicle (ITV) CTEA, and (5) Methods for the Analysis of Training Devices and Simulators (TRAINVICE I).

Most of these are described in other sections of this review. Table 2-7 shows the processes by data input requirement type.

2.4.5 Definitions of Effectiveness in CTEA. It is not always clear what is implied by the term 'training effectiveness'. Most studies documenting effectiveness research have defined the term but since each one treats the subject from a unique perspective, definitions are varied. Hawley and Thomason (1977) defined it as follows:

> Training effectiveness is defined as the degree to which soldiers or units trained using a specified training system can attain or exceed mission-related performance objectives on performance-oriented criterion tests requiring application of the skills addressed by the training system.

Jorgensen and Hoffer relate it to change in performance:

> Effectiveness is defined as the change in performance from a pre-instruction level to a post-instruction criterion.

The failure to use job performance to validate training was noted by Orlansky and String (1979). They state:

TABLE 2-7. CTEA Processes and Candidate Methods

GENERATION OF TASK LIST	PREDICTION OF TRAINING PROGRAMS	ESTIMATION OF EFFECTIVENESS	COST OF TRAINING PROGRAMS	COMPARISON OF TRAINING PROGRAM ALTERNATIVES	RESOLUTION OF ISSUES
DIVAD GUN HAWK PIP ROLAND	TEEM TECEP DIVAD GUN ATM	TEEM DIVAD GUN ATM TRAINVICE TCA	LITTON COST MODEL	TEEM TCA BDM/CARAF DIVAD GUN DRIMS ATM TECEP	ITV DRIMS TRAINABILITY ANALYSIS

Source: Matlick et al., 1980a, p. V-5

> ...the effectiveness of alternative methods of instruction must be evaluated by comparing how well personnel, ...perform in operational units.

In the case of devices (and perhaps by extension to media), the basic definition is that of Gagne' (1962) who said:

> When one inquires about the effectiveness of a device for training, one is really asking about transfer of learning to some criterion.

Thus, rationale for use of training devices rests on the body of transfer of training research.

The lowest criterion for the effectiveness of training is whether it does indeed train personnel on tasks it was designed to train. This may be determined by empirical measurement when operational and training systems, devices, or prototypes exist; or it may be predicted at early stages. If tasks it was designed to train are trained, then effectiveness in relation to alternative designs and the operational equipment (hands-on or on-the-job training) may be evaluated along other dimensions.

Measures of effectiveness of devices derive from such a definition as that of Wheaton et al. (p. 80, 1976), paraphased as follows:

> An effective training device is one which teaches the appropriate behaviors in an efficient manner. To satisfy military requirements, it may be well to modify this definition to include both the achievement of task standards and the constraint of reasonable cost. Thus, a cost-effective device is one which teaches the appropriate behavior to standards, efficiently and at reasonable cost.

It should be noted that, in order to minimize error, the familiar device concepts of transfer of training and of similarity or fidelity are not included in this definition. First, it implies that a training device is a teaching machine rather than a substitute work environment and that, therefore, the learning rather than the end performance is the primary concern. Second, if the appropriate learning does take place, there will be transfer of training; that is, the appropriate performance will also take place. Finally, similarity (physical, functional, and psychological fidelity) only usually, not always, provides for transfer of training and thus for appropriate performance.

Hall, Rankin, and Aagard (1976), examining specific problems affecting Navy training evaluation programs, distinguished between training effectiveness and job performance as follows:

> ...training effectiveness is used exclusively to refer to (measures of) the degree to which a training course or system achieves the goal established for it. ...job performance is both a measure of effectiveness and validity. Achievement of course objectives is a measure of effectiveness and <u>may</u> be a measure of validity to the extent that it is correlated with performance.

2.4.6 Costing as a Part of CTEA Methodology*

2.4.6.1 Introduction. Costing of alternative and/or recommended training systems for weapon systems is an integral part of the CTEA process. Maximum effectiveness and benefit must often be sacrificed by decision-makers because of excessive cost. This is the basis for inclusion of cost in every CTEA. In most CTEA, alternative systems are developed on the basis of predicted effectiveness, a comparison with an identified baseline made, and costs are the last consideration before a final selection is made. This is probably the result of the greater involvement of training specialists in development of CTEA methodology than of cost analyses.

*For abstracts of the methods of costing in CTEA methods and methodologies discussed in this report, see Matlick et al., 1980a, Appendix B.

Another problem exists in the costing approach. As pointed out in Department of Army Pamphlet 11-5, costing may be done using either a top-down or a bottom-up approach (Figure 2-9). Both are valid approaches, serve different ends, and derive component costs differently. Department of Army Pamphlet 11-5 states that there is a need to establish a structure that preserves and interfaces the two approaches.

All CTEA cost methodology must be set within and related to the requirements of the LCSMM. In order to understand the CTEA costing and the framework in which it sets, an examination of the Army Life Cycle Cost (LCC) matrix is required.

2.4.6.2 <u>The Army Life Cycle Cost Matrix (LCCM)</u>. The LCCM gives the approved cost element structure by appropriation and LCC category. This particular structure is designed to capture and display all costs in the life of a major weapon system and its components. Training cost is included and defined specifically in this model. It is comprised of:

(1) Cost of designing equipment and training and cost of purchasing training material in the Research, Development, Training, and Evaluation (RDT&E) phase,

(2) Initial training of operators, quantity purchase of equipment and spare parts, and investment in facilities in the investment or non-recurring cost phases, and

(3) Training to replace personnel lost to the Army and training ammunition and missiles in the operational phase.

A third problem is one of focus--the analyst specializing in one area is not always able to isolate and aggregate all relevant costs. Training is an outstanding example of such an area. A CTEA analyst who wishes to make a complete life cycle costing of training must have such data as ammunition and POL that the weapon system cost analyst may be costing in other ways and in other categories.

Interface, therefore, becomes a problem. This was recognized by Hawley and Thomason (1978) who recommended more definitive work be done on the cost models used for CTEA to make their input/output compatible with the Army's accounting system.

The TRADOC TEA Handbook (TRASANA, 1980) also sets costs within the framework of the LCSMM. Costs are to be estimated in the early stages and predicted as accurately as possible for input to the final COEA. LCC Estimates (LCCE) are mandated specifically for a list of instructional and unit categories. Unfortunately, a large number of CTEA methodologies were developed, and many CTEA (of sorts) were conducted before this handbook was published (it is still in draft).

2.4.6.3 Cost Models From CTEA. Since time constrains the analysts charged with conducting CTEA, a number of methodologies have been designed. Unique cost models are seldom a feature of these efforts. Usually, existing training cost models (LCC or other) have been found that include all the elements believed required for costing training systems. These have been added and/or adapted to a variety of methods designed to select training for the tasks and assessing the effectiveness of that training.

Obviously, a unique and complete costing effort for each CTEA would be the best approach. Since time and money are not usually available for this, good standard methodologies and models must be employed.

The more complete these are, the less danger there is of the CTEA team omitting an important element. This also is the rationale for cost analysts to work closely with training designers and evaluators. It prevents gaps in data required for the system COEA.

CTEA methodologies and other related studies examined show two approaches. They may be termed either comparative or comprehensive. In the comparative cost approach, only those areas where alternatives may be expected to differ are costed. For example, in designing training for pilots, training hours in a simulator and in the aircraft will be compared on the basis of operational costs--fuel, maintenance, etc. Elements such as number of classroom hours, preceding both simulator and aircraft training will be found the same, and excluded from consideration. This approach is the method of choice for CTEA conducted early in the acquisition process. It can identify cost drivers in a training system and eliminate enough alternatives to narrow the field to the most promising few on the basis of excessive cost. This can work also in reverse. If all training alternatives are estimated to be of approximately equal cost, that consideration can be secondary and time and manpower concentrated on other assessment areas.

The second approach is one of total or LCC. This is a highly skilled effort requiring experienced analysts. In LCC, it is necessary to attempt to capture all the costs that can be identified, subjecting them to such factors as discounting, inflation, etc.

Because of the uncertainties of costing future years in an inflationary economy, one research group, Pieper et al. (1978), devised a method of cost classes and rankings to employ cost in a cost-effectiveness assessment without time-consuming gathering and conversion of dollar estimates.

Alternative training systems usually are costed on the basis of facilities, personnel, equipment (including media and devices) and supplies (including ammunition). The institutional setting usually is chosen; occasionally the unit. On-the-job training costing is rare, although a number of good models for deriving OJT costs exist and could be added to the cost models in use as a variant of unit training. (The distinction between OJT and unit individual training in this context is that OJT trainees have had no prior institutional training in their MOS. The others have had some tasks trained in the schools and others in their first unit assignment.)

Table 2-8, displays a comparison of CTEA costing methods found in the documents reviewed.

2.5 Reports of Cost and Effectiveness Assessments

A third category of documents is relevant to the subject of training cost and effectiveness evaluation. These are the reports of various assessments conducted on training of fielded and developing systems and training devices. This very extensive category has been sampled for this review (Table 2-9). Such a review provides insight necessary to understand the TEA and CTEA process as it is currently used as well as its strengths and weaknesses.

During the last decade emphasis on CTEA has increased, the Department of Defense and Department of Army directions and guidance have evolved, and, as may be expected, the resulting mode of assessment has changed. Each study works from a unique perspective. The analysts have undertaken Cost Effectiveness (C/E) Analysis, Cost and Operational Effectiveness (COEA), Cost and Training Analysis (CTEA), Weapon System Training/Training System Effectiveness Analysis/Assessment (WSTEA, TSEA) and documented their work under these and many other variant nomenclatures. Work has taken place at all the different stages of the LCSMM. Sometimes, the effort has been fully supported and iterated as required; other work was accomplished with little allotted resources and time. Therefore, this body of literature does not lend itself to

Table 2-8. A Comparison of Cost Models Used For CTEA

	Cost By Task?	Cost by Training Programs?	Interface LCSMM ?	Cost Expression	LCC	Comparison of Activities?	Years Costed/ Cycle	Inflation Factors Inc.?	Discount Factors Applied?	Residual Assets Cons?	Computerized ?
TRASANA TLA Handbook	NO	YES	UNK	$	YES	YES	INDEF	UNK	UNK	UNK	NO
TRAM (SAT, B-1) (Ring et al., 1975)	NO	YES	YES	$	YES	YES	10	YES	YES	UNK	YES
TAEG #16 (Braby et al., 1975)	POSSIBLE	YES	NO	$	YES	YES	20	UNK	YES	YES	YES
BDM (Vector Research, Inc. 1976)	NO	NO	NO	$	YES	YES	INDEF	NO	NO	NO	NO
MODIA (Carpenter-Huffman, 1977)	NO	YES	NO	$	NO	YES	5	NO	NO	YES	YES
DAIS/TRAMOD (Czuchry et al., 1978)	YES	YES	NO	$	YES	YES	INDEF	UNK	UNK	UNK	YES
CHET (Goclowski et al., 1978)	YES	YES	NO	$	YES	YES	INDEF	NO	NO	NO	YES
TDDA (Pieper et al., 1978)	YES	YES	NO	RATIO	YES	YES	INDEF	NO	NO	NO	YES
CTEA METHODOLOGY (Hawley & Thomason, 1978)	POSSIBLE	YES	NO	$	YES	YES	20	UNK	YES	YES	YES
Prediction of Training Programs, CTEA setting (Jorgenson & Hoffer, 1978)	POSSIBLE	YES	NO	$	YES	YES	20	UNK	YES	YES	YES
Litton CTEA Guidebook (Matlick et al., 1980b)	YES	YES	NO	$	POSSIBLE	YES	INDEF	NO	YES	YES	NO

Table 2-9. Training Cost and/or Effectiveness Assessments Reviewed

AN/TSQ-73
Attack Helicopter-1 Flight and Weapons Simulator
BT 33
DIVAD Gun
Diagnostic Rifle Marksmanship Simulator
F-16 Avionics Intermediate Shop Training Program
Firefinder
Flight Simulators
Ground/Vehicular Laser Locator Disignator
Improved Tow Vehicle
LAW
Light Weight Company Mortar System
M16A1 Basic Rifle Marksmanship Training Program
M60 Firetrainers
AF Photography Course
REDEYE
Remoted Target System Non-System Training Device
Simulator for Air-to-Air Combat
Stand-off Target Acquisition Surveillance System
STINGER
TEC
XM1 System Training Device

generalization. It is, however, of great value to the analyst who may be searching for examples, models or baseline data.

WSTEA are probably the best source of good quality, empirically derived baseline data. The REDEYE WSTEA (TRASANA, 1977) and TSEA (TRASANA, 1978) illustrate this. These two studies contain data on training, job performance, attitudes, cost, retention of training, soldiers' characteristics, distribution of weapons, operators and maintainers, several simulators, and other variables as they pertain to the REDEYE weapon system in the Active Army, Army Reserve Components, and Marine Corps. Among the objectives of these studies was the provision of baseline data for the follow-on air defense system--the STINGER.

Highly relevant was the finding that 70% of soldiers could not memorize a training aid called the Range Ring Profile (RRP). A more complex RRP had been planned for the STINGER. Looking at another useful category of literature, DT/OT Test Design Plans (TDP), we find only one issue addressing training in the STINGER TDP (OTEA, 1976). This issue is:

> Is the proposed training package adequate to allow the STINGER section to successfully accomplish assigned tasks?

Because of REDEYE WSTEA/TSEA findings, STINGER training plans were modified and the RRP simplified to allow a positive response on this issue.

The early CTEA were mostly likely to be short and address certain specific questions. They did no follow-up CTEA models or methodologies. Such recent CTEA as ROLAND (TRANSANA, 1979), Ground/Vehicular Laser Locator Designator (G/VLLD) (BDM, 1976-1979), and the Stand-off Target Acquisition Surveillance System (SOTAS) (ARINC, 1977) are examples of complete CTEA and serve as excellent models. SOTAS, a CTEA conducted as input for the final system COEA, is typical. Figure 2-12 displays the methodology.

The SOTAS effectiveness model is shown in Figure 2-13. The study team

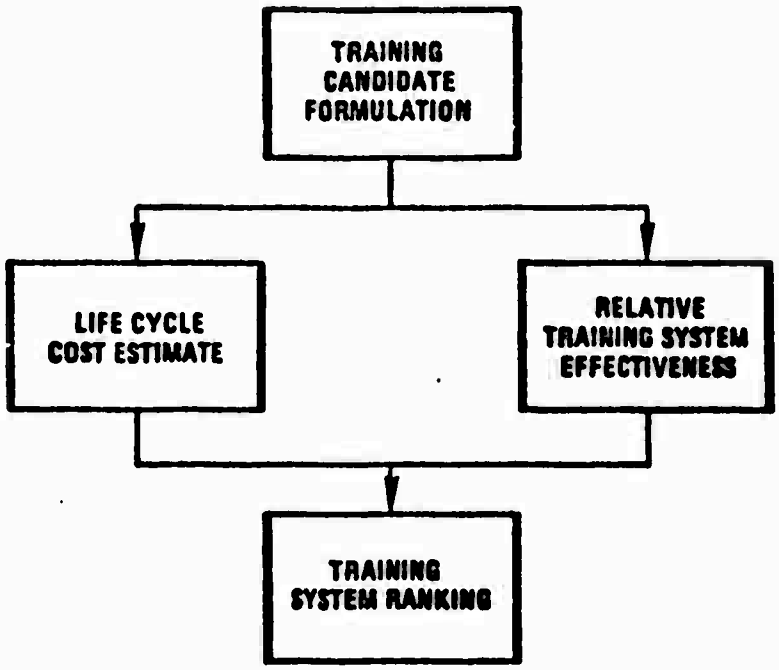

Figure 2-12 Overview of Methodology for SOTAS CTEA

Source: ARINC (1977) p.A-5

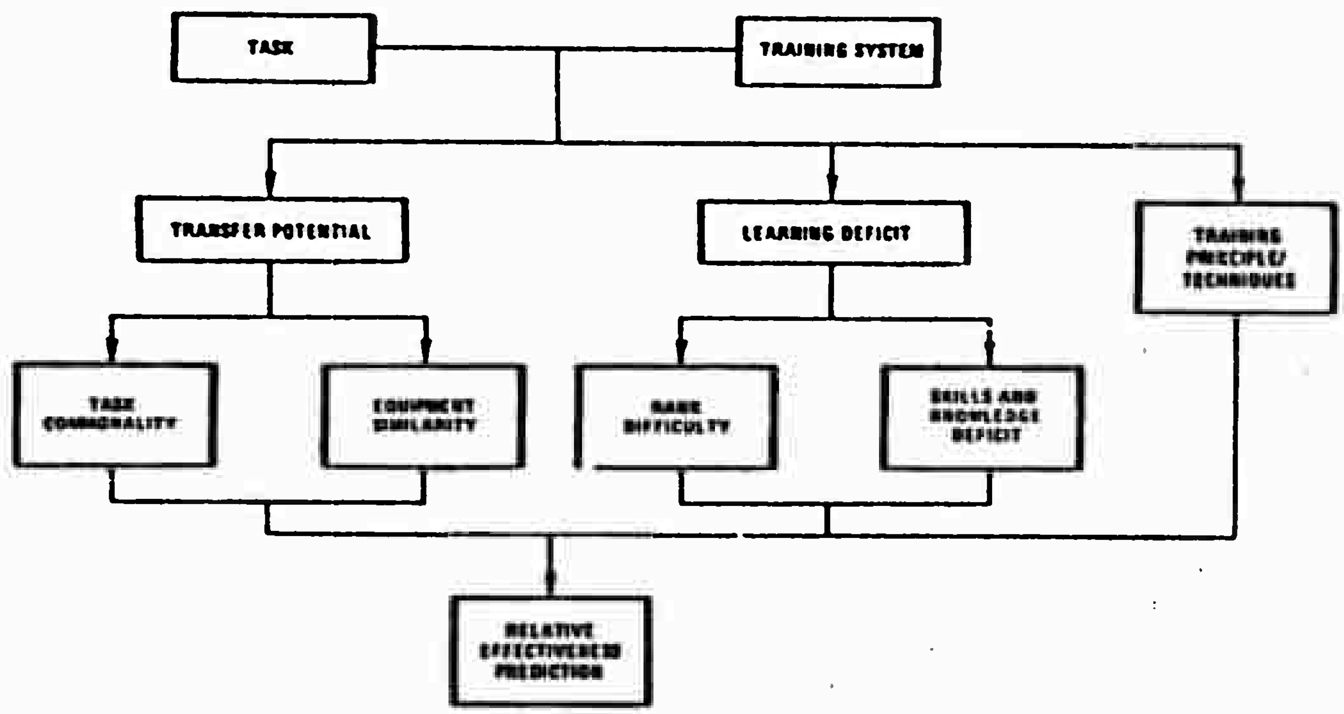

Figure 2-13 SOTAS CTEA Effectiveness Model

Source: ARINC (1977), p. A-9.

used an adaptation of the Braby approach (TAEG 16 and TAEG 23) for formulating candidate training systems (Figure 2-14). They note that a derivation of this method has been used by the Army Research Institute in the CTEA for the AN/TSQ-73 Missile Minder (prototype TEEM). The technique involves separate analysis of the tasks to be learned and the applicable and available training delivery media (TAEG 23 Guidelines). Results of these two analyses are then combined and grouped to produce separate training system candidates. The relative effectiveness of the candidate systems is assessed using a modification of the cost model that was developed by Braby (1975) and a 20-year life cycle was costed. Using these combined techniques, the SOTAS study group developed training system candidates, predicted their effectiveness, and ranked them through an evaluation of the results of life cycle cost and relative training effectiveness analyses and qualitative considerations (e.g., Army/school doctrine, training device maintenance support, in-field refresher training support).

Training device and simulator COEA and CTEA are more numerous and precise than operational systems reports to date. This is in part due to the well-developed regulations, directives and guidance pertaining to the device/simulator acquisition process. Historically, heaviest device use has been in the various flight simulators. A comprehensive review of flight simulator C/E research through the Mid-70's was conducted by Orlansky and String (1978). They compared effectiveness among studies using a transfer effectiveness ratio (TER) developed by Provenmire and Roscoe (1973). The TER has wide potential for assessment of any device or training media that substitutes (at least in part) for operational equipment. TER compares the amount of flight time saved to amount of time spent in the simulator to reach comparable levels of performance efficiency.

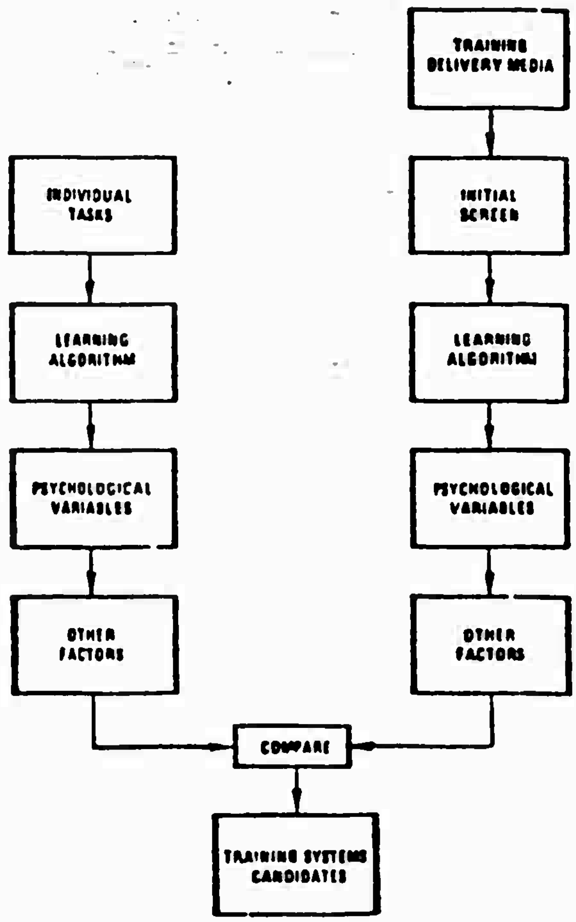

Figure 2-14. SOTAS Methodology Candidate Formulation

Source: ARINC (1977), p. A-6.

The issue of simulator or training element utilization is receiving more attention in TEA and CTEA. A training device or medium may provide satisfactory transfer of training but if it is not used, or is little used, it will not be cost effective. This is especially true if device/ medium acquisition and/or operating costs are also high. A method for assessing CE with various levels of utilization was employed in the AH-1 Flight Simulator (AH-1 FS) CTEA (U.S. Army Aviation Center, 1979) (USAAC). USAAC found that saving will result if current plans to integrate the AH-1 FS into POI take place. These savings are highly dependent upon amount of flight simulator time per student. A further complication is the known requirement for simulator maintenance downtime. Therefore, the AH-1FS study group developed a series of curves (one for each of six training sites) that related operating and support costs per hour to training hours per year based upon a range of percents of time that the simulator might be available.

Missing data are compensated for in several studies. BDM (1980) in assessing the G/VLLD Trainer found that empirical data were poor and neither time nor money was available to collect more. They were tasked with deciding whether a device was required for institutional/unit training and whether the prototype trainer was adequate. Using analytical methods, TRAINVICE I (Wheaton et al., 1977) and TRAINVICE II (Narva, 1979) were applied to three candidates. These two methods plus the questionable empirical data gave three identical rankings of the candidates although the methods' results disagree on the degree of difference. Therefore, the analysts held that this was a reliable method of producing a device assessment when test data are missing or inconclusive.

LaRochelle (1976) solved the missing data problem differently in his assessment of a System for Air-to-Air Combat (SAAC) simulation. Following an analytical examination of alternatives based on Osgood's surface (qualitative stimulus-response comparison), he concluded that positive transfer of training would take place but amount could not be predicted. Therefore, he postulated a series of transfer from 20% to 100%. When these percentages were applied to the number of flying missions in an F-15 replaced, each set was costed on a set of relevant costs for ten years. A further sensitivity analysis was the construction of graphs showing costs if SAAC and/or F-15 costs varied by 20% from the estimated costs.

The conclusion drawn from these types of reports is that a wealth of data and patterns for conduct of TEA and CTEA exists. The most relevant to a new study are those conducted on similar or replacement systems. The reports show that robustness of data and reliability of conclusions follow a pattern. The most reliable are found in such assessments as WSTEA. These deal with operational systems and have access to empirical performance data and judgmental evaluations of personnel with extensive experience operating and maintaining the system over time. The assessments of developing systems are initially analytical, the result of recourse to subject matter experts, theory, and comparison to analogous and predecessor systems. By the time they are fielded, some empirical data are available but they are not complete or extensive.

In the case of training devices in the developmental stages, new media, or other training evaluations, the most reliable assessments and prediction result when the system they pertain to is already operational. Then, performance measures exist to which the new development may be compared.

The most difficult analysis is that of a training device for a developing system. Regulations require that a device be ready for testing during system

DT/OT II. Since the device need may not be recognized early, serious compressions of time hampers device development and evaluation.

2.6 Audio-Visual Training Extension Course Lessons Literature Review

2.6.1 Background. Since 1972, the Army has developed, produced, and distributed to units instructional material as part of the Training Extension Course (TEC) Program. The TEC status list (U.S. Army Training Support Center, 1978) includes job performance aids, audio-visual lessons, audio cassette lessons, and printed texts as TEC. However, the TEC audio-visual lessons are the most widely used.

These are a series of self-paced instructional programs that combine a super 8mm projection system with audio cassettes on a Beseler CUE/SEE auto-tutorial device. There are currently over 1,000 of these lessons covering a wide array of topics. There are lessons, such as camouflage, useful to most soldiers and lessons on such specialized tasks as ocean cargo documentation for the 71N, cargo movement specialist. These are the type extension material generally referred to when Army personnel speak of 'TEC lessons'. In less then 10 years, their use has spread throughout the Army.

Earlier research provided a strong theoretical base. A variety of studies comparing the effectiveness of training media and methods suggested that self-paced, audio-visual instructional devices are a suitable (and perhaps preferred) method of providing ancillary instruction in applied training contexts (Pieper et al., 1972).

The theory has been examined and tested by TEC and TEC-related work since the inception of the program. Much has been done by the ARI, particularly the Field Unit at Fort Benning, Georgia. However, the total body of research is not extensive. A Report Bibliography conducted by the Defense Technical Information Center in September 1980 listed only 14 documents under the search term 'Training Extension Course'. These and other related documents are reviewed in subsequent sections examining TEC effectiveness, usage, cost and other related issues.

2.6.2 Effectiveness. The adoption and promulgation of TEC lessons are based on their proven effectiveness when compared to other military instructional media. A number of studies have addressed this topic. Jacobs and Hardy (1974) compared a sample of 379 TEC users with a 188-person control group and found that MOS test performance was higher in units that had TEC materials available and reported a high TEC use.

Knerr et al. (1975) studied the comparative effectiveness of TEC information versus conventional Army classroom training, evaluating both against a baseline level of performance. Measured by hands-on performance tests as well as Lesson Administrative Instruction (LAI) pre- and post-tests, the TEC-trained groups performed better than or equally well as all others. Analysis of results showed that TEC was more effective than conventional instruction in training persons of lower mental ability.

Leonard et al. (1976) conducted research that proved that TEC was an effective medium for refresher training. Using six groups including an untrained control, they administered TEC lessons on hand grenade selection, maintenance, and use to previously trained men. They found significantly higher scores for all subjects receiving TEC refresher training except in one category. This category (identification of hand grenade components) had been poorly covered in the TEC lesson.

Superior training effectiveness and retention were shown by Holmgren et al. (1978) (also reported in Strasel et al., 1977) using performance measures and tests designed for a field evaluation of TEC (Swezey and Eakins, 1977). A sample of 1320 Reserve Component and Active Army soldiers in the combat arms was used. The research team found that LAI pre- and post-testing did not appear to make a substantive contribution to the learning process. TEC instruction showed a small but distinct advantage over conventional instruction, both amount of initial learning and percent of learning retained in three of five subject areas. In a fourth subject, initial learning with TEC was no better but retention was superior.

However, the foregoing research does not specifically address one unique aspect of TEC. It is not intended to supplant conventional training but to complement it. The contribution of learning from TEC to the total learning acquired from all sources is not clearly understood or defined. This was recognized by Sassone (1978). In summarizing his literature review of TEC training effectiveness he states:

> In sum, because of TECs unique complementary role, it does not fit the usual training program mold, and analytical techniques currently available in the training literature are not completely suitable for a TEC evaluation....it appears a TEC-specific evaluation methodology must be developed.

2.6.3 Utilization. Although all work to date has shown TEC can be an effctive training medium, its effectiveness may be impaired by misuse and non-use. Therefore, a number of studies have addressed the quantititative and qualitative factors related to TEC usage.

The earliest work, McCluskey and Tripp (1975), was hampered in evaluating the TEC program implementation since sufficient time had not elapsed to permit an adequate evaluation. Nevertheless, they drew several conclusions noted in most subsequent studies. First, where TEC was available, desired levels of usage were not reached because of lack of command emphasis and dilution of emphasis and information during transmission down the chain of command. Second, they found that, although positively viewed by personnel, the mechanics and scheduling of use for individuals militated against frequent employment of TEC as a self-paced, individual learning medium. During the authors' period of study they documented an increased usage of TEC in the group mode.

A considerably more extensive survey of usage is reported in Strasel et al. (1977). (These data are reported also in Mays et al., 1977.) In answer to the research problem, "Are TEC lessons being used by members of the target audience?" this team surveyed TEC users, non-users, training officers and NCOs, and training support personnel in CONUS and USAREUR. Opinions on usage, attitudes, and problems were gathered in both Active Army and Reserve Component units. Data collected showed that about 50% of the combat arms personnel (across all categories) have used TEC lessons. However, usage at that time was relatively low--about .4 to .5 uses per man month. TEC was used in the average battalion about 350 times per month and about 4,560 times per month in TRADOC installations (schools).

Other relevant findings were related to attitudes and command and trainer emphasis. Thirty-five percent of the potential users indicated that they had never heard of TEC until the day they were answering the questionnaire. Others said they knew little about it (35%), did not know where the materials were kept (29%), their superiors (28%) or unit trainers (21%) did not direct them to use TEC (based on a sample of 3,284 soldier-users). Some write-in responses were related to use/non-use--needed lessons on additional topics, lacked time for TEC study during duty hours, not interested in TEC, and found lessons too simple and/or boring.

Mays et al. (1979) reported on a second phase of the work described. Findings in Phase 2 were essentially those of Phase 1. Some highly pertinent findings were reported for the first time. They found that 90% of all recorded use occurred in groups. Most of this use was mandatory (81.8%) and took place during duty hours (96.6%). Most users, trainers, and other interviewees preferred TEC to 4 of 7 other training methods (lectures, small group instruction, training films, and soldier's manual) and felt it should be continued.

In a recent study the Defense Audit Service* (DAS) found that TEC lessons were not properly used. The DAS noted that TEC were automatically issued to all Army units at the battalion level and that 62% of the TEC lessons issued were not used. Addressing this issue, LTG R. A. Yerks, Deputy Chief of Staff for Personnel, testified to the Subcommittee on the Department of Defense, U.S. House of Representatives Committee on Appropriations, that the Army was studying how to change policies and procedures to improve the efficiency of the Audio/Visual Distribution System. He stated that:

> Consideration is being given to a combination push/pull system. That is, use of minimum initial distyribution with user demand for additional copies of TEC materials. Products would continue to be distributed directly to using units from the central distribution facility. However, the Training and Audio/Visual Support Centers supporting these units would assume responsibility for accountability, additional loans, maintenance, disposition and reporting use of copies based on input from using units. It is anticipated that these changes will improve utilization statistics such as those developed by the Defense Audit Service, i.e., number of copies distributed compared to the number of recorded uses per copy.*

The low level of usage is a factor that must be combined with cost and effectiveness data in any assessment of TEC efficiency.

*U.S. 96th Congress, 2nd Session, DOD Appropriations for 1981, pp. 306-307.

2.6.4 Cost. Most studies of the TEC Program refer to it as a cost-effective instructional delivery medium. The proof of this is not always apparent. TEC costs can be examined as part of a weapon system's training life cycle cost, as an addition to individual MOS training or costed for annual budgetary purposes as a unique program produced and distributed from TRADOC.

The COEA conducted by the Combact Arms Training Board (CATB) (Department of Army, 1975) reported the first TEC cost analysis. They found TEC more cost-effective than conventional instruction ($42.7 mil/$50.5 mil) based on the same number of instructional hours. Much of the predicted savings was based on cost avoidance. TEC was foreseen as requiring less officer/NCO support at the battalion level.

The cost data in the COEA were supplied by ARI (Temkin et al., 1975). Temkin's report contains more detail than CATB's. Among their points was that TEC would become less costly in comparison to conventional instruction only as volume of usage increased. Their costing assumed optimal use of TEC by individuals. They did not estimate costs considering group use or under-utilization. Conventional group training was the only instructional alternative compared to TEC. Looking into the future they foresaw that the Beseler CUE/SEE and tape cassette player would be "good for another 10 years" (i.e., 1984-85).

Litton Mellonics personnel at Fort Benning conducted the most complete investigation of TEC cost (see Strasel et al., 1977, Appendix A, Cost Benefits: TEC use in TRADOC Schools and Appendix B, TEC Cost and Benefits Quantification). They report that TEC program costs for FY 78 were estimated at $22.5 million, about 1% of the total Army $2,116 million Program 8T or training budget.

This study is the first to note that there are two cost effectiveness models that can be applied to TEC as follows:

TEC COST EFFECTIVENESS MODELS

SUPPLEMENTAL MODELS:

- TEC is viewed as a supplement to conventional training
- Costs are supplemental to base costs
- Decision to continue based on value placed on relative effectiveness to cost of base and supplement (i.e., increased value of effectiveness to cost for the supplement)

REPLACEMENT MODELS:

- TEC is viewed as a replacement for conventional training
- Cost savings may accrue
- Decision to continue based on direct comparison of ratio effectiveness to cost for alternate cases (i.e., cost savings may be realized)

First, the investigation of TEC program costs developed sunk costs (money spent or obligated before FY 78 - FY 87). Displayed in many different ways and categories these analyses are a model of exhaustive cost determination and prediction. From these analyses they determined that each copy of a lesson provided to a battalion costs the Army $34.

Second, the cost avoidance to the Army resulting from use of already existing TEC materials by TRADOC Branch Schools to replace or supplement conventional instruction was calculated. Schools reported savings of over $104,000, cost avoidance of over $2 million in FY 79 due to TEC use and estimated $3 million potential costs not spent to develop new remedial instruction since TEC existing material was used.

A third cost investigation quantified the benefits that accrued when TEC was used. TEC soldiers achieved proficiency for less training resources (time and ammunition). On selected lessons they found an average 9.4% gain in proficiency of an individual skill for $0.39 per person.

The study recommended an extension of the work from individual combat arms soldier to unit. To this end, Sassone and Bercos (1979) developed a methodology for determining the value of TEC in terms of unit performance on the ARTEP evaluation. The methodology, thus far exercised only with hypothetical data, is an adaption of economic welfare models.

The DAS Report cited earlier estimated that:

> "$26.1 million could be saved in reproduction and distribution materials if the Army's training and audio-visual support center at each installation controlled and issued TEC lessons to troop units as needed instead of automatically distributing the lessons."*

LTG Robert A. Yerks, Deputy Chief of Staff for Personnel, in testimony referred to above,* stated that development for new lessons had been slowed and curtailed as well as replacing the audio-visual cassette lessons with print media where possible. He held that considerable but unquantified cost saving would accrue in this program.

2.6.5 Other Issues. This literature review uncovered other TEC-related topics in the material analyzed. Proposed management and selection systems for TEC -- both as an audio visual medium and one of many exportable

*Ibid

extension media -- have been developed (Taylor et al., 1977; Bialek et al., 1978; Butler et al., 1978). The trend seems to be toward considering TEC audio visual lessons as only one of an array of instructional media to be selected when its strengths -- use by group or individual, self-paced, some feedback, exportable to a wide variety of learning contexts -- make it an efficient choice.

Indermill and Reeder (1975) perceived a similarity between TEC lessons and self-study correspondence course lessons. They have developed a manual to teach training developers to convert TEC lessons to correspondence lessons, effecting a considerable savings in original development costs. Another effort aimed at reducing cost was Markham's (1979) work in achievement as related to aesthetic embellishment in education art. Using TEC visuals and simple line drawings to illustrate the same twenty items, he found no significant difference in learning as measured by an end of course test. He estimated that a complex art frame for TEC costs $75 while a simple one costs only $10.

Of great interest are those studies that look to the future. Although the TEC Program is not yet 10 years old, a replacement is already on the scene. Hawkins and Kribs (1979) report that TRADOC is investigating the training and cost-effectiveness of converting its TEC materials from the Beseler CUE/SEE to videodisc. Preliminary work is being conducted at Fort Sam Houston. In work for the U.S. Army Field Artillery School (USAFAS) at Fort Sill, Hoyt and his associates (1977) have determined that TEC lessons can readily be converted to computer-assisted instruction (CAI) using a "formal ISD process." They next taught USAFAS course development personnel to do this at a very reasonable expenditure of time and money. They foresee this as low cost exportable training since expensive dedicated CAI systems may not be necessary. At least for the Field Artillery, deployed time-shared, mini, and/or tactical computers may be used. Hawkins and Kribs also find the emerging video and computer-produced lessons more cost effective by 25-75%. These are savings in developmental costs since texts, graphics, etc. may be created by and stored in the computer. These types are predicted to be more effective because of superior individualization and feedback capability.

Holmgren et al. (1979) have undertaken initial work comparing the effectiveness of TEC lessons on a prototype videodisc player with the audio visuals on the Beseler CUE/SEE. They found that trainees who received either type of supplementary training did better than a control group who received neither. The difference between the two groups with augmented training was not found statistically significant for two sets of lessons. On the third set, the CUE/SEE trained soldiers had a significantly higher performance test score than the videodisc trained soldiers.

2.6.6 Abstracts. Appendix A contains abstracts of 31 documents relevant to a study of TEC. In some cases, there are more substantial condensations of the literature items with charts, tables, or other graphics as deemed especially illustrative. The abstracts are arranged in chronological order from June 1974 to the present date, enabling the reader to trace the initiation and development of the TEC programs.

2.7 Summary of Review Findings

The literature reviewed above contains many examples of CTEA applications and many different models and methods were used in these applications. Some of the applications (and methods) were neither cost analyses nor training effectiveness analyses. Some treat only a specific issue concerning a weapon system, while some consider multiple aspects and multiple factors related to training systems and their relative cost effectiveness. None of these approaches pretends to be a CTEA methodology that is generalizable to all Army training systems.

More importantly, for this report, none appears sufficiently broad in scope and approach to be developed into a generalizable methodology. For example, none of these methods provide all of the information required for decisions at all points in the LCSMM. However, detailed examination of the techniques, steps, and processes within the methods (the process elements from which the methods are built) showed that each method could contribute to the CTEA job to be performed at some point in the LCSMM. Some methods contribute more information elements within some data situations than do others. For example informal expert judgment methods are useful in generating task lists when none are available. However, when task lists are available or have been generated, the formal analytic models for prediction of training programs can provide superior CTEA outputs.

The CTEA methods reviewed above can be systematically combined and/or ordered to provide a framework for directing an analyst when to use any or a combination of these methods for a particular problem type. Such a systematic approach or framework for CTEA applications is discussed in the next section.

SECTION 3

A SYSTEMATIC APPROACH TO CTEA FOR VARIED SYSTEM SITUATIONS

3.1 Introduction

The Army's objective in the area of training must be to provide soldiers and units effective training in a time efficient manner and at the least possible cost. Effectiveness is attained when training objectives and job performance standards are met. Effectiveness can usually be increased through careful selection of what is to be trained, where it is to be trained, and how it is to be trained; by evaluating the training and job performance; and revising training until it meets the objectives. Training must be effective within the time available for it; thus, effectiveness and time efficiency must be examined together. Finally, effective training must be delivered in the available time without excessive cost. These principles imply the structuring and evaluation of alternative training programs either for competing developing systems or for a single fielded system.

Evaluation of training, taking into consideration effectiveness, efficiency, and cost, is a continuous process and is not dependent on actuality of ongoing training or performance measures. Proposed, innovative, and unique training systems and media also require assessment.

As described in the review of Section 2, techniques and processes for accomplishing the required cost and training effectiveness analyses and evaluations are available but have not been systematized into an integrated family of models suitable for use by the training developers and training analysts. Such systematization is required training analysts are to design and carry out an evaluation that considers all contingencies.

A systematic approach to training system CTEA is presented below. This includes an overview model of CTEA that is generalizable to nonsystem training and fielded systems as well as covering developing systems. This systematic approach defines the analytic processes that the analyst must consider depending on the response to specific questions. The systematic approach to CTEA identifies and relates a family of study categories. These are CTEA (TRADOC Reg. 350-4), the ISTEA, and TDS (device-related) for developing systems; and the ISTEA, TSEA, TDS, and Training Evaluation for fielded systems. Table 3-1 shows the relationships of subcategories by type. The approach leads to identification of the appropriate submodels to be applied. This then increases the precision of the questions and defines specific processes required.

The following sections present and describe the systematic approach to training system analysis and the submodels as specific components of the general CTEA approach.

3.2 The Systematic Approach to Training System Analysis and CTEA

Training analysis, as noted above, is a comprehensive process that is carried out for a number of different purposes. The Army has identified and defined a number of these as they relate to operational systems and training devices. This identification approach allows the analyst systematically to pinpoint an assessment category whose study approach is then described in the appropriate submodel. The submodels can be considered to form a general model of training system analysis.

The systematic approach classifies the assessment needs on the basis of the answers to a set of very general training questions. The regulations do not prescribe analysis models for the evaluation of nonsystem training.

Table 3-1. Categories of Assessment Types Within the Generic CTEA

	DEVELOPING	FIELDED
S	CTEA (TRADOC REG. 350-4)	ISTEA
Y	TDS(a)	ISTEA(a)
S		TSEA
T		TDS
E		TDS(a)
M		
N		
O		
N		
S	TDS(a)	TDS
Y	COEA/CTEA*	TRAINING EVALUATION
S		
T		
E		
M		

*The CTEA for a major nonsystem training device or simulation is in fact a COEA for that training device or simulation (e.g., MILES).

Taking the varieties of training analysis into consideration, a general model of training system analysis has been developed (Figure 3-1). This model separates all the currently identified common types of analysis. Using a logic approach, the analyst can identify the type training assessment required.

The analysis flow is as follows. The first discriminator is whether new training is to be developed. If the answer is yes, then the analyst determines if it is system or nonsystem training. If system training, he is directed to use the CTEA (LCSMM) and the ISD submodels. Nonsystem training also requires ISD for design but a different submodel, the Training Evaluation, for assessment. If the initial question's answer indicated that the training to be analyzed already exists, the analyst again is directed along alternate paths for system and nonsystem training. Nonsystem training is assessed using the Training Evaluation submodel. (It has been designed for use with either developing or established nonsystem training.) The ISTEA is the submodel used to answer cost, effectiveness, or efficiency questions pertaining to system training. Should the ISTEA uncover a performance gap, the analyst is directed to the TSEA. The TSEA further identifies the cause of this gap. If it is not due to training (i.e., due to hardware, personnel, or logistic support subsystems), a TSE is called for. If the training subsystem needs a fix, a TDS is conducted. This leaves only major device/simulation questions unanswered. If they have been raised in the earlier analyses, a Device Effectiveness Analysis following a device-oriented TDS completes the evaluation. If other substantive, unique analysis types are uncovered, the model is flexible and can be enlarged to accommodate them.

The submodels shown in Figure 3-1 are designated by off-page exit numbers. These numbers are the entrance symbols in the succeeding figures depicting submodel logic flow.

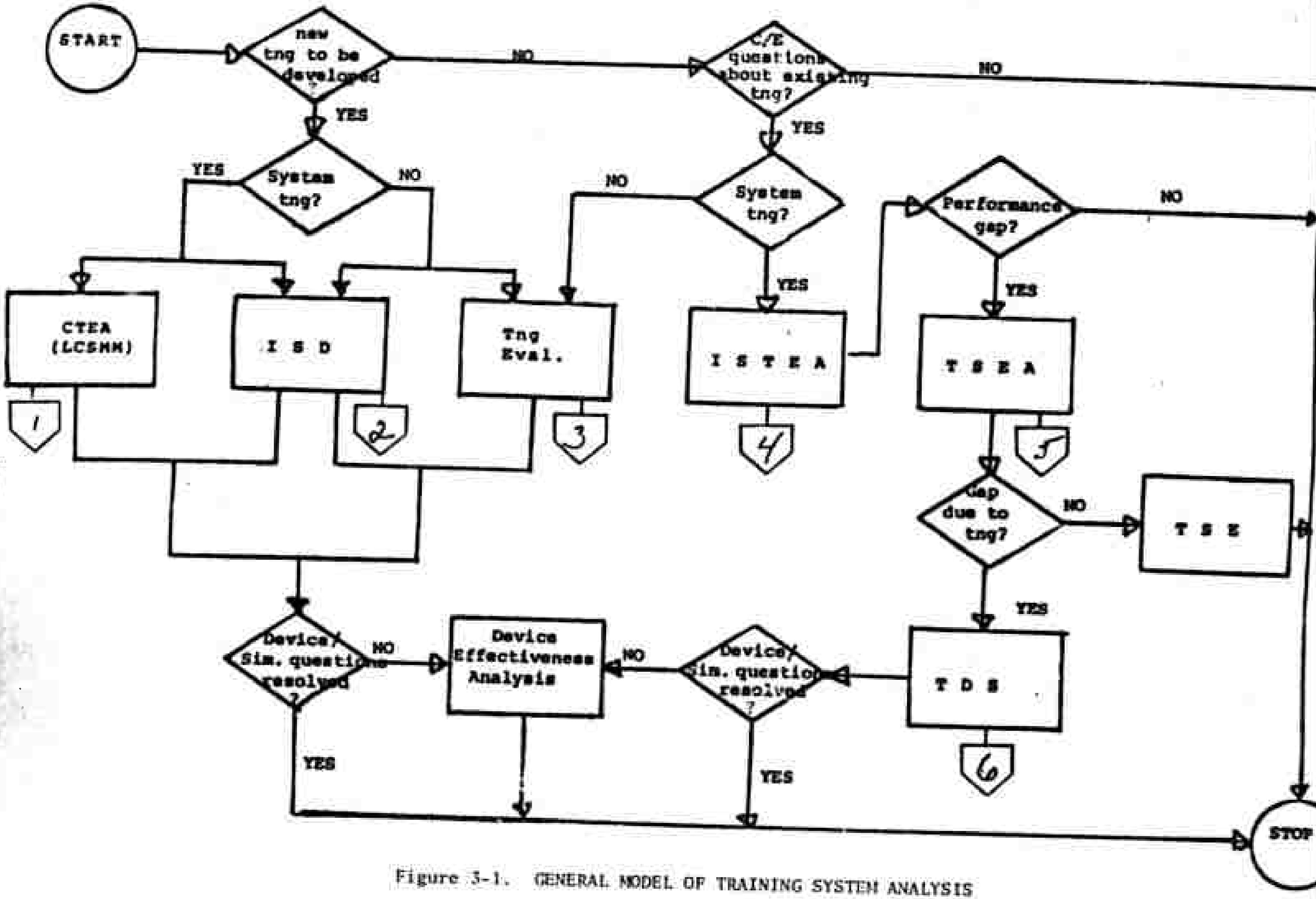

Figure 3-1. GENERAL MODEL OF TRAINING SYSTEM ANALYSIS

3.3 CTEA (TRADOC Reg. 350-4) Model

The CTEA model (Figure 3-2) is a fully developed method with suggested processes to carry out all required analysis identified (Matlick et al., 1980a). By definition the CTEA is related to an operational system and requires comparison of alternatives as to cost-effectiveness (C/E) and non-quantifiable issues. The constraints to successful analysis lie in the availability of data. The choice of methods results from the analyst's response to questions covering the existence of (1) a task list, (2) a training program, (3) training program alternatives, and (4) comparable effectiveness data for all alternatives. Processes are suggested for generating task lists, predicting training program alternatives, estimating effectiveness, costing, making C/E analyses, and resolving issues. This very adaptable model enables the analyst (within the availability of data) to conduct a CTEA and produce reliable recommendations at any stage of the LCSMM.

Litton Mellonics has prepared a guidebook (Matlick et al., 1980a, p. v2) demonstrating the CTEA model application for the most common data/no data situations. (A description of the model may be found in Section 2.)

3.4 ISD

The ISD model is a set of procedures for developing and monitoring the effectiveness of training systems (see Section 2 for a brief description of ISD). Phases I - III are developmental processes, and Phase V is a training assessment model. ISD relates to the systematic approach to TEA (as submodel 2) as a training development process. The general model directs the analysis to ISD if new system or nonsystem training development is needed. It is highly likely that when processes are identified for TDS, ISD (or ISD

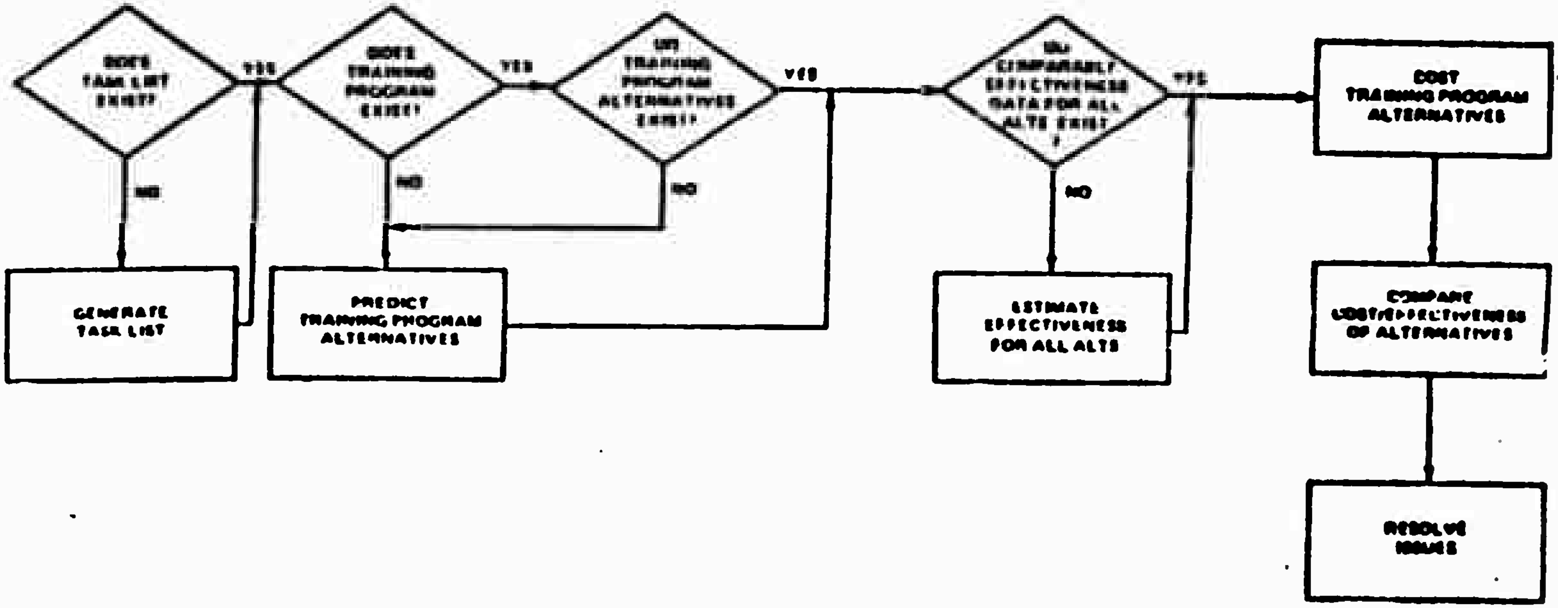

Figure 3-2. CTEA (TRADOC REG 350-4) MODEL FOR DEVELOPING SYSTEMS

abbreviated for media/method selection) will be one of the processes of choice. Since ISD is a continuous process, future work will identify the paths from ISD to the TEA submodels for appropriate analysis of training following implementation. An ISD procedures overview is shown in Figure 3-3.

3.5 The Training Evaluation Model

In order to complete the family of submodels and provide for assessment of all major training types, Litton has developed a model for the evaluation of nonsystems (Figure 3-4). The proposed model is designed to evaluate either existing nonsystem training, if available, or to evaluate developing nonsystem training. The requisite model processes have not been evaluated nor has the model been exercised. Unlike the other submodels, the training evaluation model is a new approach. Therefore, the rationale underlying the development follows.

Problems exist in approaching evaluation of nonsystem training. Training whose purpose is not directly related to an operational system may not result in observable, measurable performance. Training in military courtesy, for example, may result in measures of knowledge (written or oral test scores) or perhaps, even performances under controlled or artificial conditions. However, the analyst will not know if training has resulted in appropriate soldier behavior in regards to military courtesy in the real world. On the other hand, other nonsystem skills such as map reading can be tested in field exercises and task skill performance measured. However, such observations or measurements still leave some questions unanswered. For example, could the soldier have successfully carried out the same exercise under other conditions

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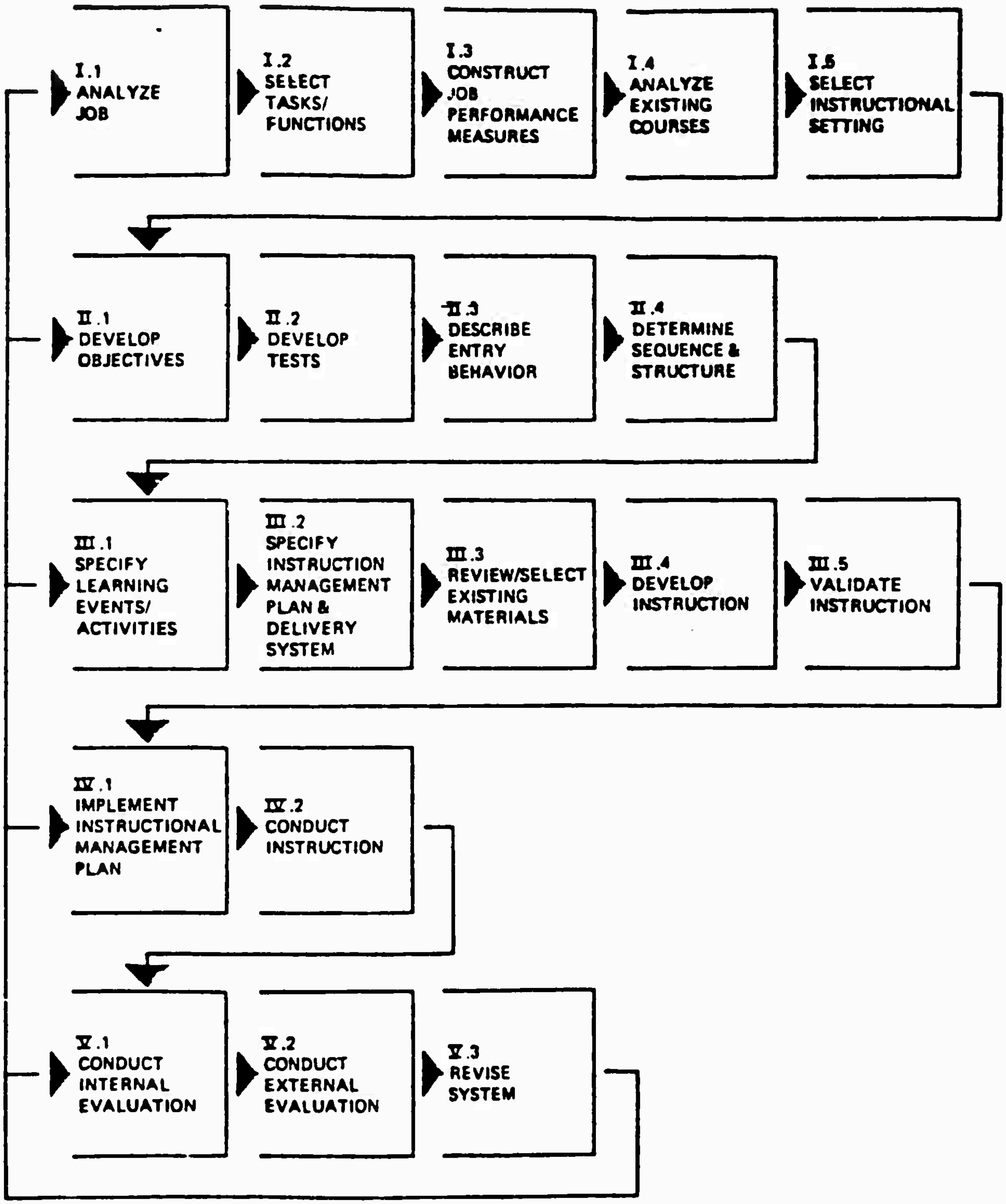


Figure 3-3. Overview of ISD Procedures

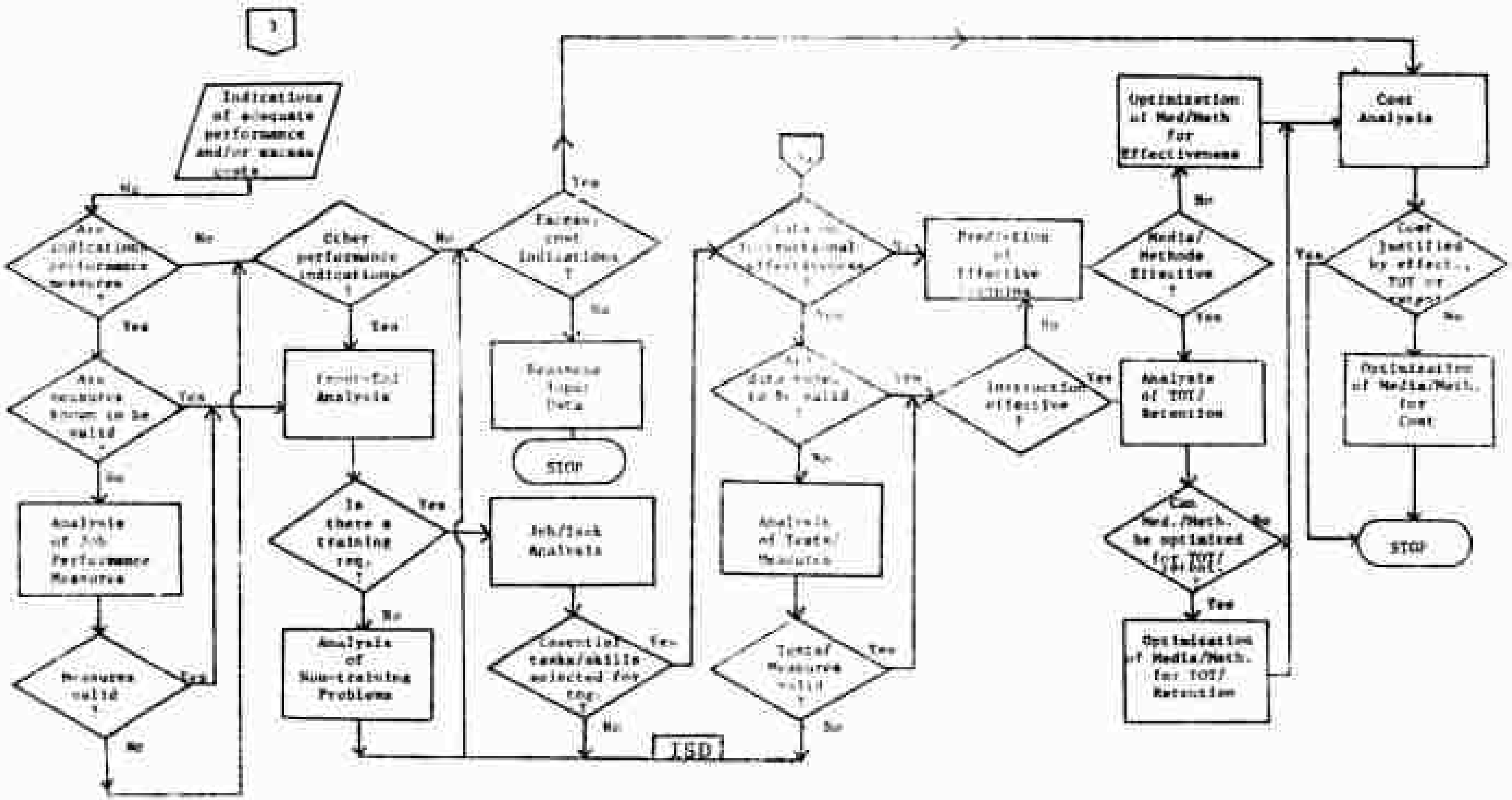


Figure 3-4. Model of Training Evaluation

of terrain, climate, and weather? Would he have been successful under combat conditions? Could he solve a navigation problem not posed in this exercise? Sophisticated simulation that could, of course, provide reasonable answers to such questions is not generally available to a training system analyst. The analyst alternatively can turn to an examination of training media and methods to determine if research and experience show them to be valid means for producing the required results.

The central question of the latter approach is: Given these required results, are these methods and media valid? Hence, knowledge of the effects of training rather than knowledge of results is pivotal. That is, an analyst's knowledge of the proven effects of methods and media can be used to predict their effectiveness in new contexts. For example, he may know that a certain method has the effect of improving the trainee's ability to generalize principles to a large variety of specific situations. He might then predict that this method is a valid way to teach map reading. Likewise, the analyst may know that the formal statement of training objectives clarifies the intended outcomes for both student and trainer or that the development of valid and reliable instruments for the measurement of learning establishes a basis for feedback to both the learner and the instructional system. This knowledge gives the analyst assurance that he can predict reliable means of enhancing desired effects.

Such an analytical process tends to mirror the ISD procedures -- the analytical processes that create new training programs. The analytical approach to training evaluation described above could, in effect, provide a quality control check on ISD processes as well as refine or correct their output. Note that this approach is distinctly different from ISD Phase V, Control. ISD Phase V is based on the feedback of performance and effectiveness data to training program proponents. In a flawed program, these data may be in error or in need of revision.

The Training Evaluation Model (Figure 3-4) depicts this analytical approach to training. According to this model, training evaluation begins with indications of some sort that performance is not adequate and/or is excessively costly. In the case of developing nonsystem training, the impetus for the evaluation will probably be to compare posed alternatives or to compare an alternative to a current baseline, although need for a "fix" might be recognized before the nonsystem training is fully developed and fielded. These indications may be formal or informal, many or few, depending on the importance attached to the training program in question. They must be examined closely for validity early in the evaluation.

If the job performance measures are valid or if there are other persuasive indications of inadequate performance, the evaluation proceeds to front-end analysis to more closely define the problem or pinpoint problem locations. If no performance inadequacies are detected, cost problems are examined. The front-end analysis may show that what initially appears to be a training problem is actually some other kind of problem (e.g., an environmental or psychological problem that has adversely affected performance). If there is a real training requirement, the evaluation proceeds to job/task analysis.

The training developers normally conduct job/task analysis for existing or new training programs. If this has not been done, the analyst must use an appropriate process for preparing a provisional critical job/task list and analysis. The purpose of the job/task analysis within the Training Evaluation

Model is to determine if the essential tasks/skills have been selected for training. If they have not, the analysis must cease, and an ISD process undertaken to develop appropriate training. If, on the other hand, the critical tasks have been correctly identified and selected for training, the evaluation moves on to an examination of how they have been or are to be trained.

If there are data on instructional effectiveness (such as written, oral, or performance test scores), their validity is analyzed unless it has already been established. If the data are not valid, the analyst must again revert to the ISD model to develop valid tests/measures/data or training. If the data are valid, they become the basis for deciding if instruction is effective (that is, if what is being taught is actually being learned). If instruction is not found effective, the evaluation proceeds to the prediction of other methods, media, or training elements expected to achieve effective instruction. This process results in a theoretical instructional system. The continuation of the evaluation is not dependent upon existence of real world instructional data. Their absence is not the same problem as that of invalid data. In the case of predicted programs, the analyst may employ judgmental and analytical methods for forecasting effectiveness. In the case of operational training systems, quite valid informal or intuitive feedback may be present and may, in fact, be discovered as the evaluation proceeds. Furthermore, the absence of such data pinpoints another deficient area. Such a deficiency is due either to a lack of formal instruments or means for assessing instructional effectiveness or to nonuse of available means or instruments. Therefore, subsequent evaluation would have a legitimate interest in discovering the reasons for such lack or nonuse and in recommending the development and use of valid instruments and means.

On the basis of comparison of alternative instructional systems (theoretical and/or existing), a judgment is made about the predicted effectiveness of the methods, media and other elements of the systems. If the empirical data or the analytical processes indicate that the instruction is (or is expected to be) effective, the evaluation proceeds to search for some other explanation for inadequate performance. Alternatively, investigation will search for an explanation of why empirical data do not demonstrate effective instruction even though analysis has indicated that methods, media, and other elements are appropriate.

This search is accomplished through an analysis of potential or actual transfer of training (TOT) and of skill retention/decay. Very little of the learning may be transferring to the job or there may be interference within the instructional system. If the resultant finding is that TOT or retention is a problem source, then the analyst decides if adequate knowledge exists that will permit revision of instruction to optimize for these factors. If such knowledge exists (or can be readily and economically acquired), the evaluation proceeds to analysis or study of such optimizing designs.

Whether or not optimization for TOT or retention is undertaken, the final area for analysis is cost. Following a cost analysis, a decision is made as to whether actual or projected costs are justified by the actual or predicted outcomes. If the answer is positive, the training evaluation is complete. If not, instructional system elements are optimized for cost (a cost-effectiveness (C/E) process) as the last evaluation step.

If following the prediction of effective training, the training system elements are not found appropriate, the evaluation proceeds to a consideration of how they may be improved. The analyst employs a process to determine the system revision or alternation required to provide effective training. This optimization-of-training process also leads to cost and C/E analysis.

The key to the validation of this model for nonsystem training evaluation is the discovery or development of methods for the execution of each embedded process (shown in Figure 3-4 as rectangles). This is beyond the scope of this project, but see Matlick et al., 1980a and b for the methods selected for each process in the CTEA model (Figure 3-2).

3.6 ISTEA

The Initial Screening Training Effectiveness Analysis (ISTEA) is an assessment of fielded hardware system related training. Its primary objective is to determine if a significant performance gap exists between designed equipment capability and actual performance achieved in operation of a given hardware system. Second, the ISTEA is conducted to provide data on the factors that affect performance. This knowledge determines the need for further study and the type of future study required.

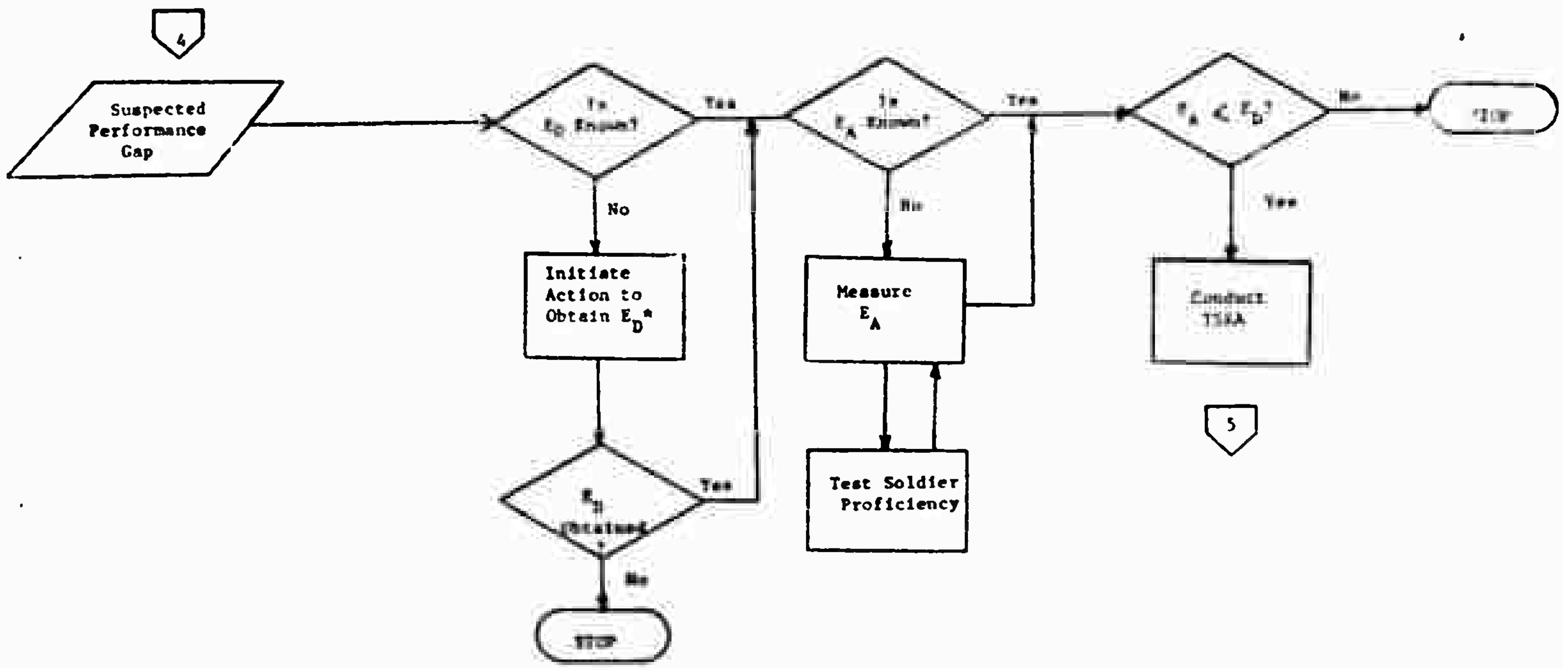
ISTEA are conducted in response to either of two requirements:

(1) to fulfill the requirement for continued quality control assessment of ongoing training;

(2) to provide a baseline of data on a fielded system to be used in the CTEA of an analogous developing system.

In both cases analysis proceeds by answering the same set of three consecutive questions.

3.6.1 ISTEA - Objective 1. ISTEA, Objective 1, (see Figure 3-5) are conducted to verify indications that actual system effectiveness (E_A) has fallen below the presumed or formerly-established system capability. The



*From DARCOM, Manufacturer, AMSAA, etc.

Figure 3-5. ISTEA Objective 1 (Detect performance gap in fielded systems) first question directing the course of the ISTEA is whether the design effectiveness (E_D) is known. If not, the analyst must procure the best empirical data available on system effectiveness. Some suggested data sources are DARCOM, the manufacturer, MASAA, OTEA, reports of COEA, CTEA, and field experiences. If the valid empirical performance data are not available, the ISTEA cannot continue. Unlike CTEA and other types of comparison, real-world data rather than estimates are required for the ISTEA. Without them it is not possible to assert that a performance gap exists or to measure its size accurately.

If the E_D is known or has been determined, the assessment moves to the second question. The analyst ascertains if E_A is known. When it is not, he employs processes to measure the E_A, including as required, a test of soldier proficiency.

When the ISTEA analyst has measures of both E_D and E_A, he can determine if design effectiveness has been substantially achieved and if not, the size of the performance gap. There is no further analytical requirement if E_A is approximately equal to E_D. When the ISTEA finding is that E_A is significantly less than E_D, it is recommended that a TSEA be conducted to locate the reasons for deficiency.

3.6.2 <u>ISTEA - Objective 2</u>. An ISTEA, Objective 2, (see Figure 3-6) is conducted to provide a comparative baseline of data from an operating system for use in the CTEA of a developing system. As such, as much detailed information as possible is gathered on the system affective factors (see Table 3-2).

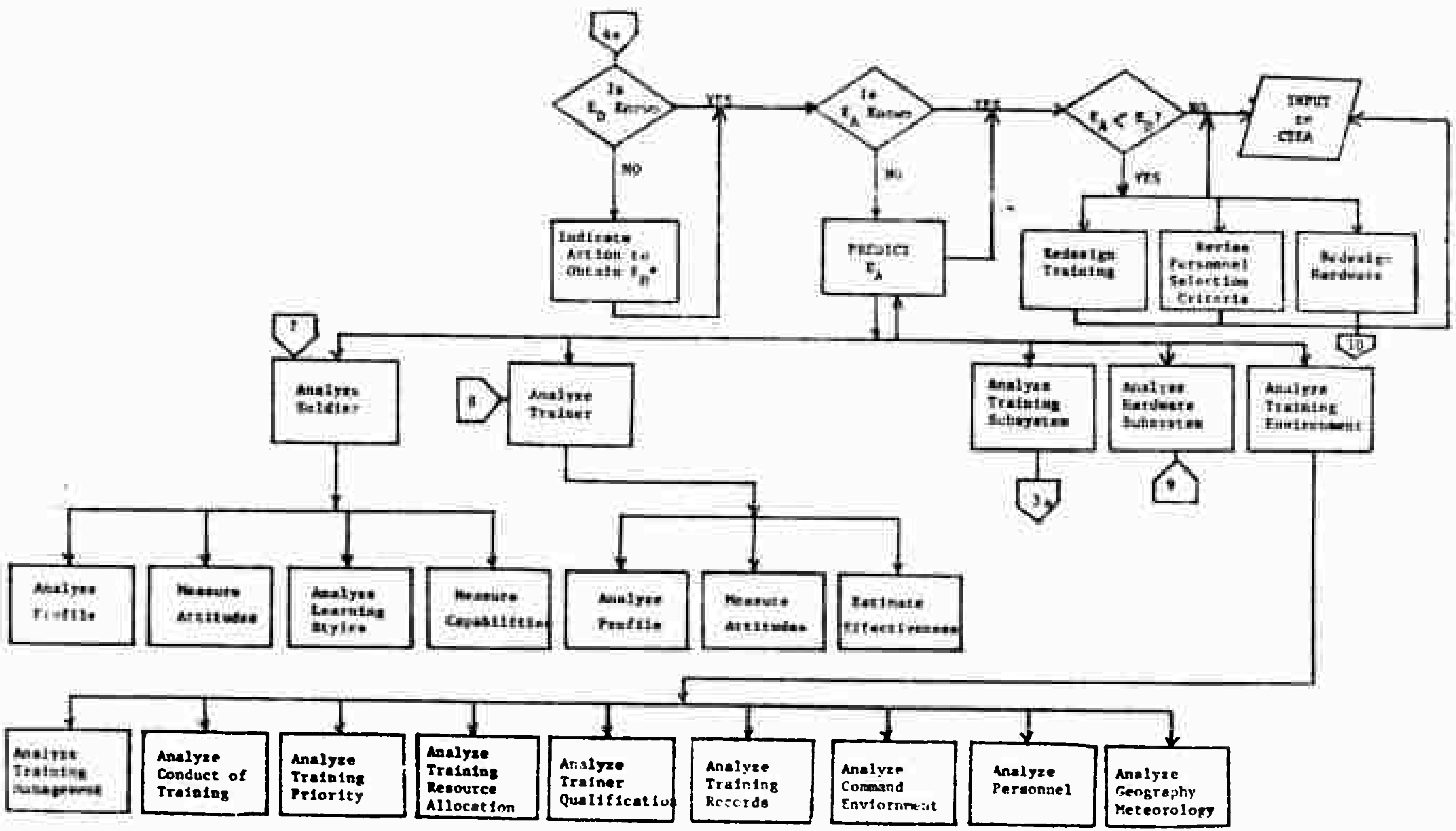


Figure 3-6. ISTEA OBJECTIVE 2 (Provide supporting data for CTEA of developing system)

*From DARCOM, manufacturer, AMSAA, etc.

Table 3-2 Data Elements Collected for ISTEA, Objective 2

Soldier
demographic
attitudes
learning styles
capabilities
Trainer
demographics
attitudes
effectiveness
Training Subsystem
Hardware Subsystem
Training Environment
management
conduct
priority
resource allocation
trainer qualifications
training records
command environment
personnel
geography, meteorology

As in ISTEA, Objective 1, the first requirement is knowledge of the E_D. Next, the analyst obtains a known or predict E_A. In the process of E_A determination, the analyst acquires detailed data on the soldier, the trainer, the training and hardware subsystems, and the training environment.

Following determination of E_D and E_A, the existence of the performance gap is verified and the size measured. For the purpose of the CTEA, if E_A is less than E_D, training is redesigned, personnel selection criteria are revised, and hardware changes recommended, depending on the reasons found for training system deficiency. All data and their assessment form the input provided to the CTEA study team.

3.7 TSEA

The Training Subsystem Effectiveness Analysis (TSEA) (see Figure 3-7) is the most rigorous investigation conducted on the training related to a fielded hardware system. It may result from the findings of an ISTEA, Objective 1 type, or if obvious, valid evidence of a significant performance deficiency exists, TRADOC Reg. 350-4 recommends that a TSEA be conducted in lieu of an ISTEA. When an ISTEA has not been done, the first task of the TSEA analyst is to collect and analyze those data elements usually collected in an ISTEA (see Table 3-2). If the TSEA is an ISTEA follow-on, the existing data are reviewed. If data gaps exist or if some data are outdated, these deficiencies are compensated for by a new data collection and analyses. These detailed analyses of the training, hardware, and personnel subsystems as well as the training/working environment lead to pinpointing of major problem areas and substantial contributory factors.

The findings and recommendations of a TSEA may identify the problem locus in any subsystem (training hardware, logistic support, or personnel) or in any combination of subsystems. If the training subsystem alone is implicated, a Training Development Study (TDS) follows the TSEA to develop a 'fix'. If other subsystems are involved, a Total System Evaluation to identify and recommend 'fixes' for these interactive subsystems is indicated.

3.8 TDS

3.8.1 General. When a training subsystem has been found deficient (e.g., as the result of a TSE), is identified in need of revision because of changed conditions or requirements, or is considered to be excessively costly, a Training Development Study (TDS) may be conducted to find the most cost-effective way to 'fix' the system. The TDS is procedurally similar to the

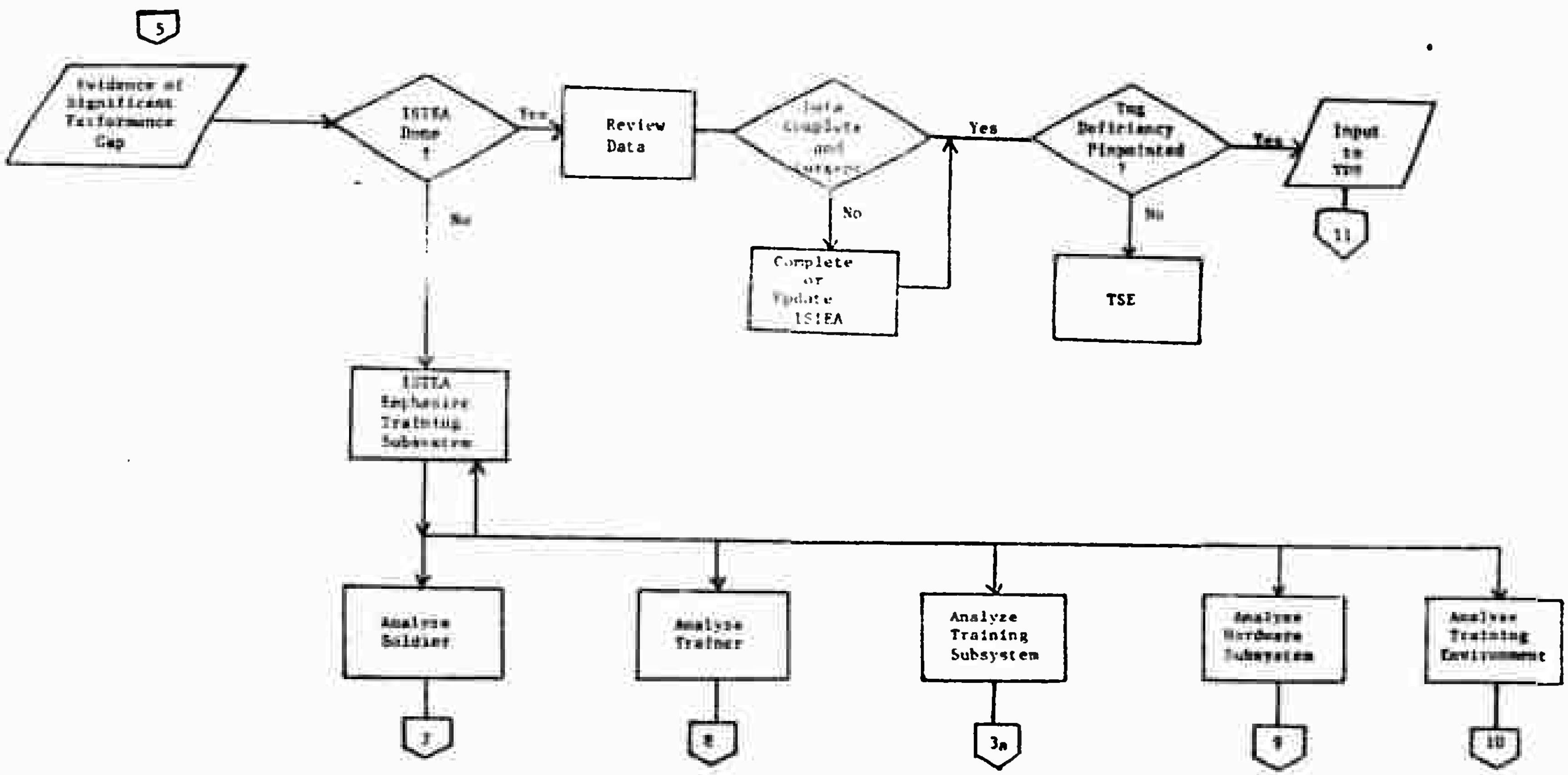


Figure 3-7. TSEA

CTEA. Both require a reasonably accurate cost assessment, the development of alternative training predicted to be effective, and a cost-effectiveness analysis. The TDS conducted for a fielded system parallels the CTEA conducted for a developing system. Another specialized specific requirement for TDS exists in relation to training devices. The two types will be discussed in the following paragraphs.

3.8.2 TDS, Fielded Systems. The general TDS is a study conducted to develop a 'fix' for the on-going training of a fielded hardware system (see Figure 3-8). The study is initiated when an ISTEA, TSEA, or other training subsystem data identify a need for training revision, improvement, or modification. The TDS objective is to find the most cost-effective ways to improve a system found ineffective, inefficient, or too expensive. As shown in Figure 3-8, any combination of these conditions may be present and confront the TDS research team. The first process is the application of ISD, Phase I and Phase II, to the tasks or subsystem elements under study. When possible, alternative effective methods should be developed since cost and other constraints (e.g., environmental impact, trainer shortages) may impact on the 'fix' selection.

The TDS group proceeds to the consideration of training devices. Has the analytic design process suggested that a device or simulator is a likely effective training 'fix'? If so, a training device requirement (TDR), a formalized statement is drawn up. If approved, the TDR is followed by a TDS of the second type (discussed later in Section 3.8.3).

After the proposed alternative training elements are designed, they are the subject of cost-effectiveness analysis. In reality, this C/E of a training

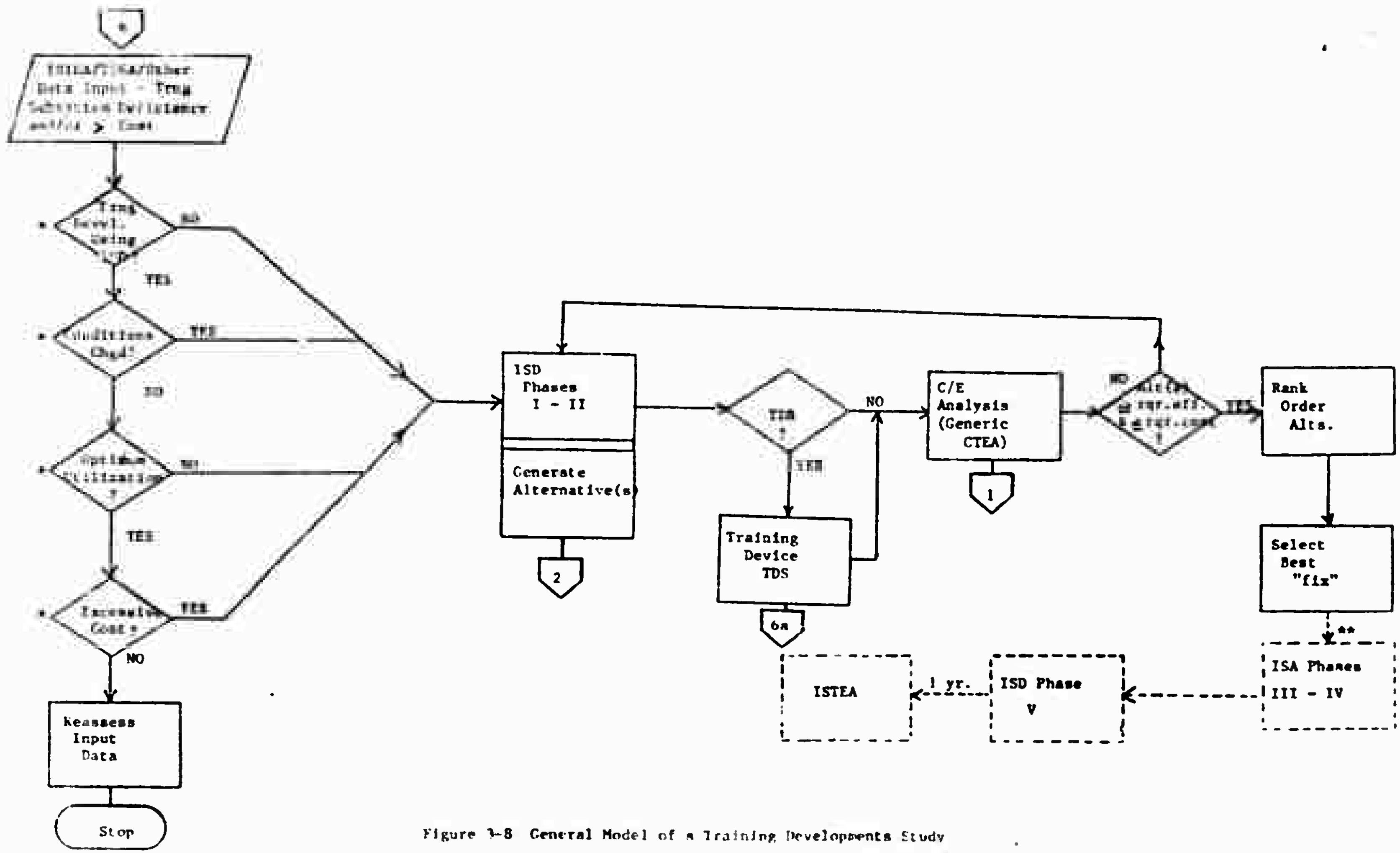


Figure 3-8 General Model of a Training Developments Study

*Any one or combination of these conditions may initiate TDS.

**Dotted lines indicate monitoring after completion of TDS.

subsystem is a generic CTEA and is conducted in the same manner as the previously discussed CTEA for a developing system (see Section 3-3, Figure 3-2). The results of this CTEA enable the TDS research group to decide whether the proposed fix (or fixes) can be expected to provide the required performance effectiveness at an affordable cost. If so, the alternatives are rank-ordered, other issues addressed, and the best fix selected. If the proposed fixes do not meet requirements, the design process must be repeated.

At this point, the TDS is completed. However, within the TRADOC TEA system, a follow-on to the TDS is implied. The selected training fix is developed and implemented according to ISD Phase II and IV procedures. It is then monitored, ISD Phase V, to watch for problems in implementation. The TRADOC TEA Handbook (TRASANA, 1979) recommends that an ISTEA be conducted after the revised training has been in operation for a year. The ISTEA will determine if the fix eliminates or adds to the performance gap.

3.8.3 Training Device TDS. When a need is formally recognized for a training device (the result of one of several types of initiating documents) a sequential series of TDS are required. These TDS are input to the requirements documents for low risk, less expensive devices or input to CTEA and COEA for hardware systems. A TDS is required before each device development decision point (ATSC, 1980; TRADOC Cir. 350-4, 1979). Each TDS requires an assessment of potential device training effectiveness as well as a determination of non-quantifiable benefits and costs. The ATSC Guide (1980) suggests that, when possible, TDS predict proposed device effectiveness by comparison to methods currently in use for training similar tasks. Table 3-3 displays the requirements for conducting device-related TDS.

Table 3-3 Decision Points Requiring TDS, Time-Phased

TDS TYPE	LIFE CYCLE PHASE	DECISION/DOCUMENT REQUIRING TDE INPUT
Preliminary	Conceptual	TDR/TDLR (full LCSMM) TDLOA
	Validation	TDR/TDLR (partial LCSMM)
Update of Preliminary (follows DT I/OT I)	Validation	TDR/TDLR (full LCSMM)
Final (follows DT II/OT II)	Full Scale Development	DEVA IPR

Abbreviations: DEVA IPR - development inprocess review
DT - development test
LCSMM - life cycle systems management model
OT - operational test
TDLOA - training device letter of approval
TDLR - training device letter requirement
TDR - training device requirement
TDS - training development study

The device acquisition process, including detailed descriptions of related study requirements, may be found in such publications as The Training Acquisition Handbook (U.S. Army CORADCOM, 1978) and Training Device Requirements Documents Guide (PM TRADE, 1979). Figure 3-9 shows a simplified, general model of the device-related ITS. Similar to the CTEA (Figure 3-2), it identifies points where requisite processes are applied. The TDS begins at a point determined by the answers to a sequential series of four questions. Each negative answer sets the TDS initiation in an earlier, more speculative context. The model shows how each TDS builds on and updates earlier efforts.

The first TDS concern is whether a device already exists that can be used to meet the TDR. If the device exists, the next concern is to obtain empiri-

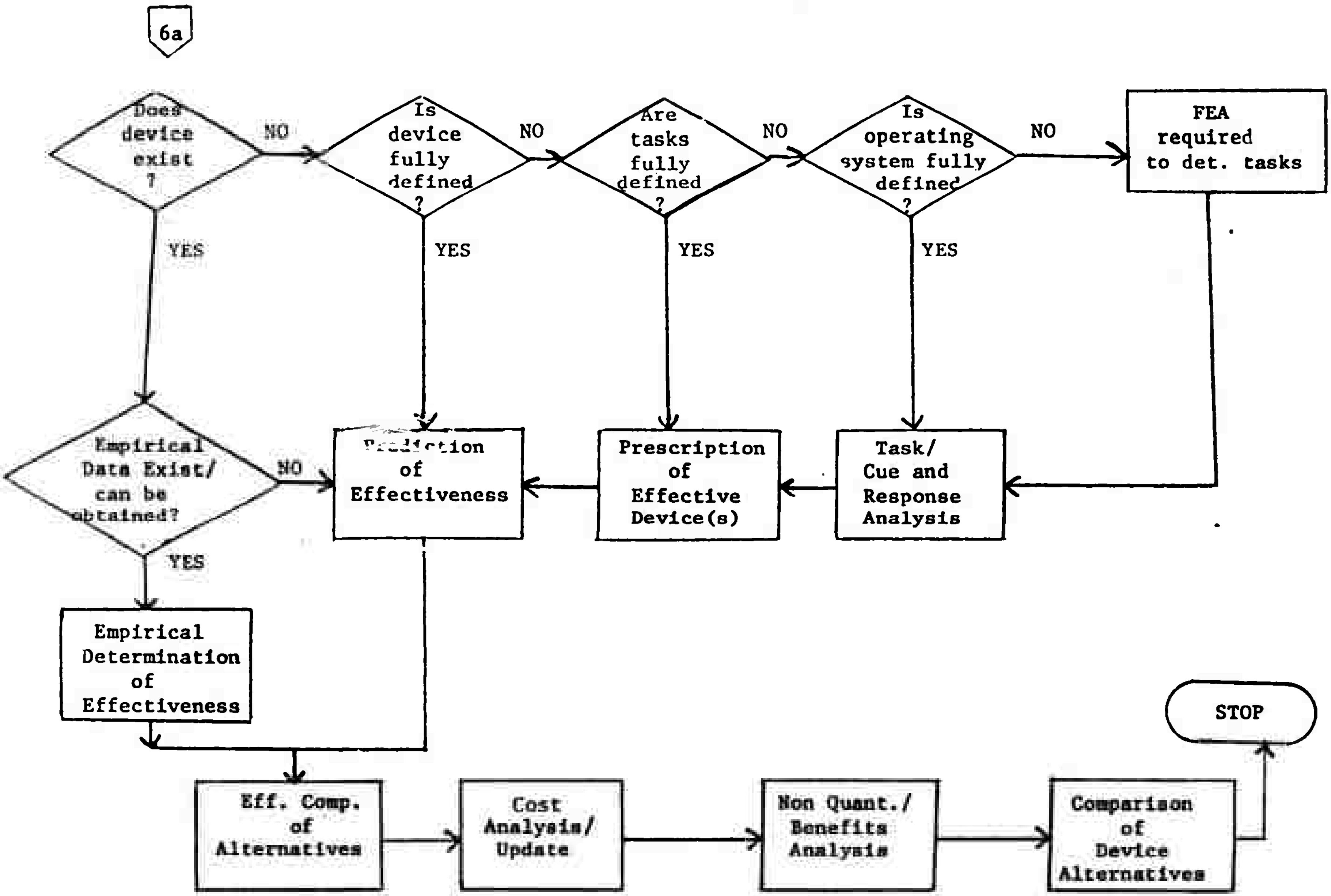


Figure 3-9. Model of a Training Device - Related TDS.

cal data that permits determination of effectiveness. If these do not exist (or cannot be readily and economically obtained), the TDS research group employs one of the methods of effectiveness prediction. The most likely are device-specific, such as TRAINVICE I (Wheaton et al., 1977), TRAINVICE II (Narva, 1979)*.

If a suitable device and empirical data do not exist but the device concept is developed, then one of the predictive methods may be employed to estimate training effectiveness on the specified tasks. When the device does not exist and has not yet been defined, the TDS research group begins work by looking at tasks. A well-specified task list permits the TDS to start with application of a device prescriptive method. At yet an earlier stage, the operational system concept may be developed but operator/maintainer task lists not yet compiled. Here the TDS process begins with a task/cue and response analysis.

In what might be considered "worst case", at the earliest development, the TDS research group may be dealing with an operational system still in the concept development stage. Sometimes a need for concurrent device development is apparent at this early LCSMM phase (e.g., aircraft, tanks, air defense weapons) because of known exorbitant operating or ammunition costs or high risk to operators. The team commences by conducting a front-end analysis (FEA) to determine the tasks to be trained on the device.

Depending upon the starting point, the sequence of analysis is (1) determination of tasks, (2) task/cue and response analysis, (3) prescription of effective devices, and (4) prediction of device effectiveness. When this

*For a description, see Section 2.4.2, Predictive Methods.

point is reached, the TDS team compares and ranks the alternatives, taking into consideration training effectiveness, cost, and any other non-quantifiable benefits.

3.9 Summary

This discussion has described a systematic approach to the selection and application of CTEA models appropriate to the analytic requirement related to a variety of training systems analysis needs. The general model of training system analysis (Figure 3-1, above), depicts the systematic logical analysis that directs the analyst to the specific CTEA submodel most appropriate to the task at hand. This logical analysis and its related analytic submodels have been described in some detail in the foregoing sections. This systematic approach applies to the selection and conduct of CTEAs for various training systems development and evaluation problems. This approach can be applied by analysts at various levels and agencies throughout the Army training and combat development structure. If it is systematically applied, the approach should lead directly and efficiently to the most appropriate analytic design for any given CTEA problem under diverse system situations.

While no truly generic model for CTEA has been identified or developed in this research, the systematic classification of the various submodels in relation to the problems to be handled may be considered a substitute for such a generic model. This systematic approach amounts to the currently achievable state of the art in the area of general CTEA methodology at this time. It is believed that further developments will require breakthroughs in analytic thought and in methods generalization that cannot now be defined. Even so, the approach outlined above can be a useful tool to training and system developers if they will apply it to their specific analytic problems.

APPENDIX A

ABSTRACTS

Jacobs, T.O. and Hardy, R. A., Jr. Test and evaluation of training extension course (TEC). HumRRO TR-74-16. Alexandria, VA: Human Resources Organization, June 1974.

This research was a pilot study designed to provide an inital evaluation of the effectiveness of TEC as training medium. At the time the TEC concept was being implemented, planning was also under way for testing the 1972 MOS 11B40 Proficiency Pay. TEC training was provided to soldiers taking MOS 11B40 tests and the MOS test scores were used as a criterion of effectiveness. Fifty-six TEC lessons covering four major MOS test areas were prepared by the U.S. Army Infantry School. Control battalions were given all preparatory material and media except TEC while "TEC" battalions received all these plus TEC material. A second control group was drawn from Army-wide test takers to ensure that the battalion control groups represented the Army as a whole. An additional correlation of MOS test score to verbal English (VE) score was also made.

Major Findings:

(1) Correlation of MOS test score with VE scores was low (.2 - .3) but significant. Therefore, it was used as a control during analysis of results.

(2) Analysis of relationship of TEC and verbal ability suggests TEC did not completely reach the target population. Low users of TEC were in unit with low average verbal ability; high users, high verbal ability.

(3) Users of TEC scored significantly better in Area One - Individual Weapons and displayed a trend (not consistent) for better scores in Area Three - Tactics.

(4) An analysis of lessons studied did not show that TEC battalion members had a greater chance of answering correctly questions covered by TEC material than questions not so covered.

(5) Amount of studying was positively and significantly correlated with MOS scores (.3). It remained significant when VE was controlled (.2). This conflicts with the preceding finding and suggests that there may have been differences between battalions in the manner of using materials and that these differences were strong enough to influence the outcome.

(6) The rank order correlation between the average number of lessons studied by battalion and the average MOS test score by battalion was .88 - a significant figure.

(7) Reasons suggested for non-use of TEC were: lack of emphasis within the unit, competing programs and priorities, and lack of time during the duty day. All were deemed sufficient reason for decreasing TEC usage.

The research conclusions were;

(1) MOS test performance was higher in units in which TEC materials were available and which at the same time reported high use of TEC materials. This is held as "suggesting" that TEC materials were useful in preparing for the MOS test.

(2) Analysis of both the MOS test and the TEC materials suggest that a penalty was paid for the urgent time pressures imposed during the initial implementation of the TEC concept. Further recommendations are made for improving both the material development and pretesting procedures.

Table 1

Pay Grade and Unit Distribution of Subjects Participating in the TEC Evaluation

Group	Unit	Battalion	Pay Grade E-5	E-6	E-7	Total
TEC Experimental (Sound/Slide)	82d	2d BN, 325th Infantry	30	29	2	61
		2d BN, 506th Infantry	54	23	5	82
		2d BN, 504th Infantry	30	21	0	51
		All	114	73	7	194
	4th	2d BN, 8th Infantry	16	5	0	21
		1st BN, 11th Infantry	5	6	1	12
		All	21	11	1	33
	2d	1st BN, 41st Infantry	18	19	0	37
		2d BN, 50th Infantry	9	7	2	18
		All	27	26	2	55
	30th(NG)	1st BN, 119th Infantry	31	5	0	36
	71st(NG)	2d BN, 143d Infantry	14	3	3	20
	73rd(NG)	1st BN, 166th Infantry	27	9	5	41
Control (No sound/ Side)	82d	2d BN, 505th Infantry	3	5	3	11
		1st BN, 508th Infantry	15	19	6	40
		All	18	24	9	51
	4th	1st BN, 10th Infantry	9	13	0	22
	2d	2d BN, 41st Infantry	7	4	1	12
		1st BN, 50th Infantry	7	12	3	22
		All	14	16	4	34
	30th(NG)	1st BN, 118th Infantry	24	5	0	29
		1st BN, 120th Infantry	22	7	2	31
		All	46	12	2	60
	71st(NG)	1st BN, 143rd Infantry	16	5	0	21
		3d BN, 143rd Infantry	13	5	4	22
		All	29	10	4	43

TEC users: n = 379

Control: n = 183

n for the Army-wide sample is not stated.

Indermill, K., Gale, P., and Reeder, J. <u>How to design and develop self and supervised instruction: A guide for developing correspondence instruction.</u> Tallahassee, FL: The Center for Educational Technology, Florida State University, 1 February 1975.

Under the sponsorship of the U.S. Army Combat Arms Training Board at Fort Benning, GA, Indermill and her associates have developed a proceduralized guide for developing correspondence course lessons with an on-the-job training (OJT) option. The manual covers: (1) how to write OJT lessons; (2) how to write training objectives in standard format; (3) how to write interactive instruction; and, (4) how to validate newly-prepared instructional material. Each of these sections provides the lesson developer with instructions, practice lessons, self-evaluation tests, checklists, and procedural guides.

The authors recognize the similarity to TEC lessons. They state:

> Many of the design techniques currently used in the Training Extension Course (TEC) self-study program, such as behavioral objectives, interactive design, and self-evaluation progress checks, need to be brought to bear on our correspondence instruction.

This method is efficient since it takes advantage of expensive prior TEC lesson development. They further state that, as a minimum, each TEC lesson should be converted to a correspondence lesson thereby reaching a larger, non-hardware dependent audience. To this end, a chapter is included that teaches the training developer how to convert TEC material to a correspondence lesson.

Two sample lessons complete the guide. One is a revised TEC lesson with an OJT option -- Signal Subcourse 000 (OJT only), Radio Set AN/PRC-77. The other, Infantry Subcourse 3-2, Map Reading was not prepared from a TEC lesson and does not offer an OJT option. The material in the former lesson is far superior to the latter. Both were prepared by participants in the developmental testing of the manual. It is not stated whether or not the lessons were validated.

McCluskey, M. R. and Tripp, J. M. *An evaluation of the utilization, maintenance, and perceived benefits of the training extension course (TEC).* HumRRO TR-75-18. Alexandria, VA: Human Resource Organization, June 1975.

The purpose of this research was to evaluate the program designed to implement TEC. Data were gathered to provide the CATB with information to identify possible alternative actions for improving the implementation, management, and distribution of TEC on an Army-wide basis. The evaluation consisted of gathering data on the utilization, maintenance, and perceived benefits of the TEC system. These data were collected by means of questionnaires, interviews, maintenance forms, and a utilization form. A survey of the initial group of Active Army and Reserve Component units that received TEC showed that desired levels of usage had not been reached because of a lack of command emphasis.

Conclusions were:

(1) TEC had not been implemented for a sufficient length of time to permit an adequate evaluation.

(2) An adequate library of lessons was not available for meaningful study in terms of either MOS proficiency or accomplishment of unit training goals.

(3) Results were biased since one unit accounted for 80% of the TEC usage.

(4) During the period of observation there was an increased usage of TEC in the group mode.

(5) Command emphasis and information concerning the TEC system were reduced in content and importance during transmission down through the chain of command.

(6) Attitudes of trainers and users were moderately positive.

(7) Battalion level TEC learning centers did not appear to be the most appropriate or effective level for distribution of TEC materials.

(8) Personal interviews suggested that TEC utilization might be increased by thorough promotion at the company level and by dividing the TEC hardware and software allocation between battalion and company levels. If equipment is to be used for groups, the projection capability should be increased to 30-200 person suitability. Learning centers should have full-time personnel assigned and an operating budget. A system of rewards and incentives for trainers and users might increase usage; and the final suggestion, some of the simple maintenance should be decentralized to the battalion level.

Department of Army, "TEC cost and operational effectiveness analysis (TEC COEA) in TRADOC TRADER format." Fort Benning, GA: Combat Arms Training Board. 4 August 1975.

When the TEC system was in its acquistion stage, a cost and operational effectiveness analysis (COEA) for TEC was conducted for TRADOC TRADER by the Combat Arms Training Board (CATB), Fort Benning, Georgia. The baseline was the then-current training system in individual skills at the unit level, described as carried out by unit officers and NCOs. It was further described as follows:

> Usually, the designated unit instructor develops a custom-made program of instruction (POI) using available training literature (which is often outdated), and whatever training aids are available. The class is normally presented by lecturer and the POI is seldom used again. Little diagnostic testing or post-instruction performance testing is ever planned or conducted.

The proposed alternative was the TEC Training System(here training system is used in a non-specific or generic sense). It was described as multimedia standardized instructional materials prepared by service schools for use in the field. The TEC material was viewed as designed for either small group or individual self-paced mode.

No new research was conducted by the COEA study group. They concluded that TEC was an extremely effective system based on an ARI COEA conducted for DCSPER. The effectiveness part of this study was the work conducted by Knerr et al. (1975). The ARI COEA also concluded that TEC trained soldiers, both Active Army and National Guard, performed significantly better than those trained on conventional methods and at lesser cost.

The CATB COEA conducted an indpendent cost analysis. They compared costs based on 1064 battalions using 100 hours of annual instruction. This level of implementation was predicted for 1977. Start-up and initial distribution costs were calculated as of 1974. They also assumed an economic life of $<$ 1 year for the baseline system since their field research showed that unit instruction was tailormade for each instructional situation and seldom recycled. The economic life of TEC hardware was estimated at 6 years; software development and revision, continuous. Total discounted costs (FY74-FY80) were shown to be almost 1½ times higher for conventional training then the proposed TEC-augmented training. (See attached tables.) The savings was based on cost avoidance --TEC was foreseen as requiring less officer/NCO support at the battalion level.

Non-quantifiable elements were also examined for the COEA. A consultant's report mentions emphasis on trainee's needs rather than instructor's, creation of a training R&D capability applicable to other future needs, and many beneficial effects at the service schools and in Army training in general. He says, "Consequently, the TEC system has become a model of (sic) other training oriented R&D projects within TRADOC."

The COEA study groups conclusions were as follows:

1. RELATIVE EFFECTIVENESS

	OVERALL EFFECTIVENESS	COST ($ MILLION)
TEC	87.5*	42.7
CONVENTIONAL	67.5*	50.5

*Active Army and National Guard averaged (Equal N's assumed).

Relative effectiveness (TEC vs CONVENTIONAL) = 87.5/67.5 = 1.30

2. RELATIVE COST

TEC/CONVENTIONAL = 42.7/50.5 = .84

3. RELATIVE WORTH

TEC/CONVENTIONAL = 1.30/.84 = 1.54

4. CONCLUSIONS OF THE ARI STUDY

1. On the average TEC instruction teaches both written posttests and hands on performance tests better than conventional, live instructor instruction.

2. The state of training in individual skills in both the Active Army and National Guard is generally poor.

3. TEC teaches soldiers with low abilities and high abilities equally well, whereas conventional instruction is not as effective with low ability soldiers as it is with high ability soldiers. Over all ability groups, TEC teaches "better."

4. Considering all costs, TEC is more cost-effective than conventional instruction in units.

Temkins, S., Connally, J. A., Marvin, M.D., Valdes, A. L., and Caviness, J. A. A cost assessment of Army training alternatives. Research Problem Review 75-3. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, August 1975.

This cost assessment was undertaken specifically to provide comparative cost data on TEC for individualized instruction and on equivalent conventional classroom Army group instruction as a part of a cost-effectiveness study of TEC. Costs were estimated based on historical data and tabulated for developmental and operational use of typical TEC lessons and conventional group instruction. The two were compared in a "comparison module" (defined as 100 lessons per year to each E3-E4 in a standard infantry battalion).

The findings were as follows:

The development cost for TEC was estimated at $15,920 per lesson. Operational cost was estimated at $38,279 per battalion (533 men). The conventional system has no development costs; operational costs equivalent to 100 TEC lessons were estimated at $47,437 per battalion, chiefly instructors' time. Under a projected expanded utilization to 1,064 battalions per year, TEC annual costs (including lesson development and revision) would total $42,100,000 against projected conventional annual cost of $50,473,000. Based on an estimated 5-year lesson life, development costs under expanded utilization are estimated at about $600 per battalion to 200 lessons, with an additional estimated annual cost for revisions of $690 (1975 dollars) per battalion.

The authors concluded that use of TEC individualized instruction with either cassette tape or audiovisual aids is projected to be less costly in comparison to conventional instruction as volume of use increases.

The finding assumes optimal use of TEC by individuals. Group use although seen as a possibility is not considered nor is under-utilization or cost effectiveness. However, the caveat was expressed that the level of implementation must be as assumed in the study to effect an annual cost savings.

The developmental costs are identified by the following categories:

Job Analysis

1. Selection of Duty Position
2. Job ID
3. Preparation of Task Statements
4. Preparation of Task Inventory (lists)
5. Selection of Tasks for Training Development
6. Job Task Data Cards
7. Selection of Common Tasks
8. Field Validation
9. Reviews

Curriculum Design

1. Coordinate Summary Test
2. Prepare Lesson Tests and Treatment
3. Draft Scripts
4. Prepare Storyboards
5. Motion Pictures
6. Group Trails
7. Art Work
8. Retrial Cycle

Curriculum Review

1. CSS Review Board
2. Final CSS and GFM Review Board
3. Review and Analysis
4. Lesson Treatment
5. Script
6. Storyboard
7. Post Individual Trial Analysis
8. Final Storyboard Review
9. Group Trial Analysis
10. Final Audio Review
11. Final Art Review
12. Answer Print Review and Approval (35mm and Super 8mm)

Operational costs were accumulated in these categories:

(1) At combat arms school

-job analysis
-curriculum design and follow-through
-curriculum reviews

(2) At USACATB

-hardware and equipment for TEC system
-development

(3) Lesson contractors

(4) Lesson masters

(5) Reviews

Conventional group training was the only instructional alternative compared to TEC. No developmental costs were included (sunk costs). Operational cost categories were as shown in Table 1. Cost for all activities common to both groups were excluded.

TABLE 1 COSTS OF PREPARATION TIME, CLASS TIME, AND INSTRUCTIONAL SUPPORT TIME

)R 10 CONVENTIONAL GROUP INSTRUCTION CASES FOR CONTENT COMPARABLE TO TEC LESSONS: IN 1975 DOLLARS

COMPARABLE TEC LESSON NUMBER BASE	NUMBER OF TRAINEES	INSTRUCTOR CLASS PREPARATION TIME COST (1975 DOLLARS)	INSTRUCTOR CLASS TIME COST (1975 DOLLARS)	SUPPORT TIME FOR INSTRUCTOR COST (IN 1975 DOLLARS)	TOTAL (IN 1975 DOLLARS)
4	17	9.47	34.75	21.90	66.12
6	10	10.68	25.67	15.13	51.48
5	8	35.00	31.50	62.78	129.28
5	10	22.15	53.16	22.80	98.11
2	10	12.62	15.78	19.89	48.29
2	20	22.59	10.04	37.77	70.40
3	20	22.60	10.17	12.40	45.17
3	10	21.00	14.00	10.67	45.67
4	7	20.04	5.01	30.04	55.09
4	15	28.25	10.17	30.06	68.48
lesson per soldier cost		$ 0.41	$ 0.42	$ 0.53	$ 1.48

Source: ARI/HRU, Fort Benning

Some other concerns were addressed. One was the implication of doctrinal change. The possibility was anticipated at different rates by four schools queried and a factor to estimate TEC revision costs included in calculations. Inflation factors were applied.

Another concern was the effect of technological obsolescence. USCATB foresaw that the Besler CUE/SEE and tape cassette player would be adequate for "another ten years" (i.e., 1984-85). They felt that "only a progression to other instructional techniques, e.g., interactive branching, would require a different kind of equipment".

Goetz, J.A., LTC, "TEC-validated service school instruction at the unit level". A paper presented at the 8th NTEC/Industry Conference and published in Proceedings: New concepts for training systems. Orlando, FL: Naval Training Equipment Center, 18-20 November 1975.

In this symposium presentation LTC Goetz presents a history and excellent description of the TEC program (to date 1975). He reports the results of TEC validation. Forty-eight Armor, 27 Infantry, 53 Field Artillery, and 53 Air Defense Artillery lessons were evaluated by students. Using the TEC Post test, students averaged 39.1% items passed before training and 91.9% passed after training. He concludes that the "validation procedure in effect guarantees that TEC lesson (sic) will teach."

Knerr, C.S., Downey, R.G., and Kessler, J.J. Training individuals in Army units: TEC lessons and conventional methods. Research Report 1188. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. December 1975.

The Army has developed a system of self-paced audiovisual lessons--the Training Extension Course (TEC) -- designed to upgrade individual skills and to help commanders conduct individual proficiency training. This report compares the effectiveness of TEC training with that of conventional Army classroom instruction, evaluating both against a baseline level of performance.

Five TEC lesson categories (courses) were used, four from infantry training and one from field artillery training. Five hundred eligible soldiers were selected by their units for training at two Army posts and from a National Guard division. Each soldier was assigned to one course. Participants were randomly divided into three equal groups. The first group received the TEC lessons; the second group received conventional instruction (CI) on the same topics; and the third, baseline (BL), group received no special training during the research.

Following administration of a pretest, a hand-on performance test for each course was given all participants after the training to measure the comparative effectiveness of each training method.

The TEC-trained groups in general scored highest in the performance tests, followed by the CI groups; BL groups performed least well. The TEC groups performed consistently better than the BL group. The TEC groups performed better than either the CI or BL groups on tests that emphasized reasoning and information. TEC and CI groups performed equally well, and better than the BL groups, on performance tests that emphasized skill with equipment and psychomotor activities.

In the Active Army, performance test scores in the TEC groups were equally high for persons with low and high general mental ability, as measured by the GT aptitude area score. In contrast, performance test scores for CI groups were generally lower for persons with lower general mental ability.

TEC lessons consistently improved soldier performance regardless of the soldiers' level of mental ability, suggesting TEC would be particularly useful for training of mixed-aptitude personnel. Where skill or practice with equipment is involved, however, conventional instruction is equally effective. Results are expected to generalize to other situations, as findings were basically the same in the three different sites of this research.

The number in each experimental group and other relevant statistics are as shown in the following tables.

(Knerr) Table C-10

ACTIVE ARMY CORRELATIONS AMONG PERFORMANCE TEST, LAI PRETEST, AND GT SCORES

Lesson Category	Training Group	Performance and LAI Pretest	Performance and GT	LAI Pretest and GT	N
Hand Grenades	TEC	.62*	-.02	.40	13
	CI	.83*	.61*	.69*	15
	BL	.41	.24	.60*	20
	Combined:	.47*	.16	.52*	48
LAW	TEC	.32	.06	.39	18
	CI	.30	.54*	.36	16
	BL	.57*	.44*	.72*	19
	Combined:	.42	.30*	.44*	53
M16A1 Rifle	TEC	.15	.02	.48*	26
	CI	.51*	.24	.46*	22
	BL	.37	.43*	.21	26
	Combined:	.36*	.21	.36*	74
Mortar FDC	TEC	.76*	-.13	.26	17
	CI	.63*	.27	.21	18
	BL	.48	.71*	.66*	16
	Combined:	.66*	.26	.44*	51
Surveyed Firing Charts	TEC	.51*	.02	.13	21
	CI	.77*	.11	.35	20
	BL	.44	.27	.48*	18
	Combined:	.56*	.09	.32*	59

*$p < .05$

(Knerr) Table C-11

ACTIVE ARMY PERCENT CORRECT ON LAI PRETESTS AND POSTTESTS

Lesson Category	Training Group	Percent Correct	
		LAI Pretest	LAI Posttest
Hand Grenades	TEC	46%	88%
	CI	42%	54%
LAW	TEC	43%	83%
	CI	44%	56%
M16A1 Rifle	TEC	44%	78%
	CI	38%	49%
Mortar FDC*	TEC	73%	94%
	CI	57%	72%
Surveyed Firing Charts	TEC	42%	67%
	CI	43%	57%

*Lesson No. 010-071-6601 tests only

Knerr (Table D-9)

NATIONAL GUARD CORRELATIONS AMONG PERFORMANCE TEST, LAI PRETEST, AND GT SCORES

Lesson Category	Training Group	Performance and LAI Pretest	Performance and GT	LAI Pretest and GT	N
Hand Grenades	TEC	.05	.58*	.40	20
	CI	.73*	.31	.21	20
	BL	.58*	.36	.63*	19
	Combined:	.46*	.32*	.40*	59
LAW	TEC	.25	.13	.06	19
	CI	.27	.15	.44	20
	BL	.08	.18	.03	20
	Combined:	.09	.18	.20	59
M16A1 Rifle	TEC	.14	.27	.23	15
	CI	.45	.37	.36	15
	BL	.04	-.01	.46	13
	Combined:	.36*	.08	.21	43
Mortar FDC	TEC	.48*	.26	.31	18
	CI	.32	.49*	.43	17
	BL	.42	.31	.41	19
	Combined:	.41*	.32*	.36*	54

*$p < .05$

(Knerr) Table D-10

NATIONAL GUARD PERCENT CORRECT ON LAI ~~POSTTEST AND POSTERS~~ PRETESTS AND POSTTESTS

Lesson Category	Training Group	Percent Correct	
		LAI Pretest	LAI Posttest
Hand Grenades	TEC	39%	89%
	CI	36%	37%
LAW	TEC	40%	83%
	CI	42%	51%
M16A1 Rifle	TEC	48%	82%
	CI	44%	57%
Mortar FDC *	TEC	52%	83%
	CI	42%	69%

*Lesson No. 010-071-6601 tests only.

Leonard, R.L., Jr., Wheaton, G.R., and Cohen, F.P. Transfer of training and skill retention. TR-76-A3. Alexandria, VA: U.S. Army Institute for the Behavioral and Social Sciences, October 1976.

The objective of this research was the exploration of the retention of training content and transfer of that training to a criterion performance test. The research team also explored the impact of refresher training on transfer. A three-phase experiment was carried out over a 17-week period using 106 Army personnel divided into six groups. The original training was provided by TEC lessons dealing with selection, maintenance, and use of hand grenades. Three groups were given refresher training by re-exposure to the TEC materials at varying intervals from the original training.

Findings provided empirical support for the Army's policy of evaluating training programs with performance oriented criterion tests.

Of relevance to a study of TEC, the research noted several problems. Quoting from their summary:

> Finally, several problems that were encountered with the TEC training materials are worth mentioning. The Bessler Cue-See machines employ separate tapes for the audio and visual portions of the program. The video portion is rewound completely by pushing a single button on the front of the machine while the audio portion can be rewound partailly just like an ordinary tape recorder. Unfortunately, the video rewind button is located adjacent to the "continue" button which the subject presses to restart the program after he has answered a question. It is quite easy to confuse the buttons and once the video rewind button has been pressed there is no alternative but to rewind the audio portion as well and start the program over. Since the programs are 30-45 minutes in length, the necessity to start over can waste considerable time. Also, the use of separate video and audio tapes makes it quite easy for the two to be out of phase, especially if the audio tape is not fully rewound from the previous use. It would seem that these features could be corrected by a fairly simple modification of the Bessler Cue-See machine since the overall value of the machines appears to be high.

This study had some potential for evaluating the effectiveness of TEC as training medium. However, all the subjects had previously received training in hand grenades during Basic Combat Training and Advanced Individual Training using other media/methods.

One of the six groups was designated an "untrained" control. They were given a criterion referenced performance test (CRT) followed immediately by TEC training and a post-TEC training test. This group was the only one to be tested before TEC training. After 17 weeks the control group received TEC training as a refresher, followed by both tests. This control group showed significantly lower scores when results were examined for transfer from TEC to four CRT subtests as a function of time since training and as a function of time between initial and refresher. On one category -- identifying components of a hand grenade -- the difference was not significant. This was blamed on poor coverage of test items in the TEC material. This indicates that TEC is a successful refresher training media, although the final sample was small.

Swezey, R. W. and Eakins, R. C. Task Report Training Extension Courses Research: Task B-1, Measures of Effectiveness: Development of Performance Tests for Use in Evaluating the Training Extension Course Program. Ft. Benning, GA. Litton Mellonics Systems Development Division, September 1977. Unpublished paper.

This task report is one of a number on the research support provided to the ARI, Ft. Benning Field Office. It documents the development and validation of tests designed to measure the individual performances of Army personnel. The authors describe the construction of the tests, content validation, trial administration of tests, revisions made during the tryout, and final revisions. Samples of the lessons and the performance measures are shown in Table 1 and 2.

Five independent performance tests were developed for use as criterion variables in a training evaluation experiment that compared Active Army and Reserve Component personnel using TEC instructional programs with similar personnel receiving conventional instruction in the same content areas.

The tests were administered to personnel in both Active Army and Reserve Component units as part of a controlled experiment analyzed in a separate report.

Taylor, John E., Suchman, J.R., Melching, W.H., and Bialek, H.M. Development of an individual extension training system for managing and conducting training in the Army unit. TR-77-A8. Alexandria, VA: Army Research Institute for the Behavioral and Social Science, October 1977.

This report documents the first year of work* to develop a performance based system for the conduct of individual training and evaluation in Army combat units. The work was undertaken in three phases: (1) Background information was gathered and prototype extension learning packages developed; (2) a model of an Individual Extension Training System (IETS) was designed; (3) the prototype IETS was field tested with units of the 7th Infantry Division, Fort Ord, California.

The authors conclude that it is feasible to develop a viable individual extension training system that will mesh with the Enlisted Personnel Management System (EPMS) and Skill Qualification Test (SQT).

*See Bialek et al., 1978 for the second report of this series.

PM TRADE, Interim specification for training extension course (TEC) materials. Orlando, FL: U.S. Army Project Manager for Training Devices, 20 October 1977.

This specification describes requirements for the development and reproduction of training kits within the Training Extension Course (TEC). As described, the kits contain training material in a synchronized audio-visual format, printed text (camera-ready) format, and audio-only format, together with adjunctive training materials in graphic format such as student checklists, hand-outs, and guides for TEC lessons. Following contractor development, the training kits are reproduced for use by Army units in the field.

Sections include required and optional items for the kits; a list of applicable military and/or federal standards; requirements for lesson design, media selection, other deliverables, and validation of lesson material; and quality assurance provisions. Although entitled "interim" and published in 1977, these specs were still in use, unrevised, in the fall of 1980.

Strasel, H.C., Holmgren, J.E. Bercos, J., Shafer, J. and Eakins, R.C. Training Extension Courses (TEC): Cost and Training Effectiveness. Research Project Draft. ARI, Ft. Benning Field Unit. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, November 1977. Draft.

This report summarizes an extensive series of research efforts on the TEC program. This program included detailed research into the training effectiveness of TEC, the current and programmed costs and usage of TEC in the Active Army and Reserve Components, and an analytic examination of the cost effectiveness of TEC.

The principal stated finding is that "TEC is both cost and training effective at the current levels of training effectiveness and the current level of usage. Analyses further indicate that if TEC usage is raised through command emphasis and development of better methods and strategies for TEC implementation, the cost and training effectiveness of TEC will be greatly increased."

Both analytical and empirical approaches to research were used. The empirical approaches included:

- An experimental study of the effectiveness of TEC training and the retention of learning with TEC in comparison to conventional training and no training, for both Active and Reserve Components.

- A survey of TEC usage and the attitudes and problems expressed by TEC users, non-users, Training officers and NCOs, and Training Support personnel, in CONUS and USAREUR Active units and Reserve Units.

- An analysis of the relationship of TEC lesson usage and SQT performance in six Battalions in CONUS.

- Collection of all identifiable costs related to previous TEC program and projected costs on a uniform annual cost basis for the next ten years.

- Collection from TRADOC Schools of ways TEC has been used to supplement or substitute for conventional training and the cost savings therefrom.

Using these and other data, a series of analyses were performed to determine the potential and real cost effectiveness of TEC training for the U.S. Army.

A study of application of TEC material at six TRADOC schools showed cost savings when TEC was used in six cases of institutional training, cost avoidance in 25 cases of usage in self-paced instruction but actual cost to the Army in 12 cases of use in the remedial or supplemental mode. An overall cost saved/avoided in FY 77 was estimated at $3.1 million.

Table 1

TEC LESSONS SELECTED FOR INCLUSION IN THE STUDY

Lesson Identification Number	Lesson and Category Title	Applicable U.S. Army Combat Arm	TEC Status Level (1 January 1977)
	Tube Artillery	Field Artillery	
041-061-6101-F	Test of the Gunner's Quadrant, Part 1		3
041-061-6102-F	Test of the Gunner's Quadrant, Part 2		3
	M60 Machinegun	All Soldiers	
941-071-0078-F	The M60 Machinegun: Mechanical Training, Part 1		1
941-071-0079-F	The M60 Machinegun: Mechanical Training, Part 2		4
941-071-0080-F	The M60 Machinegun Mechanical Training, Part 3		1
941-071-0084-F	The M60 Machinegun: Firing and Zeroing		1

Table 2

PERFORMANCE TESTS WITH ASSOCIATED PERFORMANCE MEASURE GROUPS

Performance Test:	Performance Measure Groups:
M60 Machinegun (for use by all soldiers)	1. Demonstrate changing the barrel of the M60 machinegun to prevent overheating.
	2. Demonstrate the 3 assault positions for firing an M60 machinegun.
	3. Assume correct position and grip for firing a bipod emplaced M60 machinegun.
	4. Zero a bipod mounted M60 machinegun on target.
	5. Clear ammunition from an M60 machinegun.
	6. Perform a general disassembly of the M60 machinegun into its 8 groups.
	7. Perform assembly of an M60 machinegun so that it functions properly.
Target Engagement, M551 Tank (for use by Armor branch only)	1. Aligning the missile reticle.
	2. Aligning the target and gun/launcher reticle.
	3. Aligning the target and coax machinegun reticle.

Hoyt, W.G., Bennik, F.D., and Butler, A.K. The effectiveness of alternative media in conjunction with TEC for improving performance in MOS related tasks. TR-77-A20. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Science, December 1977.

One of the series of related work conducted for U.S. Army Field Artillery Schools (USAFAS), this report addresses two research questions: (1) Does computer-assisted instruction (CAI) provide a suitable and acceptable media (sic) for delivering TEC materials to field units? and (2) Can Army lesson developers feasibly be trained to convert self-paced, audio visual material into CAI format and easily update such material?

TEC materials were converted to CAI format as the first step. The job sequence for each task was followed. New topics were introduced as needed. The research report stated that this "provided a logically-structured, integrated, functional, product-oriented, learner-centered approach" - a formal ISD process.

Four USAFAS course development personnel were taught to convert TEC audio visual lessons-to CAI. Both sets of lessons had the same training objectives. Four hundred and ninety hours were required for learning the conversion process. Two TEC lessons were converted during the training period and four more during the next six weeks. The six CAI lessons on Observed Fire were accompanied by computeruzed course listings, test scoring, student records, and other course development administration. An evaluation and review was conducted by subject matter experts (SME) and Army students. The costs were reported as follows:

Course developer	111 hours
SME (2 @ 1½ hours)	3 hours
Students (7 @ 2 hours)	14 hours
Computer	$381
Telephone	$300

Therefore they estimate 128 man-hours and $681 for each CAI lesson. Working independently the contract research team developed print media lesson material for the same six lessons. This provided three media (and combinations) to the Field Artillery School for future tests -- TEC, CAI, paper.

Although not a formal COEA, it was concluded that CAI is low cost; development and evaluation lead time, short; and Army developers can be trained to convert TEC lessons. It is suggested expensive, dedicated CAI systems may not be necessary but deployed, time-shared, mini, and tactical computers be used.

Bialek, H.M., Taylor, J.E., Melching, W. H., Hiller, J.H., and Bloom, R. D. Continuation of development of an individual extension training system for managing and conducting training in the Army unit. TR-78-B1. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. January 1978.

The purpose of research reported in this document was design of a management tool -- an individual extension training system (IETS) combined with the CATB - developed battalion management program (BMP). The components are management procedures, record keeping techniques and forms, packages (modules) of task training materials and performance checkouts for developing and assessing soldier skill proficiency, and guidance for trainers and training supervisors in operation of IETS. Compatible with SQT, EPMS, SM, TEC, and Army Correspondence Program (ACP).

Training task packages (TTP) for each duty position refer to TEC, FM, and Army Correspondence Courses (ACC) as "related sources" to use. In this system use of TEC lessons is up to individual initiative and so is record keeping. However, for some tasks, TEC is the only training aid listed.

This system would have provided excellent historical data for study of TEC utilization but it is believed not to have been implemented.

Smillie, R.J., Keller, J.M., Setzler, H.H. Task Report -- Training Extension Courses: Development of a TEC Manager's Guide. Ft. Benning, GA: U.S. Army Research Institute for the Behavioral and Social Sciences, January 1978.

This Guidebook is a job performance aid for Training Extension Course (TEC) managers and developers. As a source reference it provides information on the organization, management, and supervision of a TEC program; and the preparation, development, validation, and dissemination of TEC lessons. For other personnel involved with TEC, the Guidebook serves as a comprehensive overview of the TEC development process.

The Guide, extensively indexed and illustrated with graphics, is available as the TEC Manager's Guidebook from the U.S. Army Training Support Center, Ft. Eustis, VA.

Bennik, F.D., Eoyt, W.G., and Butler, A.K. Determining TEC Media Alternative for Field Artillery Individual-Collective Training in the FY78-83 Period. TR-78-A3. Alexandria, VA: U.S. Army Institute for the Behavioral and Social Sciences, February 1978.

This report is the second of the reports dealing with TEC conducted for the U.S. Army Field Artillery School (USAFAS). This particular document addresses planning for the utilization of TEC media during the period FY78-83. As background, the authors note that to date TEC exportable training has meant a narrow range of delivery systems -- audio visual filmstrips for the Beseler-Cue-See, printed materials, and audio-directed practice cassettes for use in fixed or portable tape players. Therefore they have expanded TEC to include more innovative delivery systems such as computer-mediated training support; simulation devices for training and evaluation in marksmanship/gunnery and fire direction; tactical games, command staff simulation exercises, and two-sided engagement simulations.

Army training doctrine and developments seen affecting resource selection and utilization in FY 78-80 are identified as are USAFAS training support situations. The research group designed a preliminary delivery systems selection model and identify delivery systems actually or potentially available. Finally, they provide a plan for export and evaluation of USAFAS-produced computer-assisted instruction lessons.

The major findings of the research are as follows:

1. A need exists for: (1) closer attention to soldier characteristics; (2) increased realism of delivery system components; (3) selection of techniques less demanding of costly resources; and (4) closer integration in the choice of training delivery systems.

2. More emphasis on personnel considerations, integrating them in life cycle management.

3. Consideration in FY 78-83 of training systems embedded in fielded weapon systems; establishment of data files containing characteristics, operational status, accessibility, and constraints of training delivery systems.

Sassone, P. G. Task Extension Course Research: Literature review, cost and training effectiveness. Ft. Benning, GA: Litton Mellonics System Development Division, July 1978.

Related earlier TEC reports in this series focused on the cost and training effectiveness of TEC, with effectiveness as function of individual performance on selected hands-on performance tests, and the relation of TEC usage to individuals' performances on their SQTs.

This report documents the conduct and findings of a training cost and effectiveness literature search and review of selected literature; it serves as the introduction to the subsequent research to develop a TEC Cost and Training Effectiveness (CTEA) methodology, where effectiveness will be a function of units' performance (squads, sections, crews) on selected missions and tasks in their ARTEP evaluation (Army Training and Evaluation Program).

Five methodology requirements for a TEC CTEA are specified; and it is suggested that the methods of microeconomics and welfare economics can be used to approach the methodological requirements. The logic of a TEC Cost Training Effectiveness Analysis (CTEA) methodology under these precepts is discussed.

Benesch, M. A., Bennik, F. D., Butler, A.K. and Silver, L. A. <u>TEC media alternatives for the FY 78-83 period: MOS 13F/FIST Sample Application.</u> P-78-5. Alexandria, VA. U.S. Army Institute for the Behavioral and Social Sciences, October 1978.

This report is a demonstration or application of the method for delivery systems selection described in Butler et al. (1978) together with the delivery systems data based described in Silver et al. (1978). The example uses tasks and personnel data from MOS 13F FIST (Fire Support Team).

The "walk-through" example is designed to be realistic as possible. A selected set of training requirements is applied to the procedure of determining a delivery system mix for the training program.

Dept. of Army, Training Acquisition Handbook. Ft. Monmouth, N.J.: U.S. Army Communication Research and Development Command, 1 November 1978.

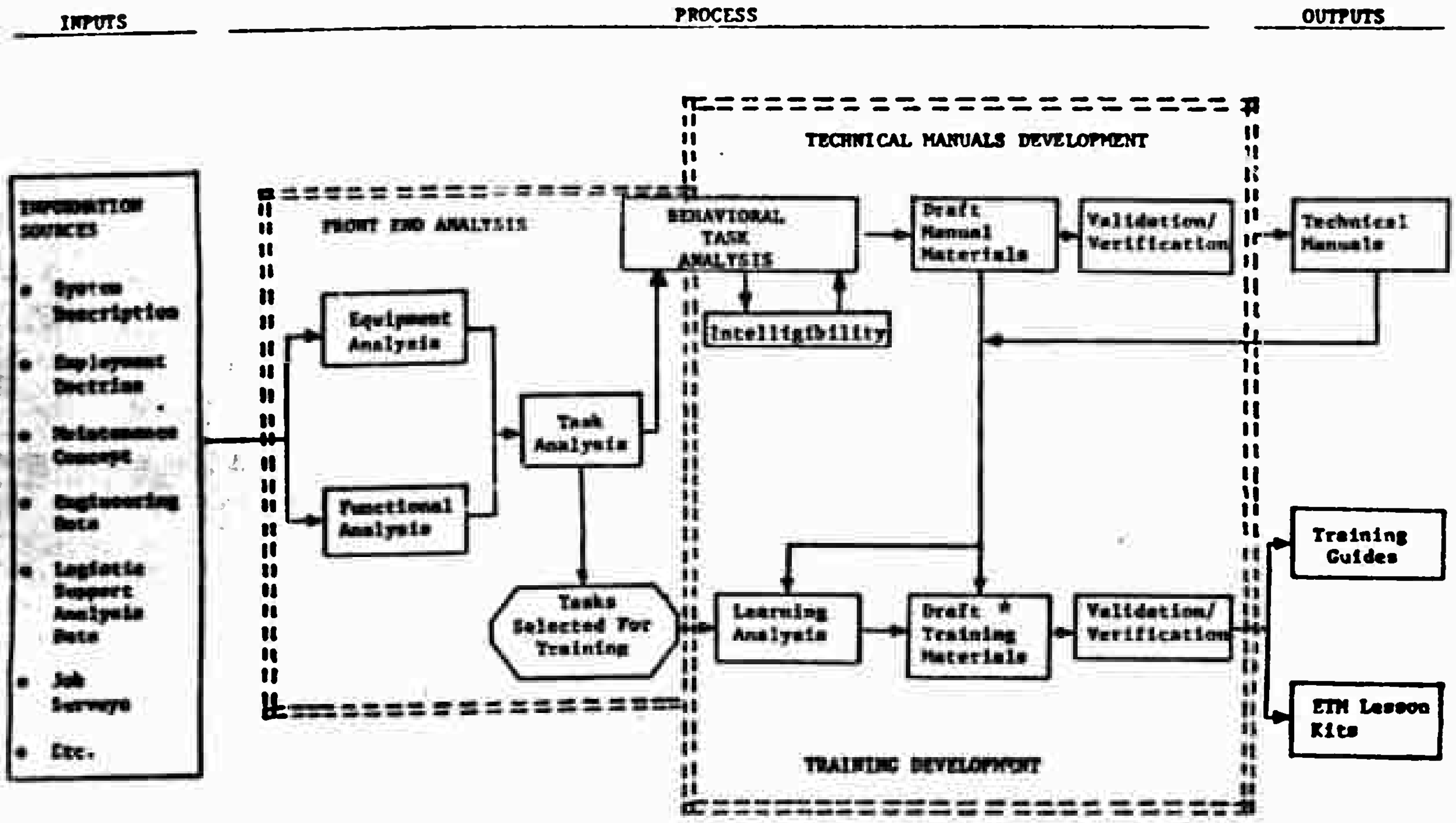
The Training Acquisition Handbook was prepared by CORADCOM to provide a consolidated set of information and guidelines covering training requirements in the Army weapon system acquisition process. It was prepared under the joint auspices of TRADOC and DARCOM.

Consideration focus is placed on acquisition of extension training materials (ETM), treated as a part of acquisition of skill performance aids (SPA). SPA are defined as an integrated package of technical documentation and training to provide the soldier with information and skills required for on-the-job performance.

Components of ETM are training managers guides (TMG), student guides (SG), lesson administrative instructions (LAI), student lesson sheets (SLS) and lesson content materials. The lesson content materials are offered in several media options -- audiovisual, written, audio, computer mediated (CAI, CMI) and training devices and simulators. It is here that TEC fits in. The lesson formats are generally modeled in a TEC format which provides for three instructional media: audiovisual, written, and audio. This guidebook holds that materials in written form are preferred and that use of other formats must be justified by a media analysis. A depiction of their process is shown in the accompanying figure. A need for TEC is discovered during the learning strategy determination which decides on the presentation media for each lesson.

The authors note that the ETM process can also be applied to fielded systems. Specifications for detailed TEC requirements are stated to be contained in MIL-M-63040, Manuals, Technical: Extension Training Materials for Integrated Technical Documentation and Training (ITDT), 1 May 1977.

Fig. 1 SKILL PERFORMANCE AIDS DEVELOPMENT PROCESS



* Development of TEC lessons at this point

Table 2-2. Representative Instructional Media

<u>Instructor with Standard Aids</u>

1. Instructor/Training Supervisor
2. Charts and Display Boards
3. Overhead Transparencies

<u>Printed Materials</u>

1. Standard Printed Materials
2. Programmed Instruction Texts
3. Microform

<u>Audio Visual</u>

1. Audio Tapes
2. Slides and Sound-Slides
3. Filmstrips and Sound-Filmstrips
4. Motion Pictures and Sound Motion Pictures
5. Television and Video Recordings

<u>Training Devices and Simulators</u>

1. Teaching Machines
2. Models and Mock-ups
3. Hardware Simulator-Trainers
4. Actual Objects

<u>Computer Mediated Training Support</u>

1. Computer Managed Instruction (CMI)
2. Computer Assisted Instruction (CAI)
3. Computer-Based Team Training

Butler, A. K., Bennik, F. D., Benesch, M. A. and Silver, L. A. TEC media alternatives for the FY 78-83 period: procedure guide for delivery systems selection. P-78-3. Alexandria, VA. U.S. Army Institute for the Behavioral and Social Sciences, November, 1978.

This volume (Procedure Guide for Delivery Systems Selection) was produced as Annex A of TEC Media Alternatives for the FY 78-83 Period: Final Report. The Procedure Guide is designed to aid the developer in deciding on selecting, or developing the best mix of Army delivery systems both for an overall training program and for each of its lesson modules. Delivery systems are defined as providing the media and training management methods to conduct training and evaluation of soldiers who are to be the users of Army material systems, or who require proficiency in the performance of tasks within a specific MOS.

The developers take into consideration the influence and impact of trainee requirements and subject matter characteristics on the decision making process for delivery system selection. In addition, the effect of the settings where initial training and sustaining skills practice occur and the relation of setting exportability of delivery systems for use at unit levels are provided within the procedure. Other factors that the procedure addresses are the overall requirements and constraints such as type of program, lead time, training method and funds available.

An overview of the procedure is shown in Figure 1, showing major inputs and results for the two major procedural blocks. The report also includes a flow chart for each major step and substep in each of the procedure blocks (Training Program Mix, Module Lessons Mix). Various guidelines and checklists have been drawn up to assist the user in applying the procedure.

Block I in the procedure is used to select a mix of delivery systems that meet the major training program requirements and constraints. The procedure directs the user to consult the Delivery Systems Data Base (Silver et al., 1978) at appropriate points to determine delivery system candidates. From this candidate pool, the specific delivery systems for the program are selected and the rationale for their selection is prepared. The delivery systems are currently available or will be available in the near future (FY 78-83).

The function of Block II is to assist the user in determining the best delivery system mix for individual module/lesson instructional materials. Block II starts with the products of the design phase: objectives, lesson design approaches (LDAs), and module objective sequence strings. The user reviews the selected delivery systems for the training program for Block I and from this pool assigns the best delivery system mix for each individual model/lesson. Guidance is given on preparing a rationale on the particular selection for the lessons in a module.

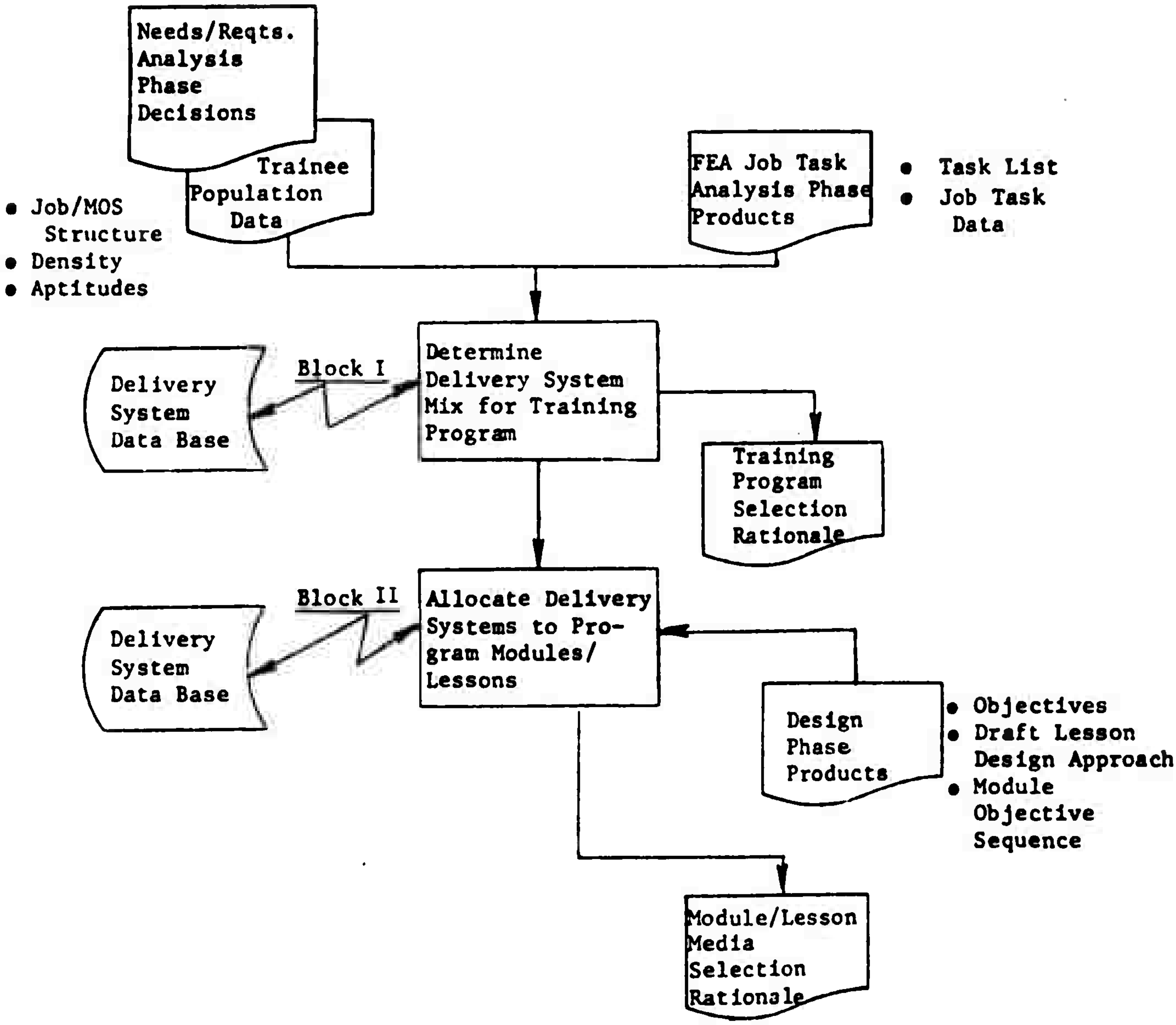


Figure 1. Delivery System Selection Procedure

Silver, L. A., Bennik, F. D., Butler, A. K. and Benesch, M. A. TEC media alternatives for the FY 78-83 period: delivery systems data base. P-78-4. Alexandria, VA. U.S. Army Institute for the Behavioral and Social Sciences, December 1978.

The 457 page volume describes a delivery system data base. It contains extensive information on a wide range of Army delivery systems either currently available to USAFAS and/or Field Artillery units, or projected to be available from DA sources in the FY 78-83 period. It was produced as Annex B of TEC Media Alternatives for the FY 78-83 Period.

The Delivery Systems Data Base is designed to be used in conjunction with key decision points of the two-stage Procedure Guide for Delivery System Selection (Butler et al., 1978). The Data Base may also be used independently as a source document. An example of the use of the Procedure Guide together with the Data Base (ARI P-78-4), using selected tasks and personnel data from MOS 13F/FIST (Fire Support Team) is reported in MOS 13F/FIST Sample Application (Benesch et al., 1978).

The data base is organized into "Family" groups, each Family containing one or more "Member" delivery system. A description of the Family precedes its collection of Member files. Accompanying the Family description is a Member Characteristics table which summarizes general information about each member that is contained in the Family file. The data base contains information on 42 members. The delivery system member files are grouped into 12 Families. The Families and Members are as follows:

A. JOB MATERIALS

1. Field Manuals (FMs)
2. Technical Manual (TMs)
3. ITDT Technical Manuals

B. PRINTED MATERIALS

1. TEC Print
2. Correspondence Courses

C. TRANING/COMBAT LITERATURE

1. Soldier's Manual/Job Book
2. Skill Qualification Tests (SQT)
3. Army Training and Evaluation Program (ARTEP)

D. INSTRUCTOR WITH STANDARD AIDS

1. Class Packets
2. Charts/Display Boards
3. Overhead/Transparencies
4. Models/Mockups

E. AUDIO-ONLY

1. TEC Audio-Only
2. Language Labs (GEL)

F. AUDIO VISUAL

1. TEC Audio/Visual (BESELER CUE/SEE)
2. Slides/Sound Slides
3. Army Training Films

G. TELEVISION/VIDEO RECORDING

1. Classroom Closed-Circuit Television (CCTV)
2. Television Trainer (TVT)
3. Video Disc

H. COMPUTER ASSISTED/MANAGED INSTRUCTION (CAI/CMI)

1. Remote-Access PLANIT
2. PLATO IV/TUTOR
3. ABACUS Computerized Training System (CTS)

I. EMBEDDED TRAINING (ET)

1. Operational TACFIRE PLANIT
2. TACFIRE Training System (TIS)
3. TACFIRE Subsystem Team Training (TSTT)

J. TRAINING DEVICES/SIMULATORS

1. Sand Table
2. Fire Control Simulator BT-33
3. Observed Fire Trainer (OFT)
4. Artillery Direct Fire Trainer (ADFT)
5. M-31 Field Artillery Trainer

K. TACTICAL ENGAGEMENT SIMULATIONS (TES)

1. SCOPES
2. REALTRAIN (Exercise for Combined Arms Elements)
3. MILES

L. COMMAND/STAFF BATTLE SIMULATIONS

1. Tactical Exercise Without Troops (TEWTS)
2. CPX Simulation Facility
3. CAMPS (Computer Assisted Map Maneuver System)
4. Combined Arms Tactical Training Simulator (CATTS)
5. FIRE FIGHT
6. DUNN KEMPF
7. PEGASUS
8. First Battle

"TEC Lessons" in the general usage of the term is one member of Family F, Audio Visual. Called TEC A/V (Beseler Cue-See), this member is characterized as suitable for individual or collective use, most levels of task training, institutional and unit setting, currently available, of low acquisition costs, and having both visual and auditory presentation. The complete and detailed description of TEC A/V as contained in this data base follows as Figure 1.

FAMILY: F

MEMBER: 1

F FAMILY: AUDIO VISUAL

1 MEMBER: TEC Audio/Visual (BESELER CUE/SEE)

F.1.1 SOURCE/PROPONENT: Director, Course Development & Training, USAFAS.
Initial Issue: TRADOC Training Material Support Detach., Tobyhanna, PA.
Copies: Chief, Production & Dist., Trng Programs Directorate, ATSC, Ft. Eustis, VA.

F.1.2 DESCRIPTION:

TEC audio/visual consists of continuous loop 8mm color film strip driven by an audio cassette. One lesson consists of one 8mm film strip; one audio cassette; one student instruction sheet pasted to inside cover of a gray plastic box which houses the lesson. This type of lesson is designed to play/operate with the Beseler Cue/See viewing machine. Lesson may also include adjunctive material such as TMs, FMs, and blank forms which support the lesson by providing hands-on application. Designed to prepare student for SQT and/or ARTEP. It is usable virtually at any location with a power source compatible with the Beseler Cue/See. Currently in use at Active, Reserve, and National Guard units, USAR schools, and ROTC schools. While only one instructor is required to run the media-paced instruction, a staff must be maintained to update programmed training materials.

Adaptation to an individual student's needs is provided by use of the Cue/See's pause-proceed system. With it, the film and audio instruction are stopped by a programmed signal to allow the student time for "hands-on" skill practice exercises or written responses to questions. The student can reactivate the program at will by merely pressing the Cue/See proceed button. By using a "Responder" accessory, multiple-choice questions can be presented during the programmed pause. The program will then resume only after the correct answer is given.

F.1.3 TRAINING AND EVALUATION APPLICATIONS:

		COMMENTS
X	Individual	Each TEC lesson is keyed to a task or task group in Soldier's Manuals. Group projection & audio, or headphones for private self-study.
X	Collective	Small-group projection & audio permits teamwork in solving problems, e.g., leadership workshop.

Figure 1. TEC A/V (Beseler Cue-See) as described in the Delivery System Data Base

FAMILY: F

MEMBER: 1

F.1.4.2	RESPONSE:	COMMENTS
	a. Verbal/Symbolic	
	X Choice Selection	Verbal, written, and/or performance,
	X Specific Recall	as programmed in the lesson - lends
	X Composed/Created	itself to multiple-choice.
	b. Performance	
	___ Indication	Depends on performance task.
	___ Manipulation	Performance must be compared with
	X Read/Interpret	lesson or checked by observer.
	X Listen/Interpret	
	___ Voice Composition	
	X Situation Evaluation	
	X Decide Action	
F.1.4.3	TRAINING MANAGEMENT:	
	a. Feedback	
	X Informative	Student can press "proceed" button only
	X Evaluative	Only if student attempts response.
	X Corrective	
	___ Summary	
	X Immediate	
	X Delayed	
	b. Presentation Control	
	X Learner	Push proceed button to advance.
	X Media	Built-in, pace designed for self-
	___ Instructor	taught lesson.

FAMILY: F

MEMBER: 1

F.1.4.3 TRAINING MANAGEMENT (CONT'D)

COMMENTS

c. Sequencing

X Linear

___ Response Branching

___ History Branching

X Repetitive Practice — May be given a series of problems.

d. Recordkeeping

___ Automatic (Temporary Storage)

___ Automatic (Permanent Storage)

X Manual — Required/optional per Trng. Mgmt. Plan.

X None

F.1.5 SETTING:

F.1.5.1 X INSTITUTIONAL

X Service School — See F.1.5.3.

___ Army Training Ctr (ATC)

___ Div/Post Installation Schools

F.1.5.2 X UNIT Active, Reserve, and National Guard units.

___ In-System (Embedded)

X Job-Station — See F.1.5.3.

X Individual Learning Ctr (ILC)

X Barracks/Home

X Garrison Training Area

X Local Training Area

___ Major Training

___ National Range

FAMILY: F

MEMBER: 1

F.1.5.3 X REQUIREMENTS: COMMENTS

Power source compatible with the Beseler Cue/See: 105-130 volts AC. 60Hz, 30-100 watts. Use in field with portable electric generator.

F.1.6 EXPORTABILITY:

X In Units ___ Planning ___ No

F.1.6.1 INITIAL OPERATIONAL CAPABILITY DATE:

X Currently Available

___ Future Date

___ Unknown

F.1.6.2 METHOD:

X Mail/Ship TRADOC, Trng. Material Support Detach., Tobyhanna,

___ Install

___ Remote Access (Telecommunications)

___ In System

___ Job Materials

F.1.6.3 BASIS OF ISSUE:

___ On Demand

X Unit Issue Per distribution plan. 8 Cue/See devices and 4 viewing screens per battalion.

F.1.6.4 SOURCE:

X Known Issue: TRADOC Trng. Materials Detach., Tobyhanna, P

___ Probable Lessons: Chief, Prod. & Dist., Trng. Programs

___ Unknown Directorate, ATSC, Ft. Eustis, VA

FAMILY: F

MEMBER: 1

			COMMENTS
F.1.7	SUPPORT REQUIREMENTS:		
F.1.7.1	LOGISTICAL SUPPORT:		
	X	Storage Areas	Beseler Cue/See, A/V kits, screens.
	X	Spare Parts	Lamps for Beseler Cue/See.
	___	Additional Copies On Hand	
	___	Expendable Material	
F.1.7.2	MAINTENANCE REQUIREMENTS:		
	X Yes ___ No		Provided by the Trng. Aids Office
	___	Operator	supporting each unit.
	___	Organizational Maintenance	
	___	Direct Support Maintenance	
	___	General Support Maintenance	
	___	Depot Maintenance	
F.1.7.3	MANNING REQUIREMENTS: Total = 1		
	___	System Operators	
	X	Instructors/Facilitators	Librarian for materials.
	___	Simulation/Monitor Positions	
	___	Support Personnel	
F.1.7.4	SCHOOL OPERATIONAL SUPPORT:		Staff of officers/civilians with developmental skills in programmed trng.
	X	Special Personnel Skills	materials. Standard photographic gear.
	X	Special Equipment	Access to audio cassette recording,
	___	Facility	pulsing, & reproduction gear unless
	___	Reproduction	contracted out.
	___	Update	

FAMILY: F

MEMBER: 1

F.1.8	COST DATA:	COMMENTS
F.1.8.1	SYSTEM ACQUISITION:	
	___ High	
	___ Medium	
	X Low	Cost of materiel to Army.
	X None	Basis of issue to units.
F.1.8.2	CURRENT OR PROJECTED OPERATIONAL COSTS:	
	___ High	
	___ Medium	
	X Low	Per user session.
	___ None	
F.1.8.3	MAINTENANCE COSTS:	
	___ High	
	___ Medium	
	X Low	Less than $50/day.
	___ None	
F.1.8.4	TRAINING MATERIALS DEVELOPMENT:	
	___ High	
	X Medium	Approximately $4-5K/lesson (30-60 mins.)
	___ Low	or 75:1 ratio (development hrs./lesson hr.)
	___ None	
F.1.9	TRAINEE PREREQUISITES:	
	___ Education	
	___ Physical Skills	
	___ Mental Skills	
	___ MOS Requirements	
	___ Aptitudes	
	___ Schools/Courses	
	___ Training	
	X Other	Lesson-by-lesson basis.
	___ None	

Mays, P. V., Holmgren, J.E., and Shelnutt, J. B. <u>Current Use, Patterns of Use and Factors Affecting Use of the Army Training Extension Course (TEC) Program.</u> TR-79-A3. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, April 1979.

This report describes research designed to determine the extent of use, patterns of use and factors affecting use of TEC lessons based on a survey.

The survey was conducted in two phases. In Phase 1, 134 selected Active and Reserve Component batallions and 37 TRADOC activities within CONUS monitored their TEC use during a two-month period. In these units a form provided by ARI was completed each time a TEC lesson was used.

During Phase 2, 3404 soldiers and 608 unit trainers in 85 CONUS and USAREUR battalions completed questionnaires regarding their TEC use. Battalion level training personnel were interviewed in 42 of these battalions, 16 associated bridgade/division level training officers and seven associated Training Aids Support Centers (TASCs).

The major findings were as follows:

(1) A total of 78,742 uses of TEC were recorded during Phase 1. This yielded, for FORSCOM battalions, an average TEC use per man per month of .353 lessons in the Active Component and .802 lessons in the Reserve Component.

(2) Over 90% of all recorded use occurred in groups. Most of this use was mandatory (81.8%) and occurred during duty hours (96.6%).

(3) Over 50.2% of soldiers sampled in Phase 2 had used TEC; 35.3% had never heard of TEC.

(4) Most soldiers (TEC users), unit trainers, and all interviewees felt that TEC should be continued. Most users, trainers, and interviewees also preferred TEC to 4 of 7 other training methods (lectures, small group instruction, training films, Soldier's Manual).

(5) Reasons most often cited by soldiers for lack of use pertained to ignorance of TEC, unavailability of equipment and lack of encouragement to use. Least often cited were reasons of lack of need for or perceived benefit from TEC training.

(6) Command emphasis on TEC was judged to be small to moderate at all levels and most often took the form of announcements, briefings or specific orders/requests.

(7) Most soldiers (74%) learned about TEC from their unit trainers.

(8) Basis of issue for CUE-SEES and TEC lessons was considered adequate by over half of battalion interviewees.

(9) Equipment failure did not appear to be a significant problem.

The authors of the report state that, "Data on TEC usage, when combined with cost and effectiveness data, will allow determination of the cost effectiveness of the TEC program. It will also be used as input to the development of an implementation plan designed to increase cost effectiveness and promote optimal utilization of the program."

Bercos, J. and Eakins, R.C. Task Report: Training Extension Course Research: Extension of Training Extension Course Cost and Training Effectiveness Analysis Data Collection. Working Paper. Ft. Benning, GA: Litton Mellonics System Development Division. June 1979. Unpublished.

This document contains forms and implementation instructions developed for the collection of unit training data required as input to the Training Extension Course (TEC) Cost and Training Effective Analysis (CTEA) Methodology.

The completed data collection forms were validated in a review by four active Army battalions and were used for the development of hypothetical unit training data.

The collected data constitutes the input requirements to the TEC CTEA Methodology.

Hawkins, W. W. and Kribs, H. D. Technology for an efficient delivery system. NAVTRAEQUIPCEN 78-C-0129-1. Orlando, FL: Naval Training Equipment Center, June 1979.

The purpose of this study was to determine the feasibility, specifications, and costs of using the emerging video and computer technologies for advanced instructional delivery systems (AIDS) in lieu of traditional audiovisual media. To accomplish these objectives the research team surveyed the current state-of-the art media used in ISD-based training for Navy Aviation Weapon Systems. These data served as a baseline. A concurrent survey of technology and costs of potential AIDS was also performed. Third, the cost of AIDS was compared to the current media.

The authors found that if AIDS were part of the media pool available for ISD selection, they would be a feasible, effective choice, delivered at projected 25-75% developmental cost savings.

Holmgren, J.E., Sassone, P.G., and Bercos, J. Task Report Training Extension Course Research: training extension course cost and training effectiveness analysis methodology, Ft. Benning, GA: Litton Mellonics System Development Division, July 1979.

The research covered in this report is the development of a cost and training effectiveness (CTEA) methodology to identify the contributions of Training Extension Course (TEC) training to a unit performance as measured by the Army Training and Evaluation Program.

The development of the Methodology required four areas of specification. First, a measure of unit effectiveness is assumed to be derivable from the pass/fail (satisfactory/unsatisfactory) scoring criteria currently in use. Second, the assumption is made that costs of field, garrison, and TEC training can be determined. Third, that a resource allocation model can be developed from which can be inferred the economic value of TEC. The effectiveness production function assumes some specifiable relation between inputs and outputs of the training process which operates under specific budget constraints. Lastly, the use of the valuation methodology in a present value analysis to derive an ultimate dollar value of TEC is outlined.

The TEC CTEA methodology can be used to provide an objective economic evaluation of the contribution TEC training makes to unit performance. This valuation methodology can also be applied to any training program which serves a complementary, rather than as a substitute, training program.

Osborne, A.D. Human Factors Research: Training Effectiveness and Training Extension Courses. Final Report. Ft. Benning, GA: Litton Mellonics, July 1979. Unpublished.

This report summarizes research undertaken to support ongoing ARI programs--four concerning training effectiveness analysis (TEA) and five related to Training Extension Courses (TEC). The five TEC research areas covered were TEC evaluation, TEC validation, a CTEA literature review, proposed TEC CTEA data collection, and TEC CTEA methodology.

Separate research reports were written fully documenting each subject area.

Osborne, A. D. Task Report: Training Extension Course Research: Training Extension Course Validation. Ft. Benning, GA: Litton Mellonics, July 1979. Unpublished.

This task report documents an investigation and determination of the effectiveness of current practices and procedures used by service schools to validate TEC lessons. The research sponsor was the ARI Field Unit, Ft. Benning, GA.

During the period August to November 1978, TEC validations being conducted by five different service schools were observed.

The validation guidance contained in the TEC Manager's Guidebook is used as the basis for planning TEC validations. Several deviations from the prescribed procedures were observed; however, these adjustments were the results of conscious decisions made with the intent of facilitating mission accomplishment with available resources. The lack of subject matter expert (SME) influence during lesson development and the failure to use hands-on performance tests in validations have an adverse impact on the quality of completed TEC lessons.

This report describes shortcomings associated with the current practices and procedures used in TEC lesson validations and presents suggested modifications.

Sassone, P. G. and Bercos, J. Task Report Training Extension Course Research: Training Extension Course Cost and Training Effectiveness Analysis Methodology. Ft. Benning, GA: Litton Mellonics System Development Division, July 1979, Unpublished Paper.

This report concerns the development of a TEC Cost and Training Effectiveness (CTEA) methodology. It covers the second phase of research reported in Sassone (1978) -- A Review of Selected Training, Cost, and Effectiveness Literature. The authors outline the development of a TEC CTEA methodology. It is unique in that it measures the cost effectiveness of a single part of a total unit training program as measured by the ARTEP. The report discusses the basis of the methodology in economic theory, describes its adaptation to Army training, explains the development of the valuation part of the methodology, presents an algebraic example, and shows the use of the valuation methodology in a present value analysis to derive an ultimate dollar value of TEC. Also discussed is the implementation of the TEC CTEA methodology in terms of data requirements, candidate effectiveness production function, and determination of the value of TEC training.

Markham, Roger D. "Immediate learner achievement as an effect of aesthetic embellishment in education art." A paper published in Proceedings of the First Interservice/Industry Training Equipment Conference. Orlando, FL: Naval Training Equipment Center, November 1979.

This paper reported research undertaken to determine the effects of levels of artwork in audio-visual sound slide teaching devices on message comprehension. An attempt was made to find out whether students can obtain as much "information from simple art (line drawings, stick figures, geometric patterns, etc.) as they can from a more complex rendition of the same subject, including full human figures, extremely detailed subject matter, use of color and more embellishment for the purpose of intensifying the aesthetic quality of the visual."

This has economic implications for the production of TEC lessons. Markham notes that the filmstrip used in the Besler Cue-See is produced by photographing commercially developed art work and each lesson on the average contains 150 pieces of art. The current cost of a simple frame is $15; a complex one, $75. He developed a simple set for $10. The author's research premise is that if a simple drawing could achieve the same results as a complicated embellished art frame, the Government would realize substantial savings in money as well as in time invested in developing and producing TEC lessons.

Using a simple set of art frames, the author tests the null hypothesis that there would be no difference in achievement of subjects who are taught the same concepts using two sets of visuals -- simple and complex (see attached figure). Using two groups, Army Reservists and college students, he found non-significant differences on a 20-item comprehension test. This work implies that dramatic saving in cost is possible using simple line graphics rather than finished art for TEC lessons.

Fig. 1 Example of Complex Art as defined by the U.S. Army TEC Program.

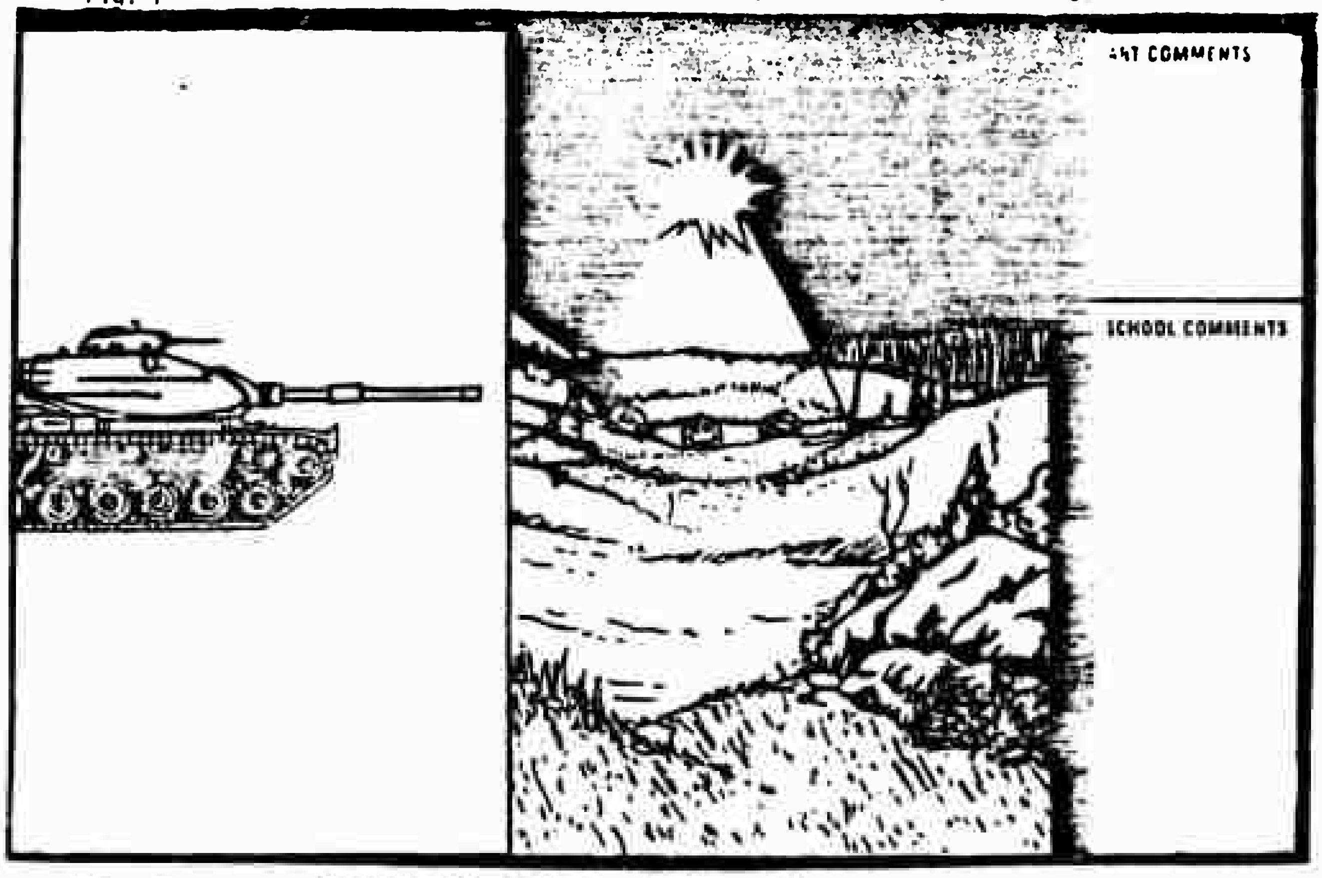
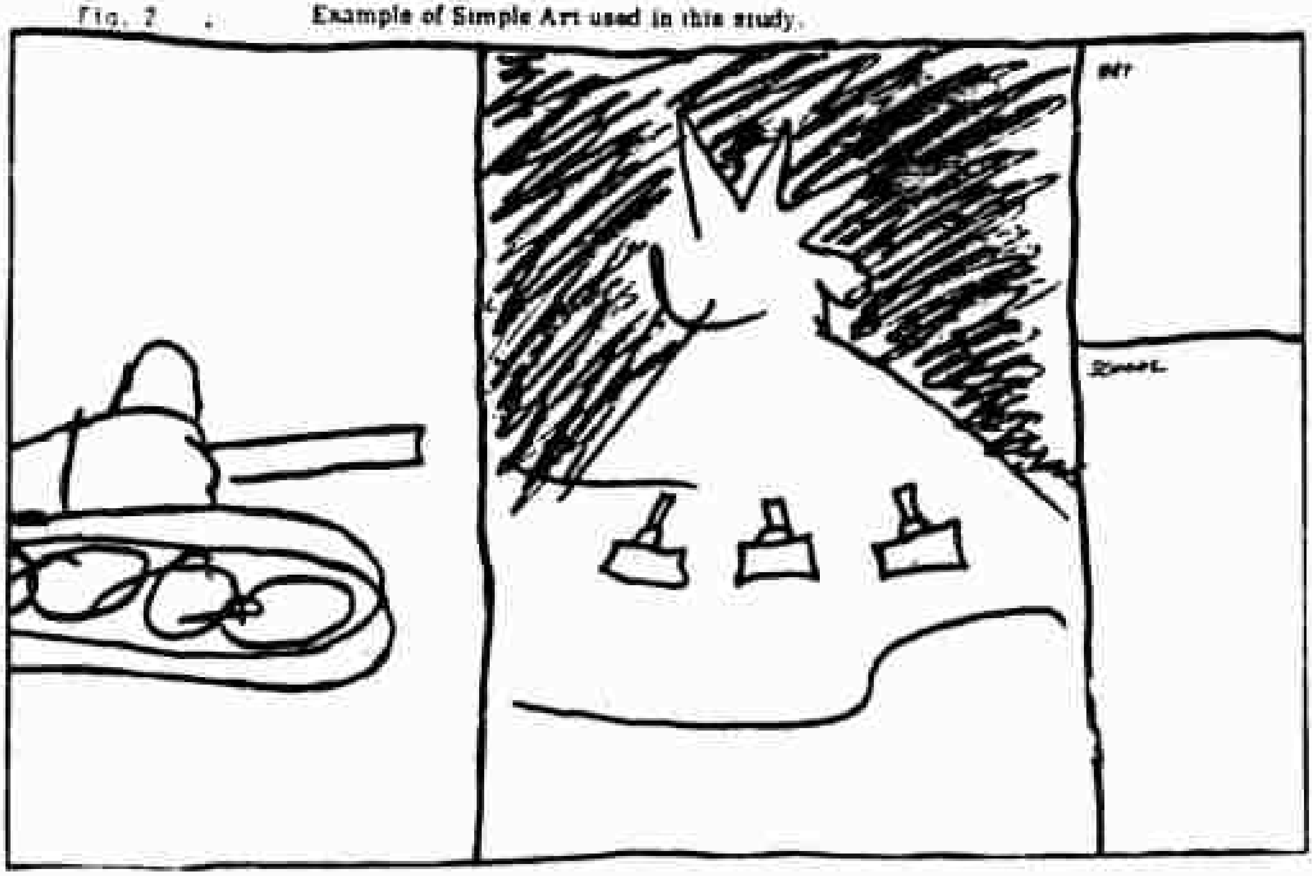


Fig. 2 Example of Simple Art used in this study.



Holmgren, J. E., Dyer, F. N., Hilligoss, R. E., and Heller, F. H. "The effectiveness of Army training extension course lessons on videodisc". Journal of Educational Technology Systems, Vol. 8(3), 1979-80, pp. 263-274.

Three sets of audiovisual lessons from the Army Training Extension Course (TEC) Program were presented to samples of enlisted soldiers on either a prototype videodisc player or the film and audio cassette player currently used for TEC lessons. The training effectiveness of the lessons was determined by administering validated hands-on performance tests to the trained soldiers and also to a baseline group that had not viewed the TEC lessons. Initial results show that, for all three sets of lessons, both groups of trained soldiers performed significantly better than those in the baseline group. The difference between the two trained groups is not statistically significant for two of the three lesson sets; for the third set, there is a significant difference of ten percent in mean performance test score in favor of the film and audio cassette player.

Three sets:

(1) Two-lesson set for Armor unit personnel

(2) Two-lesson set for FA unit personnel

(3) Three-lesson set for IN unit personnel

Demographic statistics; performance test results and number in each experimental group are shown:

Table 1. Background Information on the Three Samples

Background Statistic	*Sample* Armor	Artillery	Infantry
Mean GT score	98.4	99.8	100.0
Mean years of education	11.7	11.8	11.5
Mean pay grade[a]	3.9	3.7	3.0
Mean months in service	44.9	36.3	29.1
% with previous TEC training in subject area	18	28	18
% with BCT training in subject area	7	16	70
% with AIT training in subject area	14	49	74
% with training since AIT in subject area	24	56	49

[a] E1 through E6 were coded 1 through 6 and then averaged.

Table 2. Performance Test Results

Sample		*Experimental Conditions* Standard Beseler	Combined Videodisc	Standard Videodisc	Modified Videodisc	Baseline
Armor	$\bar{X}$	56.6	46.2	46.9	45.5	29.4
	$s_{\bar{x}}$	3.6	3.3	4.7	4.5	2.3
	N	31	32	16	16	38
Artillery	$\bar{X}$	54.1	52.6	58.5	50.5	23.8
	$s_{\bar{x}}$	5.2	5.2	10.2	6.0	4.3
	N	33	31	8	23	37
Infantry	$\bar{X}$	60.6	50.7	49.8	51.8	26.8
	$s_{\bar{x}}$	4.0	4.1	6.0	5.6	3.4
	N	31	32	17	15	33

Vineberg, R. and Joyner, J. N., Instructional system development (ISD) in the Armed Services: methodology and application. HumRRO-TR-80-1. Alexandria, VA: Human Resources Research Organization, January 1980.

This study examined Instructional System Development (ISD) methodologies and practices in the Armed Services during the period August 1977 - May 1979. The major finding is that ISD is not being used either to optimize total system effectiveness or to maximize training efficiency. Some findings are pertinent to an evaluation of TEC.

The first is the area of media selection.

Findings:

1. Methodology - Procedures for selecting training media appear adequate to match the presentation (stimulus and response) requirements of instructional activities to appropriate media, if instructional activities have been specified in sufficient detail.

2. Application - Training media are not systematically selected on the basis of requirements of instructional activities (which are also not specified).

3. Application - Developers generally do not have freedom to select among alternative media. Choices and changes in media are usually directed by command policy.

Recommendation:

1. Selection of appropriate media is contingent on how well instructional activities have been specified. No change in the current models for matching media to activities is appropriate until activities are more widely specified, and these models can be tested.

The second is in the area of review and selection of existing material.

Findings:

1. Methodology - The currently used Army model states that decisions to use existing materials (rather than author new instruction) are to be based on the appropriateness of these materials to the previously specified characteristics of objectives, methods, and media.

2. Application - Characteristics to be identified in judging the appropriateness of existing training materials are not specified.

3. Application - Review and use of existing training materials are minimal, except for those in a course that is being revised.

Recommendation

1. The specification of necessary properties of materials for particular training situations, and the description and cataloging of existing materials to permit the interchange of matching components across courses, represent a degree of perfection that is not presently attainable. An attempt to reduce the review and selection of existing materials to a systematic procedure is to act as if the methods of a well-developed technology were available in an area in which judgment is in fact the dominant factor. No change in present practice is recommended.

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TO

APPENDIX A

ABSTRACTS

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APPENDIX B

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APPENDIX C

ABBREVIATIONS AND ACRONYMS

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AD	Advanced Development
AMSAA	Army Materiel Systems Analysis Agency
AP	Acquisition Plan
AR	Army Regulation
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
ARTEP	Army Training and Evaluation Program
ASARC	Army Systems Acquisition Review Council
ATM	Analogous Task Method
ATSC	Army Training Support Center
BDM/CARAF	The BDM Service Company/Combined Arms Research and Analysis Facility
CAFTDR	Commercially Available/Fabricated Training Device Requirement
CAI	Computer Assisted Instruction
CD	Combat Development
C/E	Cost Effectiveness
CHRT	Coordinated Human Resources Technology
CMI	Computer Mediated Instruction
COEA	Cost and Operational Effectiveness Analysis
CONUS	Continential United States
CORADCOM	Communications Research and Development Command
CTEA	Cost and Training Effectiveness Analysis
DA	Department of the Army
DARCOM	U.S. Army Materiel Development and Readiness Command
DAS	Defense Audit Service
DCP	Decision Coordinating Paper
DEVA IPR	Development Acceptance In-Process Review
DRIMS	Diagnostic Rifle Marksmanship Simulators
DSARC	Defense System Acquisition Review Council
DT	Development Test
DT/OT	Development Test/Operational Test
E_A	Actual Effectiveness
E_D	Design Effectiveness
ETM	Extension Training Materials
FDTE	Force Development Testing and Experimentation
FSED	Full-Scale Engineering Development
HRDT	Human Resources in Design Trade-Offs
IPISD	Interservice Procedures for Instructional Systems Development
IPR	In-Process Review
IPS	Integrated Personnel Support
ISD	Instructional Systems Development
ISTEA	Initial Screening Training Effectiveness Analysis
ITDT	Integrated Technical Documentation and Training
ITV	Improved TOW Vehicle
JGD	Job Guide Development
LAI	Lesson Administrative Instruction
LCC	Life Cycle Costs
LCCE	Life Cycle Cost Elements

LCSMM	Life Cycle System Management Model
LOA	Letter of Agreement
LR	Letter Requirement
MENS	Mission Element Needs Statement
MILPERCEN	Military Personnel Center
MMM	Maintenance Manpower Modeling
MOS	Military Occupational Specialty
MODIA	Method of Designing Instructional Alternatives
NET	New Equipment Training
OAP	Outline Acquisition Plan
ODP	Outline Development Plan
OJT	On-the-job Training
OT	Operational Test
OTEA	Operational Test and Evaluation Agency
PM TRADE	Project Manager, Training Devices
POI	Program of Instruction
POL	Petroleum, Oils, and Lubricants
PQQPRI	Provisional Qualitative and Quantitative Personnel Requirements Information
RDTE	Research, Development, Test and Evaluation
SAAC	Systems for Air-to-Air Simulation
SAT	Systems Approach to Training
SG	Student Guide
SLS	Student Lesson Sheets
TAEG	Training Analysis and Evaluation Group
TCA	Training Consonance Analysis
TDDA	Training Developers Decision Aid
TDLOA	Training Device Letter of Agreement
TDLR	Training Device Letter Requirement
TDR	Training Device Requirement
TDS	Training Developments Study
TEA	Training Effectiveness Analysis
TEC	Training Extension Course
TECEP	Training Effectiveness, Cost Effectiveness Prediction
TEEM	Training Efficiency Estimation Model
TER	Transfer Effectiveness Ratio
TM	Technical Manual
TMG	Training Manager's Guide
TOT	Transfer of Training
TRA	Training Requirements Analysis
TRADOC	Training and Doctrine Command
TRAINVICE	Training Device Effectiveness Model
TRAM	Training Analysis Model
TRAMOD	Training Requirements Analysis Model
TRASANA	TRADOC Systems Analysis Agency
TSE	Total System Evaluation
TSEA	Training Subsystem Effectiveness Analysis
TTS	Technical Training School
USAREUR	U.S. Army, Europe
WSTEA	Weapon System Training Effectiveness Analysis