DTIC FILE COPY

(1)

AD-A204 836

US ARMY
MATERIEL COMMAND
PM TRAINING DEVICES

Research Product 88-22

Implementing Embedded Training (ET): Volume 2 of 10: Embedded Training as a System Alternative

DTIC
ELECTE
FEB 08 1989
S D
H

August 1988

Manned Systems Group
Systems Research Laboratory

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

Approved for public release; distribution is unlimited

89 2 7 065

U.S. ARMY RESEARCH INSTITUTE
FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency Under the Jurisdiction of the Deputy Chief of Staff for Personnel

EDGAR M. JOHNSON
Technical Director

JON W. BLADES
COL, IN
Commanding

U.S. ARMY PROJECT MANAGER
FOR TRAINING DEVICES

WILLIAM MARROLETTI
Deputy Project Manager

RICHARD J. LUNDSFORD, JR.
Col, EN
Project Manager

Research accomplished under contract
for the Department of the Army

Applied Science Associates, Inc.

Technical review by

Irving N. Alderman
Marshall A. Narva
Donald S. Peckham, PM TRADE

NOTICES

FINAL DISPOSITION: This Research Product may be destroyed when it is no longer needed. Please do not return it to the U.S. Army Research Institute for the Behavioral and Social Sciences.

NOTE: This Research Product is not to be construed as an official Department of the Army document, unless so designated by other authorized documents.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS --
2a. SECURITY CLASSIFICATION AUTHORITY --	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE --	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) ARI Research Product 88-22	5. MONITORING ORGANIZATION REPORT NUMBER(S) --
6a. NAME OF PERFORMING ORGANIZATION Applied Science Associates, Inc. — 6b. OFFICE SYMBOL (If applicable) --	7a. NAME OF MONITORING ORGANIZATION U.S. Army Research Institute for the Behavioral and Social Sciences
6c. ADDRESS (City, State, and ZIP Code) P.O. Box 1072 Butler, PA 16003	7b. ADDRESS (City, State, and ZIP Code) 5001 Eisenhower Avenue Alexandria, VA 22333-5600
8a. NAME OF FUNDING/SPONSORING ORGANIZATION U.S. Army Research Institute for the Behavioral and Social Sciences — 8b. OFFICE SYMBOL (If applicable) PERI-SM	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER MDA903-85-C-0078
8c. ADDRESS (City, State, and ZIP Code) 5001 Eisenhower Avenue Alexandria, VA 22333	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 62717A; PROJECT NO. A790; TASK NO. 142; WORK UNIT ACCESSION NO. 127C.1

11. TITLE (Include Security Classification)
Implementing Embedded Training (ET): Volume 2 of 10: Embedded Training as a System Alternative

12. PERSONAL AUTHOR(S)
H. C. Strasel, F. N. Dyer, J. Thomas Roth, I. N. Alderman, and D. L. Finley

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 11/84 TO 4/88	1988, August	52

16. SUPPLEMENTARY NOTATION
fr. back
Current Contracting Officer's Representative, Marshall A. Narva

17. COSATI CODES		
FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Embedded Training, System Acquisition, System Training, ~~ASAP, LCSMM~~ Training System Development, Post-Fielding Training Developments. (SDW)

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

This research product is one of a series of 10 documents produced by the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) and the project manager for Training Devices (PM-TRADE). The research will assist systems, training, and materiel developers in making the initial and iterative decisions to consider further the inclusion of embedded training in a given system development or improvement process. The product helps developers to answer four questions pertinent to the basic decision process: (1) Are there policy considerations that dictate the use of embedded training (ET) for knowledge and skill acquisition training in the system? (2) Do (many of) the proposed system's tasks require frequent sustainment training? (3) Is the development of an ET component feasible in this system? (4) Is it likely that ET will be a cost effective training alternative for the system?

Guidance provided herein should apply to the system consideration to include embedded training within the total training system concept at any point in the LCSMM or ASAP of any (continued)

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Marshall A. Narva	22b. TELEPHONE (Include Area Code) (202) 274-8876 — 22c. OFFICE SYMBOL PERI-SM

DD Form 1473, JUN 86 — Previous editions are obsolete. — SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED

Life Cycle System Management Model
Army Streamlined Acquisition Process

ARI Research Product 88-22

19. Abstract (continued)

new or existing system. The guidance will be as applicable to ECPs or PIPs and PDI as to the initial consideration of the training system for a new materiel requirement.

Keywords:

FLD18

Research Product 88-22

Implementing Embedded Training (ET): Volume 2 of 10: Embedded Training as a System Alternative

H. C. Strasel and Frederick N. Dyer
Hi-tech Systems, Inc.

J. Thomas Roth
Applied Science Associates, Inc.

Irving N. Alderman and Dorothy L. Finley
U.S. Army Research Institute

Manned Systems Group
John F. Hayes, Chief

Systems Research Laboratory
Robin L. Keesee, Director

U.S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria, Virginia 22333-5600

Office, Deputy Chief of Staff for Personnel
Department of the Army

August 1988

Army Project Number
2Q162717A790

Human Performance Effectiveness and Simulation

Approved for public release; distribution is unlimited.

FOREWORD

This document is Volume 2 in a series produced by the Army Research Institute for the Behavioral and Social Sciences (ARI) and the project manager for Training Devices (PM-TRADE). This series consists of 10 related documents to guide combat and training systems developers, including Army Materiel Command (AMC) laboratories, Training and Doctrine Command (TRADOC) Combat Developers and Training Developers, and contractor organizations involved in system development or developing technological thrust areas under independent research and development (IR&D) programs.

The series of documents includes guidelines and procedures that support the effective consideration, definition, development, and integration of embedded training (ET) capabilities for existing and developmental systems. The 10 documents share the general title of Implementing Embedded Training (ET), with specific, descriptive subtitles for each document. They are:

1. Volume 1: Overview presents an overall view of the guidance documents and their contents, purposes, and applications. This includes a discussion of

   a. the total training system concept, including embedded training;

   b. the development of training systems within more general processes of materiel system development;

   c. the effect of embedded training on this relationship; and

   d. the content and uses of the remaining documents in the series, their relationships to the training systems development and acquisition processes, and directions for use of the documents.

2. Volume 2: ET as a System Alternative provides guidelines for deciding whether ET should be further considered as a training system alternative for a given materiel system. It also includes guidance for considering ET as an alternative for systems under product improvement or modification, after fielding.

3. Volume 3: The Role of ET in the Training System Concept contains guidance for the early estimation of training system requirements and the potential allocation of such requirements to ET.

4. Volume 4: Identifying ET Requirements presents procedures for defining ET requirements (ETRs) at both initial levels (i.e., prior to initiating system development) and for revising and updating initial ETRs during system design and development.

5. Volume 5: Designing the ET Component contains analytic procedures and guidance for designing an ET component concept for a materiel system, based on specified ETRs.

6. Volume 6: Integrating ET with the Prime System contains considerations, guidance, and "lessons learned" about factors that influence the effective integration of ET into materiel systems.

7. Volume 7: ET Test and Evaluation presents guidance for defining the aspects of the ET component (test issues) to be addressed in prototype and full-scale system testing.

8. Volume 8: Incorporating ET into Unit Training provides guidance for integrating ET considerations and information into unit training documentation and practice.

9. Volume 9: Logistics Implications presents guidance regarding key logistics issues that should be addressed in the context of ET integration with prime item systems.

10. Volume 10: Integrating ET into Acquisition Documentation provides guidance on developing the necessary documentation for, and specification of, an ET Component of a prime item during the Army's systems development and acquisition process. This document discusses the Life Cycle System Management Model (LCSMM) and the Army Streamlined Acquisition Process (ASAP) and describes where and how to include ET considerations in the associated documentation. It also describes where and how to use the other volumes in the ET Guidelines series to generate the information required for the acquisition documentation, and provides guidance in preparing a contract Statement of Work for an ET Component to a prime item system.

W. Marroletti
WILLIAM MARROLETTI
Deputy Project Manager

Edgar M. Johnson
EDGAR M. JOHNSON
Technical Director

Accession For
NTIS GRA&I ☑
DTIC TAB ☐
Unannounced ☐
Justification
By
Distribution/
Availability Codes
A-1

IMPLEMENTING EMBEDDED TRAINING (ET):
VOLUME 2 OF 10: EMBEDDED TRAINING AS A SYSTEM ALTERNATIVE

CONTENTS

	Page
INTRODUCTION	1
GUIDANCE ON CONSIDERATION OF EMBEDDED TRAINING FOR INCLUSION IN ARMY SYSTEMS	2
The Decision Process and Questions	4
The Case for Embedded Training	4
Major Factors Related to Probable Effectiveness of Embedded Training	8
THE (ITERATIVE) SYSTEM ET DECISION PROCESS: ANSWERING THE QUESTIONS	9
Question 1. Are There Policy Decisions That Dictate the Use of ET for Knowledge and Skill Acquisition Training in the System?	9
Question 2. Do (many of) the Proposed System's Tasks Require Frequent Sustainment Training?	12
Question 3. Is the Development of an ET Component Feasible in This System?--Other Considerations About Alternatives	26
Question 4. Is It Likely That ET Will Be a Cost-Effective Training Alternative for This System?	32
Decisions About Sustainment Embedded Training	32
CONSIDERATION OF EMBEDDED TRAINING FOR RETROFITTING EXISTING SYSTEMS--(P^3I, ECPs, and PIPS)	33
REFERENCES	37
BIBLIOGRAPHY	39
APPENDIX RATING WORKSHEETS: SUMMARY, FACTOR 1 USING TASK-STIMULUS CHARACTERISTICS MODEL, AND FACTOR 1 USING TASK CHARACTERISTICS MODEL	41

CONTENTS (Continued)

Page

LIST OF FIGURES

Figure 1. Systems acquisition processes and ET guidelines 3

2. Basic process for consideration of embedded training for Army systems 10

LIST OF TABLES

Table 1. An overview of the initial decision process for consideration of Embedded Training (ET) in developing (or retrofitting) Army systems 5

2. Ratings of task-stimulus characteristics 19

3. Ratings of extent of performance requirement of different task types 26

IMPLEMENTING EMBEDDED TRAINING (ET):
VOLUME 2 OF 10:
EMBEDDED TRAINING AS A SYSTEM ALTERNATIVE

INTRODUCTION

Current Department of the Army (DA) policy states that "an embedded training capability will be thoroughly evaluated and considered as the preferred alternative among other approaches to the incorporation of training subsystems in the development and follow on Product Improvement Programs of all Army Materiel Systems."[1] Therefore, the initial definition process for all new and developing systems, and for all PIPs, must include a decision as to whether ET should be further considered for inclusion in the system capabilities. The policy, in effect, says: "ET will be included in all new and developing Army systems unless there are valid and compelling reasons not to do so."

This document presents guidelines and procedures for making the initial decision as to whether ET is "right" for a given system and should be considered further in system development. The guidelines and procedures also apply, with slight modifications, to decisions concerning potential for ET development and implementation in PIPs or other retrofitting conditions for fielded systems.

This guidance is intended to assist combat and training developers (or Mission Area Analysts) in making the critical initial decision about the potential inclusion of ET for a proposed materiel solution to a battlefield deficiency, whether in new system requirement development or in developing an improvement in an existing product. This decision must necessarily be made very early in the combat developer's generation of system requirements to ensure that ET (and all other training) development can be dealt with effectively in design, acquisition, and employment of the system.

---

[1] U.S. Department of the Army (1987). Policy and guidance letter, subject: embedded training. Office of the Under Secretary of the Army, signed by General Maxwell R. Thurman, Vice Chief of Staff of the Army, and the Honorable James R. Ambrose, Under Secretary of the Army, dated 3 March 1987.

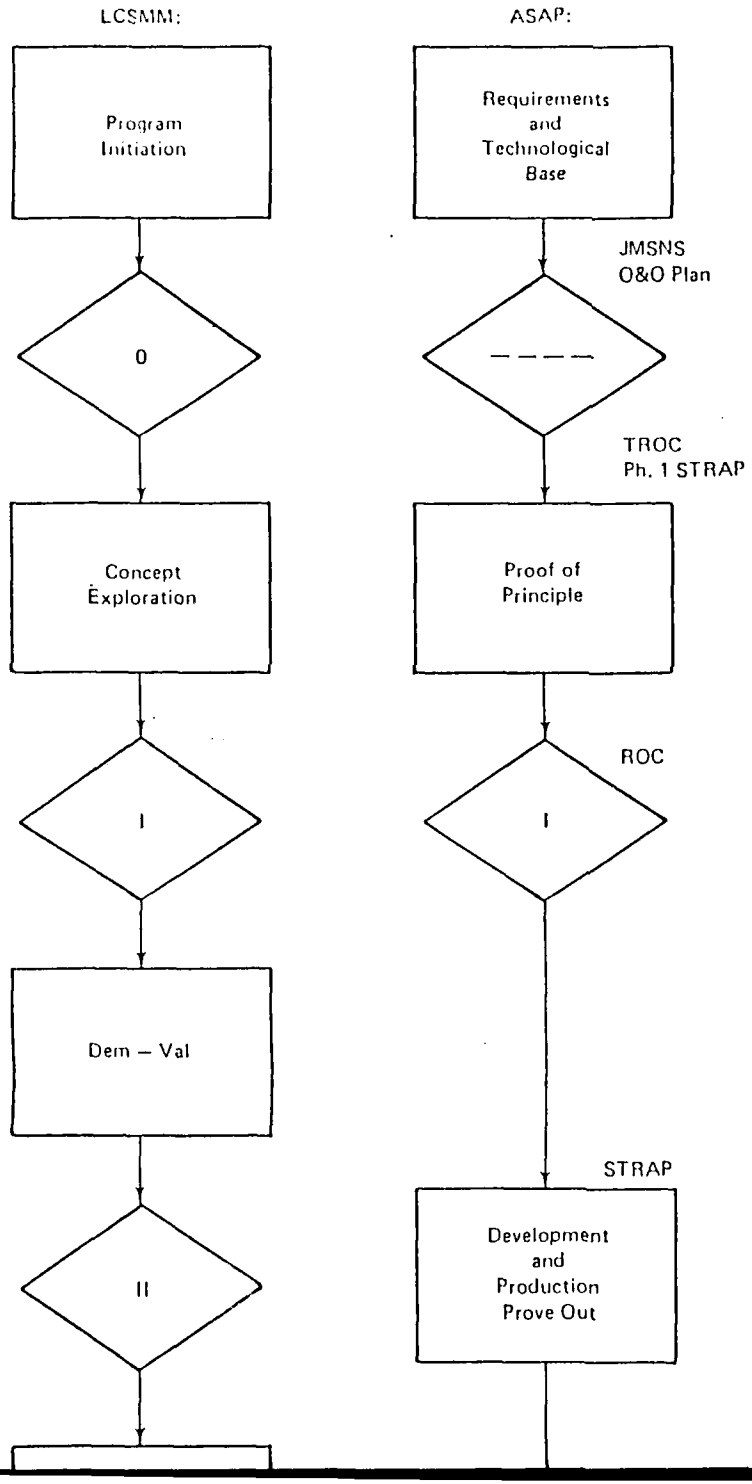
GUIDANCE ON CONSIDERATION OF EMBEDDED TRAINING FOR INCLUSION IN ARMY SYSTEMS

Consideration of ET as a major component of the training system to support a given materiel requirement must be a continuing, iterative process throughout the early stages of system development. The iterative nature of this decision is partially illustrated by the indication of utility of this Guideline at various points in the system acquisition process as shown in Figure 1 (repeated from Volume 1 of this Guideline series). As indicated in that figure, the iterative consideration and decision process may well continue into system fielding and deployment to meet the requirements for decisions posed by frequent need for product improvements and the not-infrequent needs for post-fielding training developments. This guidance is intended to provide training developers and systems developers with an approach to be used in making the initial considerations as well as those which may be required in later stages of the iterative reconsideration.

The initial consideration of ET for inclusion in a given system must be made at the earliest stages of system conceptualization and development. This consideration must take into account at least three aspects of ET as it relates to what is known about the developing system. These aspects are: the appropriateness of ET as a component of the training system required to support the defined system; the feasibility and practicability of developing and implementing an ET component for the system; and the probable cost-effectiveness of an ET component for this application.

If an initial decision is made to continue consideration of ET for the system, the decision process must, as indicated above, be iterated several times throughout the acquisition process. Such iteration is demanded because the developers' information and knowledge about the appropriateness, feasibility, or cost-effectiveness of the ET will necessarily increase as the materiel requirement proceeds into system concept formulation and subsequent development (e.g., the appropriateness of embedded training will become much better clarified when more detailed descriptions of the soldier performance and training requirements posed by the system can be made available for analysis; similarly, the feasibility of incorporating an embedded training component into the system will be clarified by more detailed statements of system hardware, software, and personnel components).

Because the initial consideration is required so early in system acquisition, the initial decision will necessarily be based on the (usually) very limited information dealing with the mission and functional requirements of the system as defined at the Mission Area Analysis (deficiency solution [MAA]) stage. The available mission and functional requirements information must be considered in relation to all factors presented in this volume, and any other relevant factors that can be identified.



APPLICABLE GUIDELINES:

1. Interim Overview.
2. ET as a System Alternative.
3. Role of ET in Training System Concept.
4. Identifying the ETR.
5. Designing the ET Component.
9. Logistics Implications.

2. ET as a System Alternative.
4. Identifying the ETR.
5. Designing the ET Component.
6. Integrating ET with the System.
7. ET Test and Evaluation.
9. Logistics Implications.
10. *Revisions to Acquisition Documentation.*

2. ET as a System Alternative.
6. Integrating ET with the System.
7. ET Test and Evaluation.
8. Incorporating ET into Army Unit Training.
9. Logistics Implications.
10. *Revisions to Acquisition Documentation.*

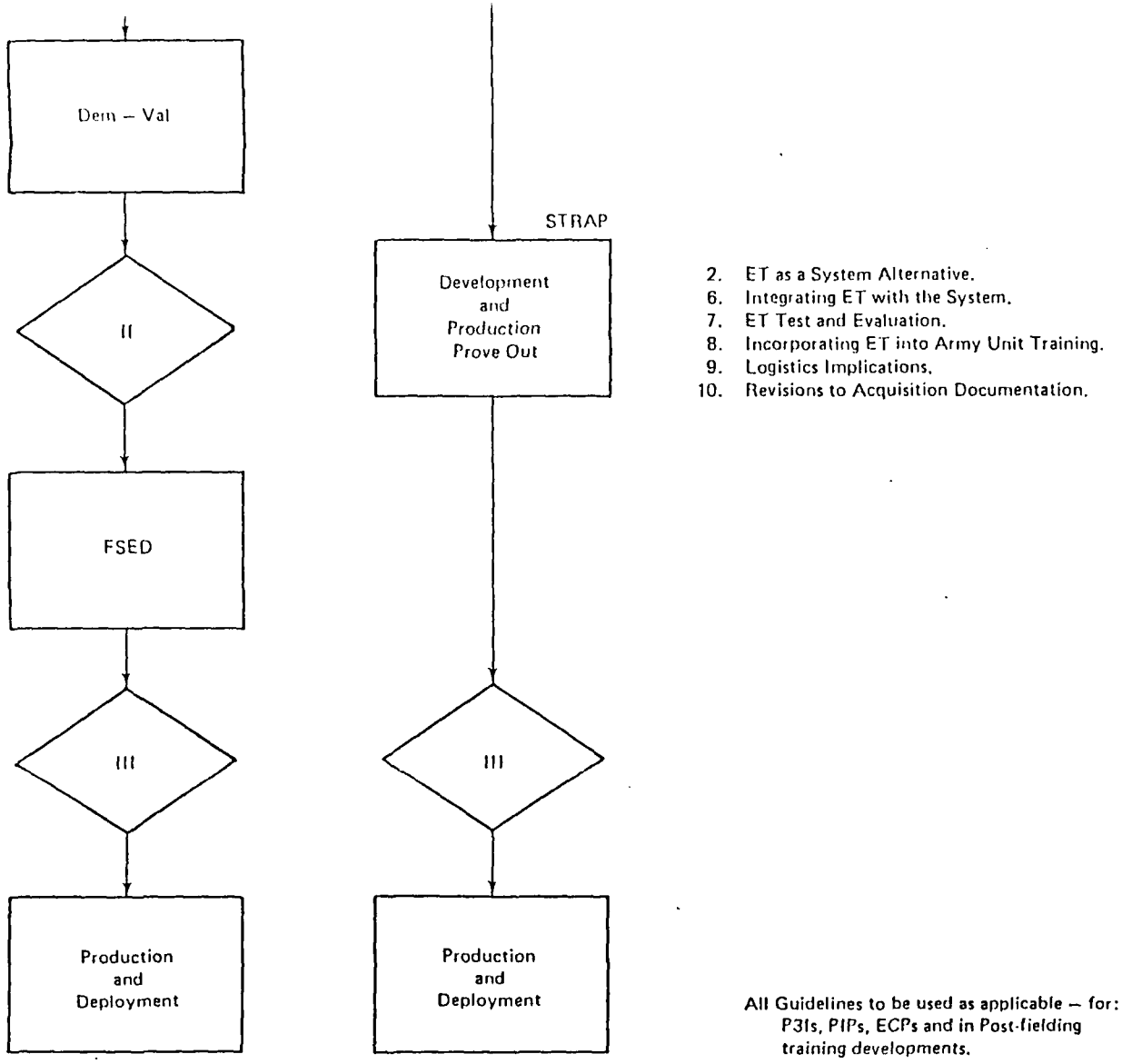


Figure 1. Systems acquisition process and ET guidelines.

292

The available information will likely consist of little more than:

1. a general definition of the missions that the developing system is intended to support and of the functional performance characteristics of the system itself (as defined by the MAA materiel solution); and,

2. knowledge of the Army's experience base developed with similar former systems (defined by MANPRINT Comparability Analyses, if available, and by field experience reports otherwise).

The Decision Process and Questions

This scanty information base must be related to that which is known or can be determined about how ET would benefit the training and operational capabilities for this system. Table 1 presents our view of the initial decision process necessary to assessing the value of further consideration of ET in system design.

The following guidance concentrates on how to answer the questions essential to the process indicated in Table 1. Answers to these questions can be determined on the basis of what is now known about the factors affecting the probable effectiveness of ET, as derived from the ARI-PM TRADE research and as reflected in all volumes of this Guideline series. Before a discussion of how to answer the questions, a brief description of ET and its importance for Army training systems development is presented.

The Case for Embedded Training

ET is generally defined as "a training subsystem (hardware and software) which is integrated with (but not necessarily fully incorporated within) the overall weapon or tactical system software and equipment configuration. The ET subsystem provides training and assessment capabilities through the soldier-system interface using software control of courseware and exercises on the operational equipment with auxiliary equipment as necessary."

A more operational definition of ET was developed for use in the current R&D effort, as follows:

> Embedded training (is that training which) results from the use of a feature (or features) incorporated into the end item of equipment (the operational system) to provide training on the end item equipment.

Table 1

An Overview of the Initial Decision Process for Consideration of Embedded Training (ET) in Developing (or Retrofitting) Army Systems.

INPUTS:	DA Policy: Embedded Training will be Considered as the First Training Alternative in Developing Systems.	Mission Area Analysis Materiel Solution to Deficiency: System Characteristics - Including HMPT. Knowledge and Guidance on Factors Affecting Probable Effectiveness of Embedded Training in Systems	Available Data on Comparable Systems: HMPT; Training, and Field Performance

PROCESS: Examine Known System Characteristics in Relation to Factors Affecting Probable Success of Embedded Training.

QUESTIONS:

1. Are There Policy Decisions Which Dictate Embedded Training for Knowledge and Skill Acquisition Training for the System?

2. Do the Proposed System's Critical Tasks Require Frequent Sustainment Training?

3. Is the Development of an ET Component Feasible in this System?

4. Is it Likely that ET will be a Cost Effective Training Alternative for this System?

OUTPUTS/ DECISIONS: Determine Whether to:

A. Continue Consideration of ET into Subsequent System Definition

OR;

B. Discontinue Consideration of ET for This System

DECISION CRITERIA:

A. If the Answer to Question 1 is YES, Embedded Training will be Included in the System Requirement.

B. If the Answer to Question 1 is NO, Embedded Training will Still be Further Considered Until There is Compelling Evidence that any One of the Other Three Questions Must be Answered Negatively.

Features should include:

1. performance assessment;

2. feedback (consistent with improving and reinforcing correct performance); and,

3. record keeping, to allow management of individual and collective performance trends, improvements and deficiencies requiring additional training.

Either definition can be interpreted to mean a (usually) computer-based system (either integral to or adjunct to the tactical system) which, when activated, interrupts or overlays the system's normal operational mode to enter a training and assessment mode. A fully functioning ET system then:

1. generates target or threat data (or other operational input signals peculiar to the system);

2. feeds these data into and through the operational equipment to the system's operator(s) or maintainer(s) by means of their normal displays and indicators;

3. presents the input data so as to realistically depict what would occur in an operational exercise of the system against a real threat (or flight, target emission, storm, or other event against which the system is employed). The system should also provide the capability to simulate faults and errors to allow training in degraded modes of operation;

4. requires the operator(s) or maintainer(s) to perform their normal and proper tasks and duties in response to the simulated mission inputs;

5. simultaneously, interactively assesses and records the performance of the operator(s) or maintainer(s) and reacts to that performance as the real threat would (providing realistic and continual feedback on the accuracy and appropriateness of the performance);

6. provides an appropriate level of performance measurement and recording to allow both individual feedback after a session and semi-permanent records of performance to provide to cumulative or aggregate records and assessments (for individuals, crews, or even units) over time; and

7. usually allows for the presentation of computer-assisted or otherwise programmed instruction on related job-relevant tasks and sub-tasks in addition to those which are strictly

operational mission performance tasks (e.g., equipment setup tasks or maintenance tasks in addition to mission scenarios).

Such a fully functioning ET system could, hypothetically, be incorporated easily into most computer-based systems and probably into many non-computer-based systems as well. Certainly most of the currently developing command, control, communications, and intelligence (C^3I) systems, sensor systems, and many weapon systems incorporate computers as integral parts of the tactical system--all such systems would be prime candidates for detailed consideration for an ET implementation.

It should also be noted that some significantly effective ET components have been and can be developed which have less than the full complement of characteristics defined by the seven points listed above. Such partial ET components should be thoroughly considered wherever it seems inappropriate or infeasible to design and develop the full ET component.

Based on these definitions and the apparent opportunities, ET should be considered as only one class of advanced training delivery methods now available to the Army. However, it must be recognized that the inclusion of ET will place demands on the system development process which may be more challenging than has previously been the case. These demands include:

1. if training subsystems are to be physically embedded within the hardware and software system, then they must be defined and designed as an integral part of the prime system, for delivery with the developed system; or,

2. if ET is to be strapped on to the system, this will still require very early definition of the need for, and the characteristics of, the strap-on ET subsystem. Designing for strap-on ET, as for integrated ET, is most cost-effectively accomplished during initial prime system design.

3. In either case, the ET requirement must be defined early; the training system definitions cannot be delayed until Milestone I or II have passed, as has frequently occurred in the past (although this has never been the intent of the "paper" requirement).

This places more stringent "timeline" demands on the identification of the training system requirements by TRADOC combat and training developments personnel than has previously been the case. TRADOC must provide the appropriate training requirements inputs to system design much earlier and more completely than has usually been the case in past developments.

The above ET definitions allow for adjunct or strap-on devices which may not be integral to the tactical system. This potential for application of ET greatly expands the range and variety of systems to which ET might eventually be applied. Strap-on devices could conceivably be used with systems which have no (or very minor) computer capabilities internal to the system. It should also be noted that ET is (naturally) extendable to retrofitting an embedded capability into existing fielded systems or those late in the development cycle. This extension also multiplies the potential number of ET applications within the Army. It must be remembered, however, that any form of ET component will require a thorough definition and inclusion of an appropriate interface to allow the ET component to interact with, and feed data and information to, the primary system components. This requirement will, necessarily, affect the RAM characteristics of the total system to some degree, but need not to a great extent given careful design of the required interface.

As noted above, the ET package can, and should, to the extent possible, include a measurement and assessment capability. Such a capability has great potential application for MOS qualification or certification and for team, crew, or unit readiness assessment, in addition to serving the usual functions of feedback and training management.

Major Factors Related to Probable Effectiveness of Embedded Training

The major factors that have been identified as impacting on the effectiveness of and the need for ET in a given system are listed below. Their use in answering system decision Questions 2, 3, and 4 about ET is discussed in subsequent sections of this Guideline:

Factor 1: The Nature of the Tasks and Skills Demanded by the System Concept - What are the Requirements for Sustainment Training.

Factor 2: The Feasibility of Implementation of ET.

Factor 3: Avoidance of ET Interference with Operations.

Factor 4: Need for Training-Specific Interface Hardware Requirements.

Factor 5: System Availability for Training.

Factor 6: Effects on System Reliability, Availability, and Maintainability.

Factor 7: Impacts on System Manpower and Personnel Requirements.

Factor 8: Cost-Effectiveness of ET (compared with alternative sustainment training capable of achieving the same training goals).

Factor 1 is considered in addressing Question 2. Factors 2 - 7 are reviewed in answering Question 3. Factor 8 pertains to Question 4.

THE (ITERATIVE) SYSTEM ET DECISION PROCESS: ANSWERING THE QUESTIONS

The system ET decision process was described in Table 1 as an examination of all available information about the system in relation to the available knowledge and guidance on the factors affecting the probable success of an ET implementation. This examination is intended to answer four critical questions, the answers to which must determine the decision. And these questions must be examined and answered iteratively throughout the system development process (the LCSMM, ASAP, or NDI process).

Once again, these questions are:

1. Are There Policy Decisions That Dictate the Use of ET for Knowledge and Skill Acquisition Training in the System?

2. Do (many of) the Proposed System's Tasks Require Frequent Sustainment Training?

3. Is the Development of an ET Component Feasible in This System?

4. Is it Likely that ET Will be a Cost Effective Training Alternative for the System?

The basic process for consideration of ET for Army systems, through examination of each of these four questions, is shown in Figure 2. The figure illustrates the sequence of answering the questions and indicates the impact on the final decision for further ET considerations of a "yes" or "no" answer to each question. How to develop an answer for each question is addressed in turn below. Worksheets for developing and summarizing the answers are provided in the Appendix.

Question 1. Are There Policy Decisions That Dictate the Use of ET for Knowledge and Skill Acquisition Training in the System?

In some system development programs, there may be policy considerations regarding knowledge and skill acquisition which pre-determine

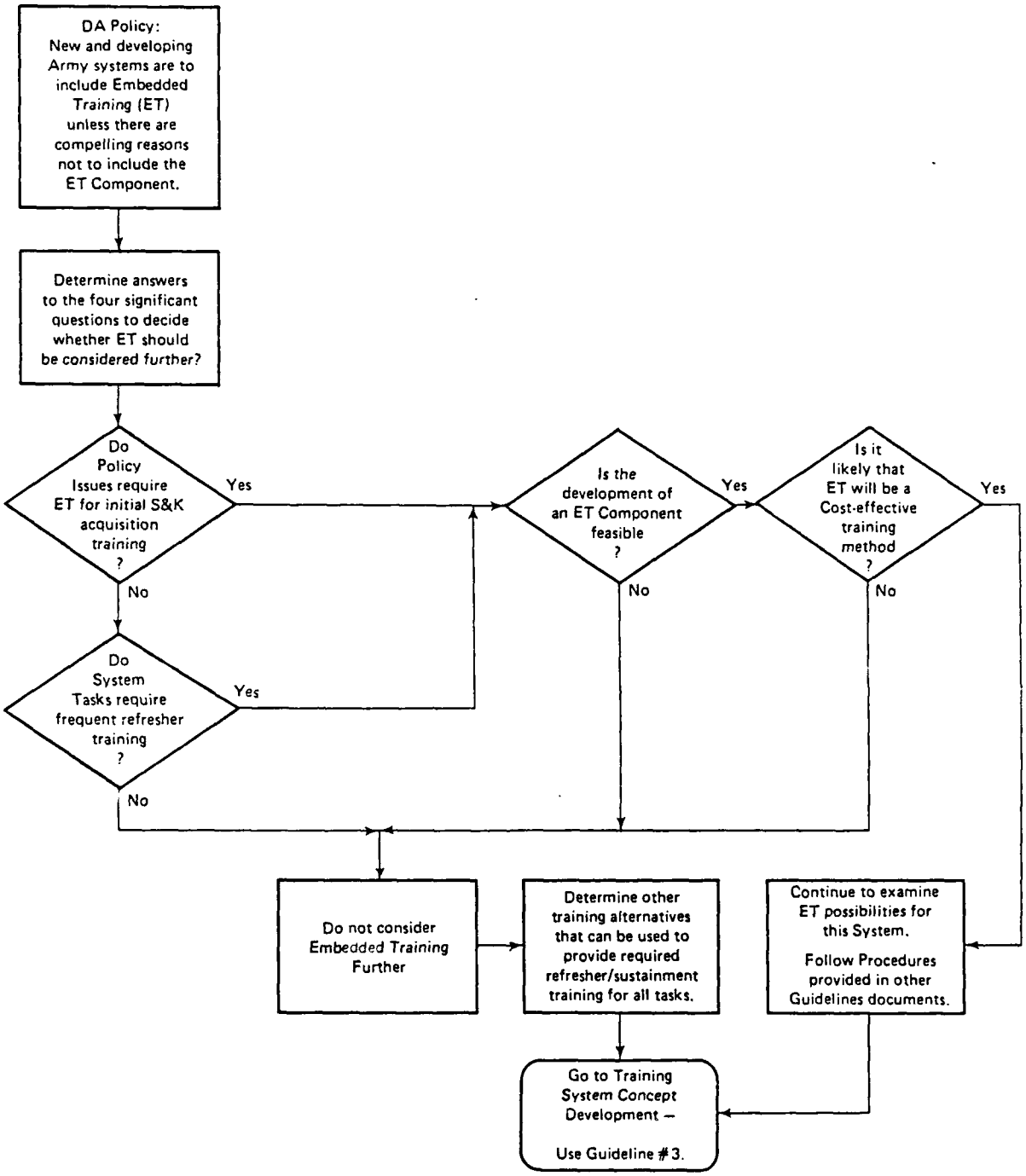


Figure 2. Basic process for consideration of embedded training for Army systems.

the incorporation of ET in the system to the extent that such is both feasible and (probably) cost-effective.[2] Two recent examples which appear to demonstrate this point are the All Source Analysis System/Enemy Situation Correlation Element (ASAS/ENSCE) and the Armored Family of Vehicles (AFV). These two examples demonstrate two different policy decisions about knowledge and skill acquisition which may dictate maximal feasible inclusion of ET in the system.

In ASAS/ENSCE, there was an early policy decision, at high levels, that ET should be made available in the system to provide acquisition (entry-level) knowledge and skill training in the institution and in the unit. There has been a simultaneous and continuing interest in the availability of ET for sustainment and other training in units, but this demand for institutional acquisition training has overridden the subordinate consideration of inclusion of ET for unit sustainment training.

Similarly, in the proposed development and fielding of the Armored Family of Vehicle (AFV), there has been an overriding policy decision that seems to dictate the inclusion of ET to the extent feasible in the system(s). In this case, the policy development is the decision to field the systems by Brigade-sized units. This unique fielding plan includes assembly of the Brigade personnel, issuing of new systems hardware, and unit training to full proficiency without benefit of (separate) New Equipment Training (NET). This fielding plan implies full acquisition training on the equipment in the fielding setting. This approach effectively requires the maximum possible training capability to be built into the AFV systems hardware.

As shown in Figure 2, and also described in Table 1, earlier, a positive answer to this overriding question should direct the systems analysts and concept developers to continue consideration of ET for this materiel requirement into larger stages of development, regardless of needs for sustainment training. This consideration should then continue into and through the later stages in the development process, until the answer to any one of the other three questions (need for ET, feasibility of ET, and probable cost-effectiveness of ET) is determined to be negative. On the other hand, a negative answer to this question should not affect continued consideration of the other three questions--determination of no immediate need for ET for acquisition does not preclude the possible real need for ET for sustainment, cross, or transition training in the system.

---

[2]Feasible in terms of engineering and programming practicality; cost-effective in terms of the overall system performance benefit to be achieved with proficient human performance.

Question 2. Do (many of) the Proposed System's Tasks Require Frequent Sustainment Training?

Although ET training components can obviously be used to provide skill acquisition training, and transition training or cross-training as well, ET is most usually first considered for providing sustainment training. Therefore, the basic need for frequent sustainment training is an obvious driver for further consideration of an ET component for a newly conceived or developing Army system.

Determining the system's requirement for frequent task sustainment training requires consideration of the specific needs for frequent refresher or sustainment training for selected skills and tasks. Certain skills degrade more rapidly without refreshment or practice than other skills. The existence of tasks requiring those perishable skills is the key determiner of whether ET must be further considered for sustainment training.

Factor 1: System Task and Skill Demands - Requirements for Sustainment Training

This demand can be expressed as: To what extent will the system operation (in either normal or degraded operations modes) or maintenance tasks demand personnel skills that require frequent sustainment training (reinforced practice) to maintain proficiency? This refers to the likelihood that critical, perishable skills will be required for operation or maintenance of the contemplated system. While detailed answers to this question will not typically be available during concept development and evaluation, this is the key issue as to whether ET should be considered further for a system, and, therefore, a preliminary estimate of the answer must be made.

Data from existing systems with similar missions or utilizing similar technologies will be useful in considering this question. If MANPRINT comparability analyses have been performed, training requirements may be approximated using these data. This may be useful in answering this question. Front-end analyses documentation on similar systems must also be reviewed for indications of the characteristics of the task populations of such systems, to the extent that such analyses are available.

If a substantial proportion of operation or maintenance tasks for the contemplated system are judged to have perishable, critical skills, then ET should be further considered as an option for providing sustainment (and, possibly, acquisition) of such skills. It is suggested that if ten (10) percent or more of the operator or maintenance skills are likely to be either critical, perishable, or both, then ET should be retained as a viable option.

Two Ways to Identify the Need for Embedded Sustainment Training. Because of the overriding importance of the nature of the tasks to be performed in determining the need for sustainment (and, perhaps, embedded) training, this factor must be considered first for any system.

The following sections present two separate models dealing with different aspects of the nature of the tasks to be performed and what these task characteristics imply about the need for sustainment training. the first model deals with the kind and number of stimulus inputs to the system operator (or maintainer), while the second deals with the "kinds of tasks" that are being required. The two approaches should, in general, derive similar indications for systems design and development. However, differing conditions of system definitions and differing amounts of available system information may make one method more appropriate than the other. Similarly, different TRADOC staff personnel may well be more comfortable with one approach or the other.

Alternative 1 - The Task-Stimulus Characteristics Model. This estimation allows the analyst to examine the stimulus characteristics of operator (primarily) and maintainer tasks that are believed to directly influence the need for sustainment training in any system. The task-stimulus characteristics believed to be of major importance to the determination of the need for sustainment training are listed below. The order of presentation of these characteristics roughly corresponds to their estimated importance in the determination, the first being the most important.

1. Need for simulation of battlefield stimuli - (need for practice in recognizing and responding to battlefield stimuli).

The contrast between operator views during garrison or peacetime operation of the system and operator views in battlefield operation of the system is frequently major. In peacetime, or in garrison practice, some systems provide a display which is very limited in variety and may be considerably different in terms of number, density, or nature of stimulus objects (targets) from that which would be seen in a wartime situation. If, as is frequently the case, battlefield stimuli do differ sharply from stimuli provided in normal peacetime or garrison use of the system, there is an implicit need for presentation of these battlefield stimuli to provide sustainment training of operators and commanders. Such a system cannot provide the operators with realistic practice or training against "realistic" events (targets) without some degree of simulation capability which will provide a basis for meaningful sustainment training.

Operators of such systems without a battlefield stimulus simulation capability are exposed to at least partially replicated battlefield stimuli only in field training exercises (FTXs) where numerous vehicles and personnel actually pretend they are the enemy. Although such large FTXs are an excellent sustainment training

technique (if accurate feedback is provided to operators on their performance), such FTXs usually cannot be conducted frequently enough to maintain operator performance at high levels. Without high levels of performance prior to real battles, operators (and systems) may not survive long enough for operators to develop high-level skills with bonafide battlefield stimuli.

Estimating this need for sustainment training at early stages of system development may be as simple as answering two questions:

1a. How much will battlefield stimuli differ from stimuli provided in normal peacetime use of the system?

1b. How important is it to effective operator performance that actual battlefield stimuli be frequently experienced in training?

If large differences are anticipated between the battlefield vs. peacetime stimulus sets, and if it is considered highly important that operators should be continually trained against realistic battlefield stimuli, then there is a definite sustainment training requirement and a need to provide a simulation capability to support such training. Even if the first answer were "no difference between garrison and battlefield stimuli," an "important" or "highly important" answer to the second question would still indicate a significant need for sustainment training, although it may not require as high a degree of simulation for training.

Many of the examples of ET in Army weapons systems which have been studied in our research have, as a primary function, the simulation of battlefield stimuli that allow operators to practice the tasks they will face on the battlefield. The Patriot Air Defense System and the Aquila Remotely Piloted Vehicle are two examples where ET includes simulations and where those simulations have been more than adequate to provide sustainment training for operators, as observed and reported in Strasel, et. al, 1986.

On the other hand, even when the need exists for simulation of battlefield situations, some sources of battlefield stimuli (e.g., the three-dimensional wide panoramas experienced by a foot soldier who is viewing the battlefield without optical or other aids or the similar stimuli for operators of most Army vehicles) are virtually impossible to simulate with high levels of fidelity. Even low-fidelity two-dimensional simulations of unrestricted three-dimensional views of the real world are very expensive and involve massive display equipment (e.g., the Bradley COFT).

2. Number of different stimulus sources to which the operator responds.

Frequently, operators must respond, sometimes nearly simultaneously, to many distinct sources of stimuli such as one or more

CRT(s), multiple indicator lights and dials, spoken radio communications, spoken instructions from team leaders and team members, and auditory alarms. The number of stimulus sources to which the operator must respond will provide a direct index of the level and complexity of his task-stimulus workload. And, an increasingly higher workload is one of the best indicators of the need for sustainment training--with the need for sustainment training increasing directly with workload (or, more simply, with the increased number of stimulus sources to which he must respond). Admittedly, no definitive research has determined exact relationships between workload and the need for sustainment training; however, the existence of a relationship is clear: the more complex the job demands, the more refresher or sustainment training is required for maintenance of high proficiency (particularly in the absence of performance in the criterion situation: War). This factor can be estimated by answering a few simple questions about the intended system; such as:

2a. Make a judgment as to whether and how frequently the operator will be required to provide rapid (time-constrained) responses to multiple audio or visual displays or stimulus sources (consider each of: one or more CRTs; Panel Displays - indicators and dials; Switch Positions; Ext. Radio; Intercom; Other Voice Commo; Other?). Indicate your judgment on the rating scale below:

Low Frequency Multiple Stimuli	Moderate Frequency Multiple Stimuli	High Frequency Multiple Stimuli

2b. Make a judgment as to how critical successful responses to the multiple stimulus sources will be to mission success:

Low Criticality to Mission Success	Moderate Criticality to Mission Success	High Criticality to Mission Success

It may be assumed that answers to these two questions which correspond to "moderate frequency" of multiple response requirements and "moderate criticality" of operator success in multiple responses to mission success (or anything higher on either scale) would clearly indicate a need for sustainment training, based on the workload assessment. In addition, "low frequency" and "high criticality" also signal a sustainment training requirement.

3. Number of different identifiable stimulus patterns to which the operator responds.

For sources such as CRTs, general purpose alphanumeric displays and the "spoken word," there are numerous different stimulus patterns which can be and usually are presented. Even for simple indicators like dials, different combinations of readings communicate different information. The total number of different stimulus patterns

to which the operator will respond will provide one of the best indicators of the need for sustainment training with the need being directly related to the number of stimulus patterns.

This characteristic will be more difficult to estimate than some others. However, personnel knowledgeable about the operational and technical conditions under which the system and the operator will be performing may be able to provide meaningful estimates of the possible loads on the operator. If possible, the analyst or subject matter expert should try to provide a meaningful rating on the following item:

> Provide a magnitude judgment about the relative number of diverse event, target, or stimulus situations to which the operator might have to respond routinely (and for judged "worst case situations") in an ordinary operational setting (another way of saying it is: how many different "things" must he be able to handle effectively per unit time - whether they were actually to occur or not?):

Relatively Few Diverse Events or Patterns	Moderate Number Diverse Events or Patterns	Relatively Many Diverse Events or Patterns

4. Number of different responses the operator makes.

This usually will be positively correlated at a fairly high level with the number of stimulus sources and even more highly with the number of different stimulus patterns, although there undoubtedly will be many fewer operator responses than different stimulus patterns. More operator responses will increase job complexity and the need for sustainment training.

Estimation of this characteristic may be simpler than some others in that the estimators may have a fairly good idea of the kind of operator or maintainer that is required in the system based on predecessor system knowledge. The variety of routine responses that can be made by an operator is usually relatively limited, in that operator responses must correspond to accomplishing each major function of the system and there will usually be only a few responses associated with each function. Analysts or subject matter experts should be able to make an estimate of the magnitude of the number of responses available to the operator using the following item:

> Provide a magnitude judgment of the relative number of different responses that the operator will be required to make (or to choose among) in normal operation.

Relatively Few Different Responses	Moderate Number Different Responses	Relatively Many Different Responses

5. Number of operator tasks and subtasks.

Number of different responses largely covers this category and the number of different stimulus patterns would also be positively correlated with number of tasks and subtasks. However, this is included since some system developers may be more comfortable with task terminology than the more atomic "stimulus-response" terminology. Again, the rule is the more tasks and subtasks the operator has to perform, the more the need for sustainment training of these skills. For the TACFIRE system, the operator had to learn enormous numbers of different message formats and other stimulus-response sequences. Only those that were routinely practiced could be produced quickly and field training exercise (FTX) success was frequently compromised by undertrained personnel (although the blame was largely given to the overly complex and user "unfriendly" system itself). It is of interest that those units who routinely conducted FTXs in the motor pool did not experience problems with TACFIRE at the National Training Center.

Provide a magnitude judgment of the relative number of different tasks and subtasks of the operator in normal operation.

Relatively Few Tasks and Subtasks	Moderate Number Tasks and Subtasks	Relatively Many Tasks and Subtasks

6. Need for speed in detecting key stimuli or stimulus patterns and in responding to them (delay tolerance of the task).

Often speed is required simply because of the large number of stimuli to which the operator must respond regardless of the number of different stimulus patterns. Large numbers of different stimulus patterns and large numbers of different responses certainly compound the problem of speeded performance, however. In Patriot, there are large numbers of targets and missiles represented on a very busy cathrode ray tube (CRT) display which also includes alphanumeric messages. These crowded CRTs of Patriot require rapid responding just to keep up with the influx of targets and messages. As a result, frequent practice is required to maintain operator skills. It is believed that when highly accurate and speedy responses are required the need for sustainment training is always high.

Estimation of the need for speed in responding (in usual operational situations) should be relatively easy. Of course, there will be those who will say that the detection and response must always be as fast as possible. But they and we know that is not necessarily true in all situations. There are many situations in which there is a great deal of tolerance for delay in response. There are also many other situations in which being sure of the correctness of the response is much more important than the speed of response.

At a later stage of training system development, the analyst might well examine the need for speeded response on a task-by-task basis. However, at this stage, the analyst will probably not have detailed task lists available to evaluate. Therefore, the overall need for speeded event detection and response can be estimated directly with the following item:

> Make a judgment about the relative importance of speed of response in performance of a significant portion of the required operator tasks:
>
> | | | |
> |---|---|---|
> | Speed Relatively Unimportant | Speed Moderately Important | Speed Very Important |

7. Need for tracking of targets.

From observations of operators of the U.S. Army Missile Command Fiber-Optic Guided Missile (FOG-M), it was noted that missile flight guidance involved delays between inputs to the controls and the missile response to transmitted digital commands. While this is not an uncommon situation for "usual" airframe control, in the remotely-steered situation it led to a tendency to over-steer the missile. This tracking task was a difficult perceptual-motor task that required much practice to be performed at a high level of proficiency. Thus, it became a prime candidate for sustainment training and was included in the list of tasks for which ET support was to be developed. Similarly, firing a rifle at a moving target is also highly difficult and also requires much initial training and sustainment training. In general, if operators need to track moving targets, it is almost certain that operators will require frequent sustainment training to maintain these tracking skills at high proficiency levels. This may be because tracking of moving targets is a speeded response task in almost all instances.

Operator movement makes even pointing at stationary targets a tracking task. Expert marksmen must practice almost daily on stationary targets in order to maintain competitive shooting skills. It might be argued that such excellent marksmanship is not needed on the battlefield, but it certainly doesn't hurt. The same is probably true during combat for the small increments in performance on other operator tracking tasks that result from daily or even more frequent practice.

The basic system concept will either involve an operator tracking task, in the sense described above, or not. The MAA or other analyst can easily answer the following item:

> Does the system require the operator to perform relatively sensitive psychomotor tracking tasks in order to accomplish the mission?
>
> Yes: _____ No: _____

The above constitutes the task-stimulus characteristics model for initial determination of the need for sustainment training, based on the stimulus characteristics of the system task requirements. Table 2 presents the possible ratings that might be assigned to the above characteristics, given that Small = 1, Moderate = 3, and High = 5. Higher ratings on more characteristics indicate stronger support for the acquisition of ET in the system. Again, the order of these characteristics roughly corresponds to their estimated importance in the determination, the first being the most important.

Table 2

Ratings of Task-Stimulus Characteristics

To what extent will the proposed system have the following characteristics:

Characteristic	Rating of Extent		
	To a Very Small Extent	To a Moderate Extent	To a Very High Extent
Battlefield Stimuli:			
Differ from Peacetime	1	3	5
Frequent Experience Necessary	1	3	5
Number of Stimulus Sources:			
Frequency of Multiple Stimuli	1	3	5
Criticality of Success	1	3	5
Number of Stimulus Patterns	1	3	5
Number of Different Responses	1	3	5
Number of Operator Tasks and Subtasks	1	3	5
Need for Response Speed	1	3	5
Sensitive Tracking Tasks	No		Yes

The above described approach to estimating the need for sustainment training emphasized looking at the stimulus inputs to the soldier. Following is an alternative approach which emphasizes looking at the types of tasks that are required.

Alternative 2 - The Task Characteristics Model. This second estimation model allows the analyst to examine the kinds of tasks that are being required of the operator or maintainer in the system and provides an indication of what each kind of task implies with respect to the need for sustainment training. This model, including the kinds of tasks identified and their descriptions, derives, in part, from the development of an ET package for the FOG-M system. It is the result of logical analyses of the general body of the Systems Approach to Training (SAT) and Instructional System Development (ISD) media decision models and the decision factors included in those models. The purpose of the analyses was to identify those factors likely to be important to the ETR definition process.

The analyses identified two major factors of task and behavioral performance objectives as most important with respect to need for ET. These two factors are:

- Criticality of the task or objective to mission success. This factor is equivalent to the conventional SAT or ISD decision factor of consequences of inadequate task performance.

- Perishability of the component skills of the task or objective when frequent reinforced practice is not provided. This factor is roughly equivalent to skill decay rate, but is more general in nature than simply skill decay, in that it includes decay of the ability to perform tasks or objectives which are dependent on a skill.

The other factors considered in the final (ET Requirements definition) model address the potential for successful implementation of the task or objective, the ability to implement the task or objective safely, and the likelihood of developing performance measurement and feedback capability for the task or objective in the ET package. This entire development, the details of these factors, and their application to ETR development are described in Volume 4 of this series, the procedures for developing detailed ET requirements (Roth, et. al, 1987).

Here, the important product of the above development is the task categorization procedures that resulted. This procedure allows the assignment of each task or performance objective to one of six categories which relate to the extent of need for sustainment training.

The underlying feature that discriminates between the six categories is the extent of cognitive mediation of task performance required to learn and then to perform the task or objective; and the effects of no reinforced practice on skill retention levels. The six categories of tasks or objectives defined are believed to be a complete and exhaustive set into which most or all tasks can be classified to support perishability decisions. Each of the six categories is assigned a level of perishability based on knowledge of the literature on skill acquisition and decay, and on extensive applied experience in instructional analyses. These task categories are discussed below.

- Integrated Multiple Skills Performance. Tasks or objectives in this category require the coordinated and rule-mediated performance of a number of complex skills in a parallel or closely linked serial fashion. An example of this type of task or objective is the execution of a ground attack from a rotary-winged platform. Such a performance requires near-simultaneous flight maneuvers, tactical navigation, and many other subsidiary skills, knowledges, and procedures. During early learning stages, these tasks or objectives require extensive mediation due to requirements to integrate component tasks and skills, and to learn the components. Patterned introduction of additional skills incremental to basic or prerequisite skills is required in early acquisition, as is extensive practice in combined skill utilization.

  In later stages of learning, overall requirements for cognitive mediation decrease somewhat due to the acquisition of inter-task coordination skills such as learning context switching cues, simultaneous use of stimuli and responses to serve multiple task requirements, and other useful coordination measures. The extent of cognitive mediation within component tasks remains task-dependent, although it may decrease due to integration of cue and response utilization between tasks. On mastery, this category of tasks or objectives displays smooth, coordinated use of multiple component skills and transitions between skills which are not exercised simultaneously. Context-switching and the ability to invoke skill use based on contingencies, rules, and situational factors are exhibited. However, the overall extent of cognitive mediation for performance remains high.

  Integrated multiple skill performance tasks or objectives are by far the strongest candidates for ET implementation, especially when highly variable scenarios are likely and where integrated skills performance in a variety of contexts is required. These tasks or objectives tend to be highly perishable in the absence

of frequent reinforced practice, since both the component skills and the inter-skill coordination elements of performance must be maintained. Ongoing assessment and feedback of behavioral performance during practice is essential to identify areas where additional skill and inter-skill practice is needed. This class of tasks or objectives incorporates the concept of "expert-level" skills which are based on an individual's experience in assessing and accommodating to a wide variety of situations and contingencies, and the tailoring of one's behavioral responses to a broad range of scenarios based on practical experience and directed training exercises.

- Variable or Contingency Procedures. Tasks or objectives in this category are procedures with inherent branching on a range of contingencies or assessed conditions. An example of such a procedure is starting a turbine engine, including reaction to all potential abnormal conditions (e.g., hot start, wet start, slow spool, etc.). Early in skill acquisition, these tasks or objectives are heavily mediated, since the basic non-contingency procedure must be learned and integrated with detection and reaction to abnormal states or conditions, which themselves may be complex.

  Later in acquisition, mediation remains heavy but gradually decreases as the non-contingency elements of the procedure are mastered, followed at varying rates by the contingency components. Frequently, contingencies are not learned to an altogether non-mediated level to allow for flexibility in operational situations. When mastered, these tasks or objectives are executed in an almost non-mediated manner except when novel conditions occur; then, extensively mediated reasoning from known contingencies is attempted to generate candidate solutions.

  Variable or Contingency Procedure tasks or objectives are strong candidates for ET implementation, since frequent reinforced practice is required to avert skill decay, which occurs at moderate rates.

- Rule or Concept Utilization. These tasks or objectives require the utilization of complex concepts for discrimination or generalization, or the application of rules or principles to make valid decisions. Examples of this type of task or objective are determining whether an aircraft is approaching or departing by analyzing its visual aspect and navigation lights, and deciding whether to execute a single or multiple missile FOG-M launch based on the number and distribution of known

threats. During early learning, such tasks or objectives are heavily mediated as the basic elements of the rule or concept involved are learned.

Later in learning, mediation continues heavy but gradually decreases, as examples of concepts and applying rules are encountered, and as application continues through practice with the entire concept or rule domain. Basic elements of concepts and rules decay slowly after they are mastered, but the ability to flexibly apply the concepts or rules decays fairly rapidly without reinforced practice.

In general, rule and concept utilization skills are strong candidates for inclusion in ET, especially where utilization of many concepts or rules is required for effective performance.

- Invariant Procedures. These tasks or objectives consist of fixed-sequence procedures with no major contingencies, such as stripping and reassembling an M-16 rifle. Early in learning such procedures, behavior is heavily mediated, since behavioral chains are being mastered. Backward chaining[3] is frequently used to reduce the extent of mediation required early in acquisition. Later, as task segments and ultimately the entire task are learned by rote, mediation fades to practically nil.

  When mastered, such tasks or objectives are almost entirely unmediated unless contingencies occur, in which case performance is frequently stymied, often beyond effective recovery. Invariant procedure tasks or objectives tend to decay slowly, unless the procedures involve many steps or complex manipulations.

  Since decay is relatively slow, invariant procedures are not prime candidates for inclusion in ET. However, if an ET implementation is foreseen to include initial skill acquisition, such tasks or objectives should be included to provide complete training. ET may also be appropriate when complex, critical stimulus-response-

[3]Backward chaining involves exposing the learner first to the events at the end of a chain of procedural steps, adding and practicing preceding steps until the complete chain is mastered.

feedback relationships need to be acquired on high-fidelity representations of equipment (perhaps in lieu of a separate training device).

- Basic Manipulative Skills. These tasks or objectives are near-term or compensatory psychomotor skills such as basic flight maneuvers or vehicle handling. Early in learning, these tasks or objectives are heavily mediated until valid ranges of the effects of inputs (e.g., control manipulations) upon outputs (e.g., aircraft attitude) are established by direct experience. Later, mediation decreases to near nil as the entire range of input and output relationships is mastered for normal states of the system.

  Such tasks or objectives are not mediated at mastery unless very unusual conditions or situations occur which are not covered in training. Then, extensive mediation directed at recovery to normal conditions occurs. The gross components of basic manipulative skills decay extremely slowly, even after long latent periods. Fine components may decay more rapidly, but are quickly reacquired upon practice of gross components. Thus, these tasks or objectives are relatively poor candidates for ET, unless ET is predicted to include initial skill acquisition. In such cases, these tasks or objectives might be considered for inclusion in ET.

- Knowledges. This category includes the acquisition of facts of any type, such as control or display locations and names. Knowledges are acquired in a rote, associative fashion, although some mediation occurs if an effective knowledge hierarchy is not provided for the trainee. Knowledges decay in a relatively slow and highly variable manner. If knowledges are integrated with higher-order tasks or objectives (as is practically always appropriate), decay for utilization is almost nonexistent, but actual rote content may decay.

  Knowledge tasks or objectives are generally inappropriate for inclusion in ET, unless ET will include initial familiarization with equipment or procedures, such as transition or cross training, or in some cases, initial skill acquisition training.

This task classification model was developed primarily to determine whether given tasks or objectives should be designated as prime candidates for ET--to develop ET requirements. This use (at a later stage of system development) is documented in full in a subsequent volume of this series. For the present purpose, the terminology has not been changed--since it is felt that the tasks and objectives identified within this model are correctly classified in respect to their relative need for ET. However, it should be clear by now that

the requirement for ET is, first and foremost, a requirement for sustainment training--with the additional recommendation that the sustainment training should be provided by embedding the training in the operational equipment to assure instantaneous availability to satisfy the needs. Thus, this task classification model can be applied at this point in system determination, also, but in a more limited fashion than used later.

The discussion above did not directly relate the classifications to perishability judgments. The following guidance applies to the evaluation of the predicted tasks of the system with respect to the need for sustainment ET:

1. Integrated Multiple Skills Performance tasks or objectives must always be classified as High perishability tasks or objectives; thus, they will always be nominated for inclusion in ET.

2. Variable or Contingency Procedures and Rule or Concept Utilization tasks or objectives will always be classified as of at least Moderate perishability. Tasks or objectives falling into these classes will, thus, generally be nominated for inclusion in ET, as well.

3. Invariant Procedure tasks or objectives will commonly be classified as Low perishability tasks or objectives, but should be considered for inclusion in ET in cases where they support multiple higher-level tasks or objectives. Further, if initial skill acquisition via ET is being considered, these tasks should always be considered for inclusion in ET.

4. Basic Manipulative Skill and Knowledge tasks or objectives will always be classified as Low perishability, and should not be included in ET unless initial skills development is being considered as a component of ET.

For the current purpose of deciding whether sustainment and, hence, embedded training is required to be further considered in system development, the above model can be applied rather easily. It requires that the analyst provide the best possible estimates about the character (or classification) of the predictable task requirements of the system. Analysts will frequently have to make sophisticated guesses at the ratings called for in Table 2 before the specific tasks are known.

In Table 2 the possible ratings for each task type are indicated. The analyst should circle the rating judged appropriate for each task type for the specific system being analyzed. Given the analyst has made the best possible estimates of the probable characteristics of the probable operator or maintainer task requirements of the system, he or she can then make an overall estimate of the sustainment training requirements of the system. The classification (and perishability rating) model suggests that when many system tasks fall into

the first two or three of the above task-type categories, then these system tasks will probably require frequent sustainment training. Therefore, the prediction would be that the system requires the capa-

Table 3

Ratings of Extent of Performance Requirement of Different Task Types

To what extent will the proposed system demand that the operator (or maintainer) must perform tasks of each of the identified types:

Task Type	Rating of Extent of Requirement		
	To a Very Small Extent	To a Moderate Extent	To a Very High Extent
Performance of Integrated Multiple Skills	1	3	5 *
Performance of Variable or Contingency Procedures	1	3	5 *
Rule or Concept Utilization	1	3	5 *
Performance of Invariant Procedure	1	3	5 **
Performance of Basic Manipulative Skills	1	3	5 **
Application of Basic Knowledge	1	3	5 **

* ET is supported.
** ET is not supported.

bility for frequent sustainment training when any of the first two or three task-type categories is rated as occurring to a very high extent or even to a moderate extent. In these cases, the analyst should recommend that sustainment training is required and, further, that ET should be seriously considered further through the early development stages.

Question 3. Is the Development of an ET Component Feasible in This System?--Other Considerations About Alternatives

Major contributions toward meeting sustainment training requirements can often be done by incorporating ET into system hardware and software, if ET itself is feasible and appropriate based on other considerations. However, ET can be either integrated or "strapped-on"

and there are several other obvious candidates for meeting sustainment training requirements. Generally acceptable sustainment training alternatives include, at least:

1. Integrated ET.

2. Strap-on ET.

3. Training devices at the unit that are separate from and do not use the operational equipment.

4. Centrally located multi-station training devices which operators periodically attend.

5. Supervisor feedback during normal practice with the unmodified system.

6. Supervisor (and other) feedback during field training exercises which include "enemy" forces that produce battlefield stimuli and other battlefield response requirements.

7. Various combinations of these alternatives.

Making the choice of ET as opposed to, or in addition to, other alternatives must be based on further analyses. Among other things, the Factors 2-7, listed earlier, must be considered. These are discussed below.

Factor 2: Implementation Feasibility

Is the implementation of ET feasible in this system? Will the mission system have sufficient processing, storage, and interface capabilities to effectively implement an ET component, or can the processing and storage of the mission system be augmented to support ET?

In general, maximum ET capability will require significant computer capability for implementation, as well as interfaces with parts of mission system equipment (sensors, displays, controls, etc.) and with operational software. This is particularly true if many aspects of the stimulus environment (including visual or auditory simulation) must be provided by ET. It is critical that providing ET not detract from the mission system's performance of non-ET functions; thus, sufficient additional - integrated or strap-on - capacity, beyond the planned allocation for mission system processing, should be provided for ET.

Of particular concern in this decision are any potential penalties to the mission system (including space or volume, mass, power, and survivability) which may result from augmenting mission system processing, storage, or interface capability to accommodate ET. Since this

decision will be addressed early in system conceptualization, the feasibility of augmenting the mission system's capabilities to accommodate ET is probably at a maximum; these capabilities can be reflected in acquisition documentation (and in system design) from the beginning of system development.

If there are no significant limitations imposed by the system's existing (or proposed) processing capacity, or if providing additional capacity is relatively trivial in potential cost and impact, then the attractiveness of ET as a system component is increased. If there are significant direct or correlated problems (i.e., mass or volume penalties in aircraft) in providing estimated processing capabilities, then ET's attractiveness decreases with the magnitude of the problem.

Factor 3: Operational Mission Interference

Will the system mission operations allow ET? What is the likelihood that providing ET will result in interference with mission system operational capabilities, or that conversion from operations mode to ET and vice versa will be effortful or time consuming?

If the provision of ET degrades mission system operations significantly or if conversion between operations and training modes is difficult, the ET capability will not be accepted or used in units.

In general, this factor should be considered in terms of the demand on the proponent or user to clearly identify the requirements for mission operational security and to inform the designer of the ET system as to what can and cannot be tolerated with respect to potential interference. It is then up to the ET designer to design in such a manner as to preclude the interference. Many possibilities for system and ET subsystem design exist (can be developed) which will allow a peaceful coexistence of the operational missions and the training capabilities.

As an example, in some systems which have multiple, redundant capabilities, it has been found acceptable to remove one or more of the redundant stations from operations and devote it to training use part of the time. Also, if the operator interface is primarily electronic (e.g., most interface with the environment is through CRT-type displays), it may be feasible to provide a "simulated-over-live" ET presentation, retaining operational capability while providing concurrent training through synthetic targets, etc. In such cases, measures must be taken to ensure that trainees do not fire on live targets but only on simulated targets (assuming the live targets are innocuous in peacetime training). Also, in the case where interfaces with other types of systems are provided through C^3I networks, simulated targets for training purposes must not be allowed to "enter the net" (e.g., allowed to enter the operational network, outside the established training net); this could result in false alarms in operational systems not directly associated with the system being used for training.

Another aspect of this factor is the time to convert from training mode to operations and vice versa, when ET is conducted "off-line." The available evidence suggests that if the conversion requires much time and effort, the ET capability will not be used, since the operational system is degraded for too long in such cases and too many resources are required. This has been observed to be a problem in at least one case, when strap-on ET capabilities were provided.

The desirability of ET clearly decreases if there are likely to be operational interference or conversion problems which cannot be avoided or "worked around" when ET is provided. Care must be taken in identifying the likelihood of such problems and in developing specifications for mission systems with ET components to ensure that operational and conversion problems are minimized.

Factor 4: Training-Specific Interface Hardware Requirements

Will additional controls and displays be required to provide ET? Can the mission system control and display interfaces be used directly to provide ET or will there be a significant requirement for training-specific controls and displays?

The training value of an ET component can be seriously eroded if training-specific controls or displays are needed simply to provide ET. Transfer of training to operational situations may be degraded significantly if trainees use different system interfaces with ET than those used in the operational mission performance. In general, the use of mission system controls and displays for providing ET is considered critical.

However, in some cases, especially for strap-on ET, it may be both feasible and advantageous (through provision of otherwise unavailable OJT) to provide separate displays for ET which are not specifically directed toward training in control or display manipulation or other system uses, but to other aspects of job knowledge and skill (e.g., provision of computer assisted instruction on system setup, march ordering or maintenance).

The need for providing training-specific interface equipment can be all but eliminated if the mission system interface is initially designed to allow support of ET also. System complexity due to the presence of an ET component will also be reduced by this integrated approach.

If it is not feasible to integrate ET display and control requirements with mission system requirements, the attractiveness of ET decreases to a certain extent.

Factor 5: Availability for Training

Is there going to be time for ET? Will mission systems be available for training use, given other system demands?

Sufficient time to utilize the ET capability must be available in the units, or there is little merit to providing ET. Both the demands on the mission systems and on personnel should be considered in addressing this questions. When systems must be continuously operational, it may be feasible to provide concurrent training during operations via the ET capability (the "simulation-over-live" capability mentioned above); otherwise, if operational interference can be minimized, ET may still be practicable. Also, in distributed systems with multiple identical stations, other stations may be able to compensate operationally for the absence of one or more stations used off-line for training. Another factor which should be considered in answering this question is the amount of time the system will be in maintenance.

If the combination of operations and maintenance consumes much of the time potentially available, and there is no concurrent operations (or maintenance) and training capability, the investment in providing ET will probably not be worthwhile.

Again, the opportunity to avert potential availability problems exists in the development process, including the potential to provide additional mission equipment for training use under the Basis of Issue Plan (BOIP). There is a clear need for dialogue, negotiation, and accommodation among training, combat, and materiel developers throughout the development process. The training developer must be prepared to rework his training objective allocation approach if the desired ET capabilities cannot be system supported.

Factor 6: Reliability, Availability, and Maintainability

Will there be significant impacts on the Reliability, Availability, and Maintainability (RAM) characteristics of the mission system due to the inclusion of an ET component?

Both any ET design characteristics which may affect RAM and the time requirements for operating the mission systems to provide ET must be considered in evaluating this factor. In general, it is expected that mission systems with designed-in ET components should have RAM characteristics similar to the conceptual mission system without the ET capability, since it is likely that similar technologies, design characteristics, etc., will be present in both. If strap-on ET must be provided, or if the ET capability is retrofitted into an existing system, then there may be significant design-related RAM impacts. Also, if one of the maintenance "high driver" factors is system "on-time," the additional use of the system for training may have impacts on the maintenance requirements.

If RAM impacts related to providing ET are judged to be nil, or of an acceptable level, then the attractiveness of ET is enhanced. Conversely, if RAM impacts are likely to be serious, then the feasibility and attractiveness of ET are diminished according to the magnitude of the impact.

Factor 7: Manpower and Personnel Impacts

What does provision of ET do to manpower requirements? Are there likely to be Manpower and Personnel (M&P) impacts as a result of including an ET component?

There are currently several apparent possible impacts on M&P issues which may be related to ET. The first is closely associated with impacts on RAM characteristics discussed above. If RAM of a system is negatively impacted by inclusion of an ET component, then there is likely to be a related increase in the number of maintenance personnel required for the system. Such an impact would probably be unacceptable, and would detract from the attractiveness of having ET for a system.

Second, the training programs provided by ET will require update and maintenance, especially if there are frequent software updates to the mission system. It is unlikely that present training support personnel (either in units or schools) will be able to maintain ET lessonware without sophisticated assistance (e.g., authoring systems). Thus, there may be requirements to provide additional personnel for update and maintenance of the ET capability. If this is the case, the attractiveness of ET may be somewhat diminished.

The potential need for additional personnel might be offset by providing organic training update capabilities (e.g., authoring systems at the proponent school; special training for existing unit personnel to allow maintenance and update of unit training materials and software), but this need must be anticipated and provided for in the design of the total training system. Such capabilities could hypothetically be shared between several mission systems incorporating ET capabilities, if there were sufficient compatibility between the ET implementations to share a single authoring system. Configuration control of ET lessonware should also be considered as a part of this factor.

A third possible impact of ET on M&P requirements is in the area of direct administration of ET. The need for instructors and instructor time to provide sustainment training may be reduced. If the ET component is a fully developed training subsystem, it may be very possible to allow individuals and teams to train with the system with no instructors or high level supervisors present. While this will not have a large impact on the M&P requirements, it will free up instructor or NCO time to perform other duties in units. If the ET subsystem is also used at the institutions or other non-unit training sites, this facility may in fact lead to a reduction in the number of training instructors required to support the system training base.

Question 4. Is it Likely That ET Will be a Cost-Effective Training Alternative for This System?

Factor 8: Cost Effectiveness

Will ET be cost-effective relative to other training approaches?

This question will be one of the most difficult to address definitively during system conceptualization until an ET cost database has been developed through experience. At present, segregated ET costs are nearly impossible to obtain (similar to the situation with other training alternatives); thus, cost tradeoffs are problematical. Further, data to support Cost and Training Effectiveness Analysis (CTEA) are typically not available early in the system life cycle, where ET potential must be addressed. Methods for determining cost effectiveness of ET in relation to other training means have yet to be derived or applied.

Volume 3 of this Guideline series, "The Role of ET in the Training System Concept," provides a means for deriving potential total training system concepts (limited to hands-on training approaches) very early in the materiel system acquisition cycle. The procedures in this document structure the identification of hands-on training support concepts including ET, stand-alone training devices, and conventional hands-on training approaches such as exercises, range firing, etc. These procedures contribute to the formulation of alternatives to be considered in the conduct of a CTEA and, hence, decisions regarding the overall training system configuration.

If ET is judged not likely to be more cost-effective than other alternatives in providing the same training with the same effectiveness, it should obviously not be pursued. Conversely, if ET were determined to be the only way to provide needed sustainment training on system-necessary and critical system tasks, then it should be implemented without question. Obviously, the systems developer might well reexamine the need for any such tasks and some of these might be eliminated by this reconsideration.

Decisions About Sustainment Embedded Training

Consideration of the above four questions and their component factors should lead the analyst to a general conclusion that ET should or should not be further considered in further system exploration and development. It must be remembered that consideration of ET at this and early succeeding stages does not preclude the provision of sustainment (and other) training through other means as may be shown desirable by subsequent training system design and development (per the application of the succeeding Guideline, Volume 3, [Roth, J. T., 1987], and other required training systems analyses).

As an obvious example, field training exercises (FTXs), including "enemy" forces that produce battlefield stimuli and other battlefield response requirements, provide excellent training and should be part of the sustainment training for all systems. However, such exercises are costly and typically cannot be conducted as frequently as needed to maintain operator skills at highest levels. Therefore, FTXs are not likely to fully meet the total need for frequent sustainment training when required. And, when frequent sustainment training is required. some form of simulation of battlefield stimuli should be used as a supplement to FTXs. This sustainment can be provided in the form of ET, if otherwise feasible, or through some other training mode, such as simulators or conduct of fire trainers, for example.

If ET is judged to be a continuing option, it must be remembered that some systems will lend themselves readily to fully integrated and incorporated ET components. For other systems, ET will only be a possibility in the strap-on or adjunct mode. Obviously, some systems' sustainment training needs will not be optimally suited for ET of either form and will necessarily require separate training devices, or other training modes, to provide the required sustainment training.

Another factor that may determine the form of sustainment training is the operational and maintenance requirement of the system. It is possible that some systems cannot be taken off line to permit training. If the system is actually being used to monitor potentially hostile aircraft, missiles, artillery projectiles, land vehicles, etc., as in boarder, sea, or air surveillance, it probably cannot be taken off line to simulate nonexisting entities and otherwise to provide for operator sustainment training. However, backup monitoring systems and overlap of the coverage area from adjacent units will probably exist. These capabilities would allow the system to go off the air for routine maintenance and also cover for the system in the event that it fails; they could also provide for off-the-air time for training. There probably are few systems which will not also allow time out from operational use to allow the system to be used for sustainment training as well. Patriot in Germany fits this classification and ET of operators occurs routinely, presumably while one unit covers for another.

CONSIDERATION OF EMBEDDED TRAINING FOR RETROFITTING EXISTING SYSTEMS - (P^3I, ECPs, and PIPs)

Theoretically, an ET component could be developed for any system which demands tasks which require training, given that the systems were more complex than a hand grenade or similarly non-complex item of War. In fact, the potential applications do seem almost limitless after examination of a number of actual and potential systems which have or certainly could have an ET component. Many of the Army's existing or currently late-in-development systems could conceivably be updated with

respect to this evolving aspect of training subsystem development. The guidance provided in this document can be applied equally as well, and probably much easier, to existing systems as it can be used with newly conceived and developing systems.

In the recent past, opportunities for incorporating ET into operational systems have been overlooked more frequently than not. Engineers and other designers face compelling major problems with mechanical and electronic subsystems and these palpable problems tend to overshadow poorly defined problems in the human-system interface and even less salient problems related to initial and sustainment training of system operators. Typically, it is after the obvious technical problems have been "solved," after the engineers turn the system over to the military, and after the system is found not to meet expectations that attention is finally directed to those less obvious human-system interface problems, and operator and maintainer training problems. However, it is our contention that even though most of such problems could have been identified earlier, it is never too late to start with the correctional approach.

Many of the currently developing systems are intentionally being developed under the Planned Programmed Product Improvement (P^3I) approach to system acquisition. This approach essentially accepts that the initially acquired system will be somewhat less than the objective system that is desired and that the way to achieve the objective system is through a series of programmed upgrades over a number of years with gradual developments and improvements.

A system currently developing under this approach is an ideal candidate for examination with respect to potential incorporation of ET. If ET should prove desirable for the system, it can be designed and developed into one of the subsequent iterations of the development process.

Similarly, many systems go into a series of (not necessarily) planned or programmed updates by way of the Engineering Change Proposal (ECP) or Product Improvement Program (PIP) routes. Here again, if a system is being changed and improved through one of these processes, and if ET is determined to be desirable, then ET components can be developed and incorporated through the same change or improvement mechanisms.

Unfortunately, this late identification of the training requirements may prevent the development of a completely integrated ET component, in the sense of being fully incorporated into the system equipment, due to the particular system design involved. This in no way precludes the proponent agency from identifying and demanding the development and incorporation of an adjunct or "strap-on" ET component for any system that would benefit from its availability.

It is our contention that the procedures and guidance outlined in this document apply equally well to the determination of the desirability of consideration of ET for an existing or late-developing

system as for one newly conceived. The procedures should be applied to the existing system in exactly the same manner as they would be applied to a new system.

The specifics about answering the four essential questions should be made much easier for the analyst working with an existing system simply because the facts about the system's functional performance requirements and task demands on the staffing personnel will be clearly known. Certainly for such systems, all the relevant policy questions and issues will have been perfectly clarified (e.g., if the proponent has determined that ET should be developed for skill and knowledge acquisition training, this will be known, etc.). Even in late-developing systems, much more will be known than is available for newly conceived systems.

This fact means the analyst will be able to not only examine closely the tasks required by the system, but will also be able to review field experience with both operations and training for operational tasks. This breadth of available data will feed directly into the determination of both the sustainment training requirements and the likely cost-effectiveness of ET as compared with other available training alternatives.

Even the question about the feasibility of implementation of ET will be easier to answer. The equipment will exist; it and its supporting software and courseware can be examined and reviewed to determine the feasibility of ET for the system. There will also be a history of development or fielding experience that will provide the analyst with indications and direct answers about the soldier-machine interface and about the RAM and logistics characteristics of the system. The analyst can incorporate all of such data and information into his analyses and come up with the right answer about ET and the candidate system.

If the answer is to proceed further with consideration of ET for the system, then the analyst should proceed to Guideline 3, to assist examination of the current or developing training system to determine how best to integrate the system's to-be-developed ET capabilities into the total training system.

REFERENCES

Purifoy, G. R., Jr., Chenzoff, A. P., Harris, C. B., Roth, J. T., & Strasel, H. C. (1985). FOG-M system task and training requirements analysis for embedded training (ET). Valencia, PA: Applied Science Associates, Inc.

Purifoy, G. R., Jr., Harris, C. B., Ditzian, J. L., Meerschaert, M., & Wheaton, K. L. (1985). Design concepts for FOG-M system embedded training (ET). Valencia, PA: Applied Science Associates, Inc.

Roth, J. T. Implementing embedded training: Volume 3 of 10: The role of ET in the training system concept. Butler, PA: Applied Science Associates, Inc. (Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences--Research Product). November 30, 1987.

Roth, J. T. Implementing embedded training: Volume 4 of 10: Identifying ET requirements. Butler, PA: Applied Science Associates, Inc. (Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences--Research Product). November 30, 1987.

Roth, J. T., Fitzpatrick, J. A., Warm, R. E., & Ditzian, J. L. Implementing embedded training: Volume 5 of 10: Designing the ET component. Butler, PA: Applied Science Associates, Inc. (Alexandria, VA: U.S. Army Research Institute for Behavioral and Social Sciences--Research Product). November 30, 1987.

Stasel, H. C., Dyer, F. N., Aldrich, R. E., & Burroughs, S. L. (1986). Review of eight Army systems: Characteristics and implications for embedded training. Columbus, GA: Hi-tech Systems, Inc.

BIBLIOGRAPHY

Applied Science Associates, Inc. (1984). Systems design concepts to support embedded training (ET). (Technical Proposal P-60-3-1010). Valencia, PA: Applied Science Associates, Inc.

Harris, C. B., Shipton, D. L., & Bogner, M. S. (1985). Tri-service review of existing embedded training (ET) systems. Valencia, PA: Applied Science Associates, Inc.

Purifoy, G. R., Jr., Chenzoff, A. P., Harris, C. B., Roth, J. T., & Strasel, H. C. (1985). FOG-M system task and training requirements analysis for embedded training (ET). Valencia, PA: Applied Science Associates, Inc.

Department of the Army. (1979). Army training and evaluation program 7-15: Army training and evaluation programs for infantry battalions (infantry, airborne, air-assault, and ranger). Washington, DC: HQ, Department of the Army.

Department of the Army. (1984b). Field manual 25-2: Unit training management. Washington, DC: HQ, Department of the Army.

Department of the Army. (1984c). Field manual 25-3: Training in units. Washington, DC: HQ, Department of the Army.

Department of the Army. (1984d). Field manual 25-4: How to conduct field exercises. Washington, DC: HQ, Department of the Army.

Department of the Army. (1985b). Field manual 25-1: Training. Washington, DC: HQ, Department of the Army.

Department of the Army. (1985c). Field manual 25-5: Training for mobilization and war. Washington, DC: HQ, Department of the Army.

Ditzian, J. L., Adams, J. E., & Sullivan, G. K. (1985). FOG-M system embedded training (ET) demonstration courseware outlines. Valencia, PA: Applied Science Associates, Inc.

Mizel, T. (1985). Briefing on potential use of Training Extension Courses (TEC) and developmental process for the Fibre Optics Guided Missile System Operator's Manual. Briefing conducted at U.S. Army Missile Command, Redstone Arsenal, AL, 18 October 1985.

Meerschaert, M., Rainaldi, W., Smith, R., Thompson, D., Frederick, C., & Wheaton, K. (1985). Embedded training software specifications for the FOG-M system demonstration. Ann Arbor, MI: Vector Research, Inc.

APPENDIX

RATING WORKSHEETS: SUMMARY, FACTOR 1 USING TASK-STIMULUS CHARACTERISTICS MODEL, AND FACTOR 1 USING TASK CHARACTERSITICS MODEL

EMBEDDED TRAINING AS A SYSTEM ALTERNATIVE

SUMMARY WORKSHEET

1. Are there policy decisions which dictate the use of ET for knowledge and skill acquisition training in the system? Yes____ No ____

2. Do many of the proposed system's tasks require frequent sustainment training?

   Factor 1: System task and skill demands - requirements for sustainment training - Yes____ No ____ Maybe____

3. Is the development of an ET component feasible in this system?

   Factor 2: Implementation feasibility Yes____ No ____ Maybe____

   Factor 3: Operational mission interference Yes____ No ____ Maybe____

   Factor 4: Training-specific interface hardware requirements Yes____ No ____ Maybe____

   Factor 5: Availability for training Yes____ No ____ Maybe____

   Factor 6: Reliability, availability, and maintainability Yes____ No ____ Maybe____

   Factor 7: Manpower and personnel impacts Yes____ No ____ Maybe____

4. Is it likely that ET will be a cost-effective training alternative for this system?

   Factor 8: Cost effectiveness Yes____ No ____ Maybe____

EMBEDDED TRAINING AS A SYSTEM ALTERNATIVE

FACTOR 1 WORKSHEET FOR THE

TASK-STIMULUS CHARACTERISTICS MODEL

SUMMARY

Characteristic	Rating*
1. Battlefield Stimuli:	
Differ from Peacetime	_____
Frequent Experience Necessary	_____
2. Number of Stimulus Sources:	
Frequency of Multiple Stimuli	_____
Criticality of Success	_____
3. Number of Stimulus Patterns	_____
4 or 5. Number of Different Responses or Number of Operator Tasks and Subtasks	_____
6. Need for Response Speed	_____
7. Sensitive Tracking Tasks . . . . . Yes___	No___

* small extent = 1, moderate = 3, high extent = 5

---

1. Need for simulation of battlefield stimuli - (need for practice in recognizing and responding to battlefield stimuli)

a. How much will battlefield stimuli differ from stimuli provided in normal peacetime use of system?

_____	_____	_____
To a Very Small Extent	To a Moderate Extent	To a Very High Extent

b. How important is it to effective operator performance that actual battlefield stimuli be frequently experienced in training?

_____	_____	_____
To a Very Small Extent	To a Moderate Extent	To a Very High Extent

2. Number of different stimulus sources to which the operator responds.

a. Make a judgment as to whether and how frequently the operator will be required to provide rapid (time-constrained) responses to multiple audio or visual displays or stimulus sources (consider each of: one or more CRTs; panel displays - indicators and dials; switch positions; ext. radio; intercom; other voice commo; other?):

Low Frequency of Multiple Stimuli	Moderate Frequency of Multiple Stimuli	High Frequency of Multiple Stimuli

b. Make a judgment as to how critical successful responses to the multiple stimulus sources will be to mission success:

Low Criticality to Mission Success	Moderate Criticality to Mission Success	High Criticality to Mission Success

3. Number of different identifiable stimulus patterns to which the operator responds. Provide a magnitude judgment about the relative number of diverse event, target, or stimulus situations to which the operator might have to respond routinely (and for judged "worst case situations") in an ordinary operational setting (another way of saying it is: how many different "things" must he be able to handle effectively per unit time - whether they were actually to occur or not?):

Relatively Few Diverse Events or Patterns	Moderate Number Diverse Events or Patterns	Relatively Many Diverse Events or Patterns

4. Number of different responses the operator makes. Provide a magnitude judgment of the relative number of different responses that the operator will be required to make (or to choose among) in normal operation:

Relatively Few Different Responses	Moderate Number Different Responses	Relatively Many Different Responses

NOTE: Respond to 4 above or 5 on the next page. You do not have to respond to both unless you wish to do so.

5. Number of operator tasks and subtasks. Provide a magnitude judgment of the relative number of different tasks and subtasks of the operator in normal operation:

_____	_____	_____
Relatively Few Tasks & Subtasks	Moderate Number Tasks & Subtasks	Relatively Many Tasks and Subtasks

6. Need for speed in detecting key stimuli or stimulus patterns and in responding to them (delay tolerance of the task). Make a judgment about the relative importance of speed of response in performance of a significant portion of the required operator tasks:

_____	_____	_____
Speed Relatively Unimportant	Speed Moderately Important	Speed Very Important

7. Need for tracking of targets. Does the system require the operator to perform relatively sensitive psychomotor tracking tasks in order to accomplish the mission?

Yes: _____ No: _____

EMBEDDED TRAINING AS A SYSTEM ALTERNATIVE

FACTOR 1 WORKSHEET FOR THE

TASK CHARACTERISTICS MODEL

SUMMARY

Task Type	Rating of Extent of Requirement*
1. Performance of Integrated Multiple Skills	_____
2. Performance of Variable or Contingency Procedures	_____
3. Rule or Concept Utilization	_____
4. Performance of Invariant Procedures	_____
5. Performance of Basic Manipulative Skills	_____
6. Application of Basic Knowledge	_____

* small extent = 1, moderate = 3, high extent = 5

---

1. Integrated multiple skills performance. To what extent will tasks in the proposed system require the coordinated and rule-mediated performance of a number of complex skills in a parallel or closely linked fashion?

To a Very Small Extent	To a Moderate Extent	To a Very High Extent

2. Variable or contingency procedures. To what extent will performance of tasks in the proposed system vary as a function of situational differences or contingencies?

To a Very Small Extent	To a Moderate Extent	To a Very High Extent

3. Rule or concept utilization. To what extent will performance of tasks in the proposed system require the use of rules or concepts to correctly understand the situation, make correct decisions, or take the correct course of action?

To a Very Small Extent	To a Moderate Extent	To a Very High Extent

4. Invariant procedures. To what extent will tasks of the proposed system consist of fixed-sequence procedures with no major contingencies?

To a Very Small Extent	To a Moderate Extent	To a Very High Extent

5. Basic manipulative skills. To what extent will tasks of the proposed system consist of basic manipulative psychomotor skills such as vehicle handling?

To a Very Small Extent	To a Moderate Extent	To a Very High Extent

6. Knowledges. To what extent will performance of tasks in the proposed system predominently require application of knowledge of basic facts?

To a Very Small Extent	To a Moderate Extent	To a Very High Extent