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Engineering Functions in Formulating Training Device Concepts

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U.S. Army Research Institute

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Cost-effective application of technology to the design of training devices requires careful matching of training requirements with training device options. The goal of the training device concept formulation process (CFP) is to identify a cost-effective device or combination of devices to address a training requirement. The U.S. Army Project Manager for Training Devices (PM TRADE) Research and Engineering Management Division, known as E Division, performs system engineering activities during concept formulation that assess, integrate, and develop training device design concepts and cost estimates. This report presents the results of an E Division effort to define methods for aiding the training device CFP, emphasizing engineers' consideration of factors influencing skill acquisition and retention when defining materiel solutions to training requirements. It defines a baseline process model of the role of engineers in the CFP for training devices, identifies targets of opportunity for increasing the effectiveness and efficiency of CFP, and recommends courses of action.

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FOREWORD

The high cost of training on operational equipment, safety and environmental considerations, and lack of adequate resources have increased the need for effective training devices and simulations. Progress in instructional technology, such as improved simulation technology and computer-assisted instruction, has greatly expanded the range of options available to the training device designer. This expansion has produced an increase in the complexity of the process for designing training devices.

The Project Manager for Training Devices (PM TRADE) and the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI)/PM TRADE Field Unit are collocated to encourage the integration of complementary engineering and behavioral efforts in fielding training devices and simulators. This report documents an ARI survey of PM TRADE engineers who design training devices. The survey focused on members of the Research and Engineering Management Branch (E Division) of PM TRADE. The objectives of the research were to (1) describe a baseline process model of the role of engineers in the concept formulation process (CFP) for training devices, (2) describe the need for training decision aids within E Division, (3) describe the need for improving the information flow within PM TRADE and between PM TRADE and other organizations involved in developing training devices, (4) capture engineers' ideas for improving E Division operations, and (5) compare the fit between the baseline process model and a prototype decision support aid for device design.

This research was performed as part of the program task "Advanced Technology for the Design of Training Devices." The sponsor of the research was PM TRADE. The research was accomplished under the Memorandum of Understanding between PM TRADE and ARI dated 14 July 1986. Preliminary research findings were briefed on 11 December 1989 to Dr. Ronald Hofer, Chief, Research and Management Division, PM TRADE. Dr. Hofer reviewed the final report.

EDGAR M. JOHNSON
Technical Director

Research Report 1599

Engineering Functions in Formulating Training Device Concepts

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Technical Director

ENGINEERING FUNCTIONS IN FORMULATING TRAINING DEVICE CONCEPTS

EXECUTIVE SUMMARY

Requirement:

The goal of this project was to define a baseline process model of the role of engineers in the concept formulation process (CFP) for training devices, identify targets of opportunity for increasing the effectiveness and efficiency of CFP, and recommend courses of action. A major concern of this project was the examination of learning principles considered by engineers in training device CFP.

Procedure:

The training device CFP was defined as it is described in Army regulations, SOPs, and pamphlets. A questionnaire was designed for collecting data on the work experience of engineers, job task descriptions, obstacles to job performance, and ideas for improving job performance. This questionnaire was administered to all engineers within PM TRADE's Engineering and Research Management Division. Fifteen engineers were then selected for interviews based on responses to questionnaire items. Preliminary conclusions were discussed with various engineers, and conclusions were revised where appropriate to reflect engineer comments.

Findings:

Engineers make decisions about materiel solutions to training requirements that require consideration of the principles of learning, but the principles considered vary among engineers. All engineers appear to be concerned with identifying the minimum cue and response fidelity requirements necessary for effective learning. Some engineers go beyond the consideration of fidelity requirements to address such issues as how to measure performance and provide feedback.

The task of obtaining the information about training requirements needed to apply learning principles to device design often continues throughout the CFP. No standard set of procedures is used for considering learning principles in the design of training devices.

Five factors were identified that influence training device CFP:

- whether a school specifies that it wants a specific training device;
- the extent to which the project involves novel applications of training technology;
- whether the project addresses individual training or collective training;
- training device policy statements;
- whether the project addresses school or unit training.

Targets of opportunity for improving the training device CFP include linking learning variables to materiel variables as a function of project categories, and clarification of the intended relationships between major components of CFP. An example of the latter target is the Trade-Off Analysis (TOA) conducted to identify the best materiel solution and the Cost and Training Effectiveness Analysis (CTEA).

Utilization of Findings:

These findings are being used by PM TRADE to increase the effectiveness and efficiency of targeted areas of CFP. These findings are also being used to guide a joint PM TRADE and ARI project to refine the Optimization of Simulation-Based Training Systems (OSBATS) decision support system.

ENGINEERING FUNCTIONS IN FORMULATING TRAINING DEVICE CONCEPTS

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ENGINEERING FUNCTIONS IN FORMULATING TRAINING DEVICE CONCEPTS

Introduction

The Importance of the Training Device Concept Formulation Process

The high cost of training on operational equipment, combined with safety considerations and lack of adequate resources, have acted as stimuli to the development of training devices. Certain training devices, such as SIMNET (simulation networking), provide a means of conducting maneuver training without operational equipment and help units to compensate for reductions in OPTEMPO. Other devices, such as the Multiple Integrated Laser Engagement Simulation System (MILES), help to reduce ammunition costs associated with training while also providing a degree of realism that is not normally possible outside of a combat situation. Effective training devices can lead to better, safer and less costly training.

The technological tools that can be applied to training device design are continually growing in number and power. The ability to simulate the combat environment has been enhanced by procedures for preparing high-resolution graphics, improved visual and auditory signal generators, and increasing power of microprocessors. These innovations make it technically feasible to create training environments that were not possible a few years ago, but the costs associated with applying these innovations can be high.

Cost-effective application of technology to the design of training devices requires careful matching of training requirements and training device solutions. The process of formulating a concept for a training device is a critical phase of the device design process in which trainers convey information to engineers about training device needs, and engineers begin to define a materiel solution to these needs. The goal of the training device concept formulation process (CFP) is to identify a cost-effective device or combination of devices that might be used to address a training requirement.

This report presents the results of an effort to define methods for aiding the training device CFP. It emphasizes engineers' consideration of factors influencing skill acquisition and retention when defining materiel solutions to training requirements.

Background: Training Device CFP as Described by Regulation

The CFP process for weapon systems and training devices is governed by Army Regulations 70-1 (Department of the Army, 1986) and 71-9 (Department of the Army, 1987). These regulations are supplemented with guidance in the form of a Memorandum of Instruction (U.S. Army Materiel Command and U.S. Army Training and Doctrine Command, 1988) and AMC-TRADOC PAM 70-2 (U.S. Army Materiel Command and U.S. Army Training and Doctrine Command, 1988).

These regulations and the supplementary guidance describe the CFP from a high level perspective. This high level view of the CFP as it applies to training devices is presented below.

Before the formal start of the CFP a dialogue is maintained between the U.S. Army Project Manager for Training Devices (PM TRADE) and school training developers concerning the training requirements to be addressed by a device (U.S. Army Materiel Command and U.S. Army Training and Doctrine Command, 1988). The purpose of the dialogue is to insure that adequate information is developed about a requirement to facilitate a search for a materiel solution. PM TRADE initiates the CFP when it receives a valid description of training requirements from a school (PM TRADE, 1986).

PM TRADE takes the lead, with TRADOC support, in performing a Trade-off Determination (TOD) to provide the information needed to compare device alternatives (Department of the Army, 1988). "The TOD documentation includes technical analyses or trade-offs; risks, capabilities needed; costs; integrated logistic support (ILS) requirements; estimated total Army manpower requirements; health, safety, and human factors engineering (HFE) requirements; and ecological factors" (Army Training Support Center, 1988) to establish a set of viable alternatives.

TRADOC takes the lead, with support from PM TRADE, in conducting a Trade-off Analysis (TOA) to identify the preferred materiel solution. To a large extent, the conduct of the TOA involves analyzing the data collected in the TOD. TRADOC takes the lead in preparing a Cost and Training Effectiveness Analysis (CTEA) that compares the cost and training effectiveness of training device alternatives (Department of the Army, 1988). The TOD, TOA, and CTEA are intended to be integrated with one another, and they are expected to overlap in time (see Figure 1).

PM TRADE then takes the lead, with support from TRADOC, in preparing the Best Technical Approach (BTA). This phase involves refining and further specifying the description of the selected materiel solution in adequate detail to allow for writing technical specifications. In addition, engineers are responsible

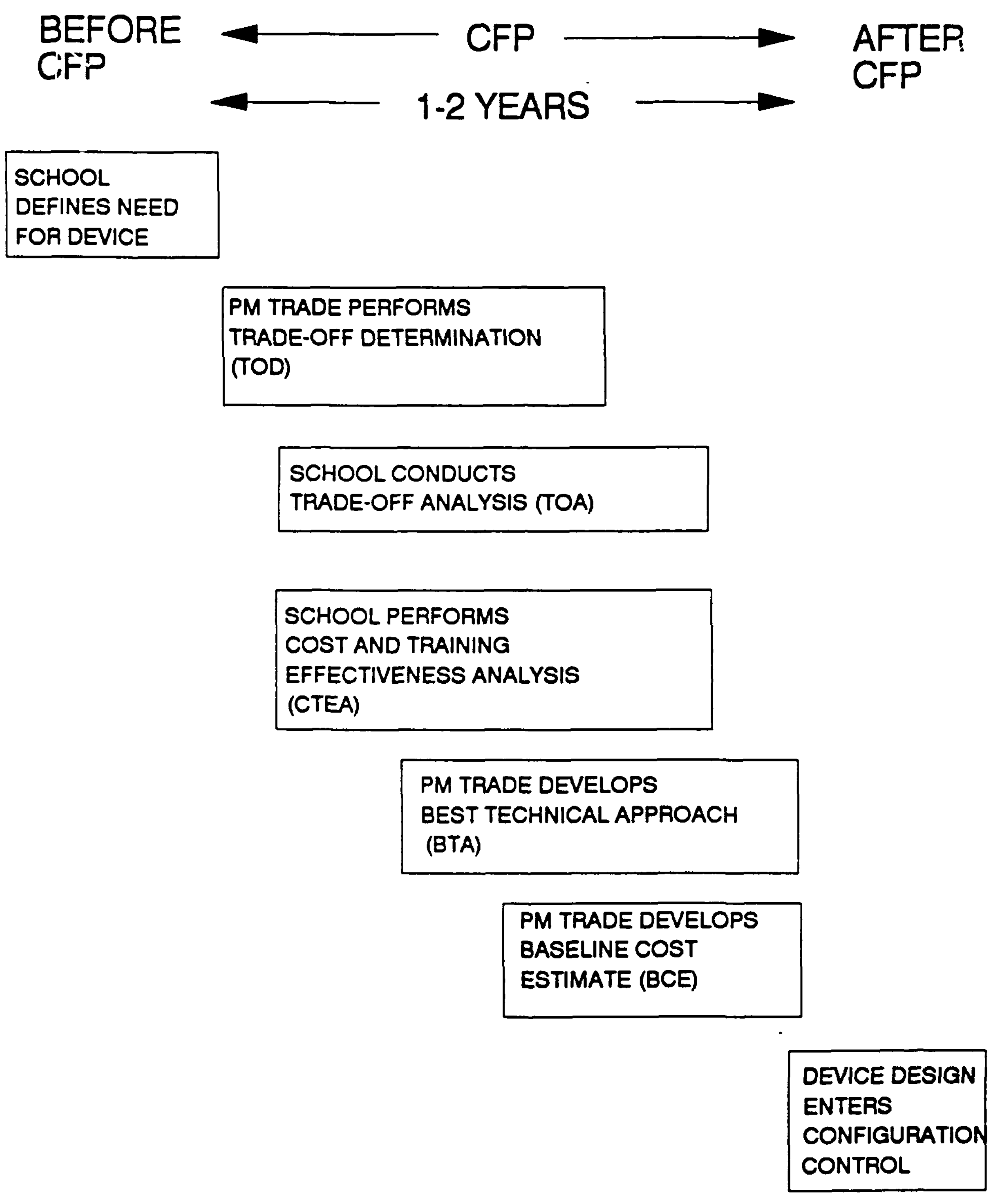

Figure 1. The training device concept formulation process (CFP) as described by regulations.

for preparing a Baseline Cost Estimate (BCE) to provide the government with a valid estimate of the life cycle cost of the training device.

CFP ends when the various documents constituting the CFP have been approved at the Milestone I/II IPR. The concept for the device then enters configuration management control. That is, the technical specifications may be changed only if approved by a Configuration Control Board internal to PM TRADE (PM TRADE, 1986).

A different picture of the training device CFP can be gained by viewing it as a series of reviews in which interested parties come together to insure that adequate information has been developed to move on to the next phase of CFP. Table 1 is based upon PM TRADE Standard Operating Procedure 66 (1986), and it lists the major reviews in CFP and describes the purpose of each review.

Project Goals and Objectives

Turning descriptions of training deficiencies into hardware and software specifications for training devices requires the expertise of training developers and materiel developers: CFP is a joint effort of school training developers and PM TRADE engineers.

PM TRADE has three divisions involved in CFP (PM TRADE SOP 66, 1986). Project management is provided by the Resources Management Division (R Division). The Technical Support and Readiness Division (S Division) is concerned with MANPRINT, logistical, product assurance and RAM (reliability, availability and maintainability) aspects of training device concepts. PM TRADE's Research and Engineering Management Division, known as E Division, leads the system engineering activities during concept formulation that assess, integrate, and develop training device design concepts and cost estimates. Key elements of E Division's mission that relate directly to concept formulation are to maintain a technical database appropriate to the concept formulation process, work with other organizations in formulating training device concepts, and guide technological research to insure that emerging technology can be applied to future concept formulation efforts.

E Division is divided into three branches. Two of these branches, Engineering Concepts and Engineering Development, serve identical functions. These branches are concerned with developing the information used to compare training device options and writing the functional specifications for the training device option or options that are selected. In terms of the concept formulation process shown in Figure 1, these branches perform a TOD, support the conduct of a TOA, develop the BTA, and develop

TABLE 1. PURPOSE OF THE VARIOUS DECISION MEETINGS AND REVIEWS IN TRAINING DEVICE CFP

REVIEW	PURPOSE
PROJECT SCREENING COMMITTEE (PSC)	An internal PM TRADE review conducted to assess whether PM TRADE has the manpower to devote to a particular project.
JOINT WORKING GROUP I (JWGI)	A joint meeting of TRADOC and PM TRADE to decide if Training Requirement is adequately defined by a TRADOC-prepared Training Development Need Statement (TDNS)
MATERIEL ACQUISITION REVIEW BOARD (MARB) I	PM TRADE internal review of data developed by PM TRADE for Trade-Off Determination (TOD) to insure that all issues relevant to training device selection have been addressed
JWG 2	A joint meeting between TRADOC and PM TRADE to perform a Trade-Off Analysis (TOA)
MARB II	PM TRADE internal review of the BTA and validated Baseline Cost Estimate (BCE) to insure that all items are adequate to support a Milestone I/II IPR
AMC MILESTONE I/II POSITION	A review to adopt the AMC position regarding the Best Technical Approach (BTA) in preparation for the Milestone I/II In Process Review (IPR)
MILESTONE I/II IPR	A review to decide whether to proceed with full scale development of a training device
DATA REQUIRE-MENTS REVIEW BOARD (DRRB)	A review to validate the contents of training device procurement packages
QUARTERLY REVIEWS	Quarterly PM TRADE internal review of each project regarding cost, schedule and performance

the BCE. The third branch, Technology Management, plays a distinctly different role in the design of training devices. ET branch is concerned with guiding industry in the conduct of training technology research and development to insure that the outcomes of these efforts will be responsive to the needs of the Army.

We analyzed E Division's functions in training device CFP in order to address two goals. The first goal of this effort was to describe targets of opportunity for increasing the effectiveness and efficiency of CFP. The second goal was to develop information to guide the refinement of the prototype Optimization of Simulation-Based Training Systems (OSBATS), a software package and underlying model designed to support the TOA portion of concept formulation (Sticha, 1990). OSBATS is a computer-based model that interactively uses rule-based procedures and databases to aid in specifying the design and use of training equipment to satisfy training requirements at a minimum cost, or to provide the greatest training effectiveness for a given cost (Singer and Sticha, 1987). A thorough description of the OSBATS model is provided in Sticha, Blacksten, Buede, Singer, Gilligan, Mumaw, and Morrison, 1990).

The objectives of this project were to:

a. describe a baseline process model of CFP from the perspective of E Division engineers;

b. describe the need for training decision aids within E Division;

c. describe the need for improving the information flow within PM TRADE and between PM TRADE and other organizations involved in developing training devices;

d. capture engineers' ideas for improving E Division operations;

e. compare the baseline process model of the CFP with the OSBATS model.

Method

Respondents

A questionnaire was distributed to the Division Chief and all engineers within E Division's Engineering Development (ED), Engineering Concepts (EC) and Technology Management (ET) Branches. ED and EC branches are responsible for concept formulation, while ET branch is responsible for managing the technology database. Nineteen of the 21 engineers working in the concept formulation process completed the questionnaire, and four of the five engineers working in ET Branch completed the questionnaire. Eleven engineers from ED or EC Branch were interviewed on the concept formulation process, and two members of ET Branch were interviewed regarding management of the technology database.

Procedure

Data were collected through a review of written CFP guidance, questionnaire administration, and interviews with selected engineers. Engineers were given three weeks to complete the questionnaire. Responses to questionnaire items were used in selecting engineers to be interviewed and deciding which topics to address in each interview.

Responses to the background section of the questionnaire provided information about who had experience with specific concept formulation tasks, and engineers were selected for interviews when task requirements were found to be unclear. Engineers were selected for interviews, in part, on the basis of reported problems in making training-relevant decisions and reported obstacles to job performance.

The preliminary results and conclusions of questionnaire response analysis and interviews were discussed with the Division Chief and two Branch Chiefs. As a result of these discussions, additional information was obtained regarding the reasons behind selected observations.

Questionnaire

Appendix A provides the four-section questionnaire used in this project. The first section was concerned with the education and experience of respondents. Aspects of experience addressed in this section are listed below, and summaries of the responses to these questions are provided in Appendix B.

- Length of time engineer has worked within E Division and PM TRADE in general

- Number of years of experience designing training devices
- Types of devices on which engineer has worked
- Identification of TRADOC schools that engineer has worked with in the preceding two year period
- Identification of formal reviews for which engineer has developed input
- Experience or lack of experience with the various activities and documents that might be involved in a concept formulation project
- The amount and kind of training each engineer has had in systems engineering
- Whether an engineer is required to make specified training decisions, if problems have been encountered in making these decisions because of a lack of information or decision criteria, and if the engineer was able to overcome the problem or has knowledge about the problem
- The software and databases used by engineers in their work

The second section of the questionnaire was used to collect data regarding the work flow in CFP. Engineers were asked to list their major job functions, list the major tasks performed within each function, describe the input and output associated with each function, and list sources of information used in performing each function.

The third section was used to collect information on the decisions engineers make that require consideration of variables influencing skill acquisition and retention. Engineers were asked what training or learning issues they consider in their work, and they were asked to identify the most significant training decisions that bear upon the selection of a Best Technical Approach (BTA) to a training device requirement. In addition, they were asked to list the most significant steps or decision points in arriving at the BTA.

The fourth section addressed job satisfaction and defining areas for improvement in concept formulation. These questions were:

- What are the major obstacles to performing your job efficiently?
- What information would better assist you in performing your job duties?

- Of the tasks you perform in your job, which would you most like for someone else to perform? Why?
- Of the decisions that you make in your work, which would you most like to have someone else make?
- Which parts of your job give you the greatest satisfaction?
- What training would you like to receive that you feel would help you to better perform your duties?

Baseline Concept Formulation Process (CFP) for Training Devices

The training device CFP is described at a general level in regulations and guidance documents. The description of CFP described here is based upon responses to survey items, formal interviews, informal discussions with engineers, and observation of engineer's activities in the context of project meetings. In the resulting summary we have tried to:

- identify and explain the manner in which general regulations are applied in practice
- examine the depth of activities performed by engineers in adequate detail to identify major variables that influence their jobs
- identify issues about the intent of CFP regulations that have not been resolved through application of the regulations
- identify sources of information currently used in performing CFP

How CFP Regulations and Guidance Documents are Applied in Practice

Many of the regulations and guidance documents for performing CFP are written at a general level and apply to both the prime weapon system and training device CFP. This fact was reported by a number of engineers. However, even when examining the training device CFP at a general level there are important differences between regulations or guidance and what actually happens in practice that help to define targets of opportunity for improving CFP. Listed below are three important ways, relating to school description training requirements, in which CFP as defined by formal guidance differs from CFP as practiced within E Division . For a more detailed listing of CFP tasks and subtasks performed by engineers the reader is referred to Appendix C.

- E Division often agrees to initiate CFP before TRADOC has defined training requirements in the manner specified by regulations and guidance documents. In practice, the definition of training requirements may continue throughout training device CFP, rather than being completed prior to the start of CFP.
- PM TRADE plays active roles in helping to define the training requirements to be addressed by devices through reviews of Training Device Requirements (TDRs), Training Development Need Statements (TDNS), and other documents TRADOC is responsible for preparing.

- In certain cases the engineer also assumes responsibility for ensuring that adequate task analyses and media analyses are performed to provide the information required to execute a TOD.

The substantial role played by engineers in attempting to define the training requirements to be addressed by a materiel solution can be credited, in part, to the fact that schools do not provide the descriptions of training deficiencies as specified in regulations and guidance documents. This is a problem that has previously been reported (Heeringa, Baum, Holman, and Peio, 1982), and it will be discussed in greater detail later in this report. For the present it is important to note that the major deficiencies in the training requirements developed by schools are a failure to list the tasks to be trained, and a failure to describe the minimum fidelity requirements necessary for effective training.

Would the need for engineers to play an active and substantial role in defining training requirements be reduced if schools defined training requirements in accordance with regulations and guidance? Probably not. The reason for this assessment is that the guidance for describing training requirements (Army Training Support Center, 1988) is essentially the same for all projects. The scope of current CFP projects, on the other hand, ranges from part task trainers intended to train selected individual operator or maintenance tasks for a single duty position to networked simulations at the Battalion Task Force level. Further, many projects involve novel applications of training technology; engineers discover many of their information needs regarding training requirements during the course of the CFP.

A fourth difference between regulations or guidance and practice is that engineers sometimes perform a preliminary TOA for review by schools, rather than waiting for schools to initiate this process. This preliminary TOA serves as an internal check on the quality of the TODs performed by engineers, since the TOA employs the information developed during the TOD.

<u>Major Project Variables That Influence the Training Device CFP</u>

At the task level, described in Appendix C, there is a roughly uniform CFP within PM TRADE that differs from regulations and other guidance as described immediately above. When one starts to look at the subtask level and observes what engineers do in performing these subtasks, it becomes apparent that the CFP differs among projects. At the start of data collection, we expected differences in domain (e.g., armor, aviation, combat service support) to have a significant effect on the procedures employed during the CFP. Instead, we found that other factors appeared to have a more pronounced effect on the CFP. In all but one case, these factors surfaced during the course of interviews and in the context of project meetings in which we participated. These factors surfaced as problems in the context of more than one project, while not being common to all projects.

Five factors were identified as having a substantial impact on the CFP. These factors are:

- whether a school specifies that it wants a specific training device;
- whether the project addresses individual training or collective training;
- the extent to which the project involves novel applications of training technology;
- training device policy statements;
- whether the project addresses school or unit training.

Whether a TRADOC School Specifies That It Wants a Specific Training Device

Requirements documents vary in terms of whether they describe a training requirement or specify a particular device. A critical portion of a school's job in developing training device requirements is the identification of a variety of training options, including training on operational equipment (Army Training Support Center, 1988). However, the range of devices to be considered is often restricted by premature commitment to a specific technology or device option. For example, the commandant of a particular school might attend a device demonstration and decide that the school needs to have a device like the one demonstrated. Engineers provided many examples of training device requirements in which a school specified a particular device, even going as far as using a corporate brochure. As one engineer stated "The 'Training Device Requirement' should be renamed 'Training Requirement'. Too often the TDR lists specifications for devices but not training requirements." The artificial restriction of device options to be considered influences the engineer's job in one or both of two ways. First, the engineer may spend considerable time and effort convincing the school to consider other device options. Second, if the engineer is unsuccessful in convincing the school to expand the device options, the TOD and TOA process will be modified by PM TRADE and TRADOC schools to fit a constrained set of training device options.

Individual Versus Collective Training

We found that the application of training devices to collective training requires engineers to address unique variables. For example, one engineer was concerned with figuring out how a device could be used to train soldiers with different Military Occupational Specialties at the same time. The engineer reasoned that the equipment status required to support the training of one MOS, such as allowing a soldier to turn off electrical power to troubleshoot and correct a simulated equipment malfunction, might interfere with the training of other MOSs. In the case of the power example, the engineer described a situation in which other soldiers would be unable to operate their portion of the equipment while the power was off.

In addition to requiring unique considerations, the design of collective training devices involves developing methods for designing training devices. Although the Army of the future is expected to make extensive use of collective training devices to complement field training exercises (Armstrong and Deaver, 1990), the Army does not currently have a substantial set of guidelines for developing collective training devices. The application of simulation networking (SIMNET) to collective tactical training, for example, is only a few years old, and many of the rules for applying SIMNET to collective training are still under development. In fact, in the course of this effort, E Division engineers developed and implemented a data collection plan as part of an assessment of the application of SIMNET to large scale exercises. The lessons learned from this assessment feed into the device design process for collective training devices.

Extent to Which a Project Involves Novel Applications of Training Technology

When a project involves the novel application of training technology, the workload of an engineer increases substantially, because the engineer must figure out the methods for applying the new technology. One example of the novel application of training technology is the application of embedded training (use of operational hardware, training software, and sometimes auxiliary hardware to provide training in comparison with stand alone discrete devices) to collective tactical training requirements. The fact that considerable time will be required before engineers know what information about training requirements they will need to develop a materiel solution to this problem can be appreciated when one considers:

- A ten volume series has been developed on the application of embedded training (Finley, Alderman, Peckham, & Strasel, 1988), but does not address the issue of collective tactical training.

- The Army is still in the process of learning how to apply training devices to collective tactical training through its work with SIMNET.

- The embedded training concept has been divided into two classes; devices that are a permanent fixture on the operational equipment, and devices that are temporarily appended to operational equipment to support training exercises.

Training Device Policy Statements

Training policy statements influence the range of training device options to be addressed in TODs, TOAs, and CTEAs. They also influence the weights assigned to certain variables in conducting TOAs and CTEAs. The effect of policy statements on CFP has recently been reported (Hinton et al., 1990). For example, a policy statement signed by the Vice Chief of Staff of the Army and the Under Secretary of the Army, and dated 3 March 1987, states that an embedded training (ET) "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" (Department of the Army, 1987). Still other forms of policy guidance provide goals that are specific to a given CFP project. Words from such policy statements influencing current PM TRADE projects include: "low-cost", "modular", and "expandable."

School Versus Unit Training

Consideration of the environment in which a device will be employed is an important part of the CFP. The environmental variables mentioned by engineers as being important to the design of training devices include the physical resources necessary to support the equipment, training schedules, skill level of the soldiers to be trained, and qualifications of trainers and instructor/operators. Devices destined for use in a school are designed to meet a carefully described training environment, while devices destined for use in units must be designed to accommodate a wide range of training environments.

The difference between designing a device for a school versus unit training environment, unlike the other factors influencing the CFP, was not identified as a direct result of data collection within PM TRADE. No engineers reported problems in obtaining and applying information about the unit training environment; however, most of the CFP projects involve training devices intended to be used in an institutional setting. Information obtained outside the context of data collection within PM TRADE indicates that the design of devices for use in an institutional setting is perceived as differing from the design of devices for use in a unit setting. For example, the developers of OSBATS state that this tool applies to designing devices for an institutional setting (Sticha, 1990), and the developers of the MANPRINT Product Four tool for early estimation of training requirements for new weapon systems state that this tool applies to institutional training (Ditzian, Roth, and Johnston, 1987).

Factors That do not Influence the Training Device CFP

During the course of data collection it became apparent that certain factors that we expected to have a substantial impact on the jobs of engineers, based on our review of formal regulations and guidance documents, have little impact. For example, the U.S. Army Training Support Center (ATSC) Training Devices Management Directorate decided that differences between system and nonsystem device design warranted the publication of two separate procedural guides for training device requirements documentation, one for system devices and one for nonsystem (ATSC, July, 1989; September, 1989). However, engineers report that their job differs little between these two types of devices. For example, there are a variety of documents that schools can use to describe their need for a training device depending upon a number of factors. Engineers simply refer to all of these documents as "requirements" or "the user's requirements." In attempting to discuss fine points of the various types of documents with engineers it became apparent that even some senior engineers were confused by the proliferation of document titles.

In reviewing CFP regulations and other guidance one notes the frequent mention of the Life Cycle Systems Management Model (LCSMM) with its three decision points and the Army Streamlined Acquisition Process (ASAP) with its two decision points. The distinction between LCSMM and ASAP, like that between system and nonsystem devices, has little impact on the job of engineers except that the job may need to be performed more quickly under ASAP. Names of requirement documents and specifics of the review process might change as a function of differences among projects, but the job of the engineer remains the same; make sure a device is truly required, and look for a materiel solution that is effective, affordable, technically feasible, and supportable.

Issues Raised by Engineers Regarding CFP

The requirement to conduct a TOA and a CTEA separately raises quality control issues. Separate analyses suggest, for example, that cost and training effectiveness are not considered during the TOA and materiel issues are not directly relevant to a CTEA. At least some engineers think that all issues involving potential trade-offs need to be considered at one time. This idea is not entirely in conflict with regulations or other sources of guidance, because they indicate that information is exchanged among these analyses.

Questions were also raised regarding the relationship between the training device CFP and subsequent configuration management of the device design. In certain cases, engineers said that significant changes are made in a device when it reaches configuration management that seem to contradict the results of the CFP. Configuration management per se is outside the scope of the current project, but the relationship between configuration management and the TOA, CTEA, and BTA warrant future investigation.

Data Sources Used in the Training Device CFP

No formal databases are used to support the technical decisions made by engineers. Databases are available that are indirectly relevant to CFP or might cover a portion of CFP under some situations, but these are not employed. One example of such a database is the Training Cost Data Enhancement System (T-CODES) database developed by the Training Performance Data Center to assist in estimating the cost of training devices. More will be said about databases in the chapter on engineers' ideas for improving the CFP.

The data sources most frequently referred to by other engineers are TRADOC schools, engineering colleagues, support service contractors, and vendors. Some engineers also referred to using ARI reports, ARI personnel and Human Engineering Laboratory (HEL) personnel.

Conclusions

- The differences and relationships among TOA, CTEA, BTA, and device configuration management are not clearly defined in regulations or other guidance documents. Further, engineers have raised questions about how these components of training device CFP and design relate to one another.

- At a high level the baseline CFP is a relatively uniform series of events that reflects CFP regulations. At a lower level there are substantial differences among the projects in terms of procedures used as a function of five variables; whether a school specifies that it wants a specific training device; the extent to which the project involves novel applications of training technology; whether the project addresses individual training or collective training; training device policy statements; whether the project addresses school or unit training.

- Formal and informal research on how to apply new training technologies and/or expand the application of more mature technologies is a significant portion of CFP. To some extent engineers continually develop specific CFP procedures.

- The system and nonsystem categorization of training device projects, as well as the ASAP and LCSMM categorization of projects, have little effect on the nature of the job performed by engineers.

- There is no formal system of data sources available to support training device CFP.

Recommendations

- A working group composed of school and PM TRADE representatives should define the expected outcomes of a TOA and CTEA and assess whether two separate analyses are required.

- A task force within PM TRADE should examine the relationship among TOA, BTA and configuration management.

- The factors that influence how CFP subtasks are performed across projects and the effects of these factors on performance should be defined in adequate detail to guide efforts to assign responsibilities within training device CFP. A starting point for this effort might simply involve distributing copies of Appendix C to all engineers and asking them to add or delete subtasks based on their experience with the CFP.

Need for Training Decision Aids Within E Division

A major question that confronted the researchers at the beginning of this project was whether or not engineers consider variables that influence the acquisition and retention of skills when formulating the concept for a training device? The previous chapter alluded to the fact that engineers do indeed consider these variables. This chapter attempts to express the depth and scope of decisions about learning variables made by engineers, but first it is useful to discuss an important lesson learned about the perceived difference between the terms "training" and "learning."

The questionnaire and interview process made extensive use of the term "training" to refer to the psychological process of acquiring skills. This proved to be a poor selection of terms, because, by mission definition, every decision made within PM TRADE involves consideration of training variables. Therefore, from the perspective of engineers, the term "training" includes a host of factors that are distantly related to skill acquisition.

Table 2 summarizes the results of a questionnaire item in which engineers were asked whether they made specified decisions and if they encountered problems in making each decision. Responses to this item were discussed with engineers during interviews to gain more detailed information about the extent to which they consider learning principles in their work. Identifying cue and response fidelity required to provide effective training appeared to be the most important training decisions from the perspective of engineers, because fidelity issues tended to be raised in the context of discussions regarding many of the decisions listed in Table 2. As shown in the table, more engineers reported encountering problems in making decisions regarding fidelity requirements than reported making these decisions, contrary to the trend shown for all other types of decisions.

"The customer always asks for the moon." Disagreements between training device designers and proponents about fidelity requirements were frequently referred to by the engineers. Many of the engineers recognize that high fidelity is not always needed in training simulations. The users consistently insist on high fidelity. For example, command and control training normally does not require a high level of fidelity. However, if the user wanted to make the training model comparable to combat development models, that probably should be high fidelity. "High fidelity requirements are often overkill, [the proponent] has lost sight of the training requirement."

Examples were also given of arguments about fidelity requirements for flight simulators, driving simulators, and tank gunnery simulators. For the flight simulator the proponent

TABLE 2. NUMBER OF ENGINEERS REPORTING THAT THEY ARE REQUIRED TO TO MAKE VARIOUS KINDS OF TRAINING DECISIONS AND NUMBER REPORTING PROBLEMS IN MAKING THESE DECISIONS

Decision	Number of Engineers Making Decision	Number of Engineers Encountering Problems in Making Decision
If a proposed training device would duplicate an existing device (or device under development)?	12	10
If fidelity requirements (e.g. degrees of motion for a flight simulator) are clearly specified?	12	12
If fidelity requirements are valid?	12	15
How much it will cost to include a particular instructional feature in a training device?	15	12
Which instructional support features should be included in a simulator or embedded training application?	11	11
Which training device options (e.g., full mission simulator,embedded training) or combination of options are the most/least cost-effective?	10	9
Whether a particular training device is compatible with the institutional or unit training environment	10	10
If a Trade Off Determination (TOD) adequately defines the issues to be addressed in a Trade Off Analysis (TOA)	13	12

argued for graphics with a level of visual resolution that was much higher, and more expensive, than the engineer thought was necessary. For the driver trainer the proponent wanted a motion platform with six degrees of freedom, the engineer argued that a seat shaker would be adequate.

In each of these examples the engineers are arguing for lower fidelity and the resulting significant savings. The engineers point out that they do not have ready access to published research or accepted training effectiveness models to support the argument for using lower fidelity in training simulators.

Engineers were asked to list what they consider to be the most important training decisions influencing the selection of a Best Technical Approach (BTA). The responses to this question were quite diverse. Four engineers reported that deciding fidelity requirements was among the most important training decisions, and two engineers reported that deciding how many training devices are required is one of the most significant training decisions. These were the only clear-cut instances where there were any agreements upon significant training decisions. Further, certain of the responses (How much will the device cost? How much does the school want to spend and when?) were unrelated to the learning process. However, the reader should keep in mind the problems with using the word "training" within PM TRADE mentioned at the beginning of this chapter.

Engineers were also asked "what types of training or learning issues do you consider in your work?" The responses to this question were as diverse as those to the question about the most significant training decisions that bear upon the BTA. Below is an edited list of training considerations, based upon responses to two questions about types of learning issues and important training decisions in the BTA.

- Is the device needed?
- Who will be trained?
- What tasks will be trained?
- What types of skills are involved in performing the tasks (e.g., motor versus cognitive)?
- Where will the training be conducted?
- When will the training be conducted?
- What is the goal of the training?
- How easy to maintain is the device?

- What is the minimum degree of fidelity that will support effective training?

- How does the soldier interact with the equipment?

- How will performance be scored?

- How will After Action Reviews (AARs) be conducted?

- Does the device reflect a knowledge of training principles (reinforcement, progressive training, corrective feedback, etc.)?

- What training methods should be employed (e.g., train entirely by a single trainer, part task trainers or a combination of the two?)?

- Is the device part of an integrated training strategy?

- How well does a particular alternative achieve the desired training objectives versus life cycle cost?

- Who will support this device in the field?

- How many training devices are required?

- Is the training device needed?

- How will the device be used or interfaced with other equipment?

- What existing resources are available..."as is" or easily modified to meet the training requirements?

- How effective are training device options?

- What are the performance standards?

- Does the device duplicate an existing device?

In the course of interviewing individual engineers it became apparent that there are large differences in terms of the extent to which they considered training and learning variables during device design. At one end of the training consideration continuum are those engineers who believed that any device that meets fidelity requirements is an effective trainer. Further along the continuum are engineers who are concerned with issues like how to provide feedback to students. Yet further along the continuum are those engineers who grapple with such problems as integrating individual skills training with collective training in a single device. This sophisticated end of the continuum is illustrated by the comments provided below.

Which instructional support features should be included in a simulator or embedded training application? "[We] always try to reduce the instructor load. Instructors do not realize how much they are not doing until you free them from some responsibility by using CAI [computer assisted instruction], CMI [computer managed instruction], etc., these features allow them to do other things." The same engineer who made this statement also pointed out that instructional support features help to standardize training across instructors.

"The Army overall and we as an organization are woefully delinquent in 'productizing' the instructional elements of devices and so I am beginning to think in terms of "teaching machines" opposed to training devices." As indicated by an additional statement made by this engineer, the view expressed by this statement involves examining the entire learning process to decide how the device fits into the learning process. "The system engineer needs to have a context perspective of the training objectives(s), training audience and intended use (operational environment) of the device or simulator."

Throughout the interviews, and during project meetings with engineers, many other examples surfaced where engineers considered variables influencing skill acquisition and retention. One engineer was concerned with how to integrate the training on a collective training device of soldiers representing multiple duty positions without detracting from the ability to meet either individual task or collective task training objectives. Another engineer wrestled with the problem of deciding how a vehicle commander might be both a trainer and a trainee if a crew training device were embedded in a vehicle. Yet another engineer was concerned with the problem of taking the results of performance measures and organizing the results of the measures in a way that could be used to provide effective feedback.

No set of procedures is used uniformly by engineers to make decisions that require consideration of learning variables, and no such set of procedures exist. As mentioned in the introduction to this chapter, formal regulations on training device CFP address the process of using learning relevant information about tasks to make a decision about training device hardware and software requirements at a very general level. Many of the decisions described above are not covered by formal regulations, but formal guidance in the form of research products addresses certain portions of the decision process in detail. For example, the second volume of a ten volume series on the application of embedded training addresses the process of deciding which weapon subsystems and tasks are good candidates for embedded training (Strasel, Dyer, Roth, Alderman, and Finley, 1988), and the OSBATS (Sticha, 1990) addresses the process of comparing the relative cost-benefits of using various mixes of training devices (full mission simulators, part task trainers, and operational equipment). The lack of an overall, integrated set of procedures is demonstrated by the fact that there are no relations linking the embedded training decisions to the decisions facilitated by the OSBATS (Meliza and Knerr, 1990).

The process of deciding how to address training requirements with a materiel solution is not driven by available information concerning learning variables. Instead, it is driven by an engineer's recognition of the fact that specific learning variables have to be considered when examining materiel solutions to a training requirement. The engineer identifies information needs and attempts to draw this information from schools or other organizations. The ATSC Training Devices Management Division is attempting to modify this situation somewhat by enhancing the information provided by schools regarding training requirements, such as calling for training strategies (Army Training Support Center, 1988).

Further, there are training decisions that engineers may be in a better position to make than are TRADOC schools. These decisions concern the application of specific training technologies. It is difficult to envision a situation where each branch school would have the resources necessary to track these technologies and consider their potential applications to training. PM TRADE's ET Branch devote their efforts to this area on a near full time basis, and many engineers involved directly in concept formulation also devote some of their time to this area.

Conclusions

- Engineers make decisions that involve consideration of learning issues.

- Engineers vary in terms of their appreciation of the importance of learning variables in device design.

- The learning variables that are considered most universally by engineers are cue and response fidelity requirements, and engineers want more information about these requirements than is currently available.

- No systematic process is used to insure that learning variables are considered in device design.

- No overall systematic process even exists to insure that learning variables are considered in device design,

- Learning variables to be considered vary to some unknown degree among projects.

- The process of developing information about training requirements must be driven, to an extent, by the information needs cf engineers.

- The information needs of engineers regarding training requirements varies among projects and over time as new training technologies become available.

Recommendations

- Learning variables must be linked to engineering variables to help insure that adequate information about training requirements is available to guide training device design. This recommendation concerns a method for linking these variables and, at the same time, it would help to insure a uniform and high level of appreciation of the importance of learning variables in device design. It is recommended that a series of brief (thirty minutes or less) presentations be made to engineers concerning major topics in training (such as the integration of individual and collective training, combined arms training). Engineers would be asked to respond to these presentations by pointing out if and how the information presented would be used to guide engineering decisions.

Information Flow

A problem in information flow, inadequate description of training requirements, has been noted in the past two chapters of this report. This chapter provides additional information relevant to this problem, describes information flow between PM TRADE and other organizations involved in training device development, and discusses information flow within PM TRADE.

School Descriptions of Requirements for Training Devices

Comments made by engineers helped to clarify the nature and causes of problems in the information provided by schools about training requirements. Two types of problems tend to surface, in isolation or in combination, with the training requirements prepared by schools. First, schools frequently attempt to specify training devices prematurely. "The 'Training Device Requirement' should be renamed 'Training Requirement'. Too often the TDR lists specifications for devices but not training requirements." Second, schools do not consistently describe training requirements in a manner that meets the information needs of engineers. Further, in the course of communicating with schools about device requirements, engineers frequently discover that no task analysis or media analysis has been performed by the school.

The ATSC Training Devices Management Division is aware of the problem in the quantity and quality of information provided by schools in the various documents they prepare to describe their device needs. ATSC has prepared a number of procedural guides intended to aid schools in preparing these documents (U.S. Army Training Support Center, 1988, 1989a, 1989b).

The inadequacy of the information provided by schools is due, in some cases, to the fact that the weapon systems on which soldiers are to be trained are themselves being defined through weapon system CFP. More than one engineer mentioned that schools said they could not identify and describe the tasks to be trained until they had more information about the design features of a new weapon system.

Disseminating Information to Industry Regarding Training Technology Research and Development Needs

An important part of the job of E Division is the dissemination of information to industry and universities about technological needs, and E Division employs a variety of mechanisms for influencing future training technology. E Division engineers present papers at professional meetings such as the Interservice/Industry Training Systems Conference describing needs for training technology research. Through membership on interservice panels, E Division helps to define standards for training technology such as the standards for digitized terrain databases and simulation networking protocols.

PM TRADE is also a direct sponsor of training technology research. For example, the PM TRADE/ARI Broad Agency Announcement (BAA) describes training technology issues that warrant being addressed on a high priority basis, and research and development organizations submit proposals for conducting research addressing these issues. Finally, E Division helps to guide training technology research through formal review of research proposals and progress reports for projects funded by other organizations. One example of this process is the review of industry sponsored research as described by Independent Research and Development (IRAD) reports. Another example is the review of research proposals funded by the Florida Council for High Technology.

This project did not include an assessment of the quality of guidance provided by PM TRADE regarding research and development needs. However, the extent to which this guidance helps to focus limited resources on addressing critical needs, as opposed to "nice to have" products, is important.

Integration of ET Branch Functions With the Day to Day CFP

Problems with the flow of information within E Division were noted in terms of the perceived relevance of ET Division to day to day CFP operations. A substantial portion of the work of ET Division is concerned with guiding the development of technology to meet future training device needs. These individuals tend to work in one or more specific technical areas involving technologies that involve developmental risks. This work often does not have an immediate payoff from the perspective of engineers working on concept formulation projects who want to know what technologies are available for application in the present.

The expertise ET personnel have gained in various areas of training technology would allow them to make important contributions to CFP projects, and some engineers do seek information from ET personnel for application to CFP projects. However, as a general rule, ET personnel are not tasked to work on CFP project teams, thereby reducing potential interactions between ET personnel and engineers working on CFP projects. For example, one instance was observed where two individuals from ET had gained extensive research experience with a particular training device. When a training device requirement was received which described the possibility of using a modified form of the device to meet the needs of a school, these personnel from ET branch were not tasked to take part in the initial review of the requirement.

Feedback Regarding Training Device Effectiveness

There is no formal mechanism for providing E Division engineers with feedback regarding the effectiveness and utilization of training devices. E Division's role in the development of a particular device is generally completed long before the device undergoes operational testing, and the operational testing and evaluation that is conducted is concerned with assessing whether the device meets technical specifications. Assessing how well a device supports skill acquisition and retention is not consistently addressed by operational testing.

Information about training device utilization is provided for use by PM TRADE in a hit or miss fashion. For example, many engineers within PM TRADE know that instructional support features for simulators are often underutilized in institutions. However, there are little data that can be used to prove that specific instructional features are likely to be underutilized.

Conclusions

- The most severe problem with information flow concerns information provided by schools regarding training requirements. Engineers want more information from schools about device requirements. In particular, engineers want schools to specify the tasks to be trained and provide information about cue and response fidelity requirements.

- Our description of the information flow between E Division and schools is only partial, in that it is not based upon input from school. Until school input is obtained regarding this problem, it is premature to propose a solution.

- In general, members of ET Branch are not assigned to work on concept formulation projects. This reduces potential interactions between ET Branch and engineers engaged in the CFP on a daily basis.

- E Division employs a variety of mechanisms to help guide training technology research and development. Participation of ET personnel on CFP projects would help to insure that the work they conduct in training technology research fits the information and product needs of engineers working on device design efforts. On the other hand, tasking ET personnel to work on CFP projects runs the risk of creating a situation where these personnel would end up performing tasks that would otherwise be performed by other engineers at the expense of ET's unique mission.

Recommendations

- The policy regarding assignment of ET personnel to CFP should be refined to allow these engineers to contribute their knowledge of specific areas of training technology. However, this involvement in projects should be carefully controlled to prevent distraction of these personnel from ET branch's unique mission.

- ET Branch should make aggressive attempts to keep engineers from ED and EC Branch informed of the projects on which they are working. At the same time, ED and EC Branch should make aggressive attempts to keep ET Branch aware of training technology issues that surface during the training device CFP.

- Conduct of the training device CFP should be examined from the perspective of Army schools and from the perspective of other PM TRADE divisions.

Engineers' Ideas for Improving CFP

Responses to the six questions in the "Career Development and Job Satisfaction" portion of the questionnaire were used to gain information about interventions that might help support CFP. During interviews, engineers were asked if they had any suggestions for improving the training device CFP. Discussions of the preliminary results of this project tended to elicit disagreements about certain obstacles to CFP and the proposals for addressing these obstacles. These disagreements helped to clarify the nature of the obstacle and provide guidance regarding possible interventions.

Inadequate description of training requirements was viewed as a major obstacle within CFP. A few ideas for addressing this obstacle involved the employment of the U.S. Army Research Institute (ARI). One proposal concerned ARI developing a decision support system that would help schools develop training requirements. A second proposal involved ARI working directly with schools in preparing training requirements.

Other ideas for improving the CFP involved developing databases to support CFP and refining CFP procedures. These ideas are presented and explained below. Statements in quotation marks were made by engineers.

Develop Databases to Support CFP

Formal databases are not used to support technical decisions made during CFP. The databases engineers believe might aid them in the training device CFP include training technology databases, cost databases, historical databases, and procedural databases. In some cases engineers specified automated databases, and in other cases they merely defined the need for an organized and accessible body of information.

"Most places that do engineering have a library of tech books, catalogs or something. We have nothing, absolutely zero. The old TRADE location had old references that were better than nothing. We need an in-house database and tech library."

There are databases to which engineers have access, but they are not used to support CFP. The reasons why existing databases are not used are important, because they help to define the characteristics of a database that engineers will choose to use. The only database that contains training technology information is the Independent Research and Development (IRAD) database maintained by ET Branch. This database covers only those projects being conducted in-house by industry, and it is rarely used by engineers during CFP. The IRAD database is not used by engineers during concept formulation, because they are expected to propose technologies that have low or no developmental risks, and the risks associated with many of the IRAD projects are perceived as being high.

Engineers reported that cost databases would be useful, because it is difficult to obtain cost data. The costs of instructional features change rapidly, and it is especially difficult to estimate the costs of features that differ from those used on previous trainers. Engineers have access to a cost database known as T-CODES that is maintained by the Training Performance Data Center, but only one engineer mentioned using this aid. That engineer concluded that T-CODES is a start in the right direction but "it is at too high of a level." Cost estimates need to be broken down into functional areas (e.g., costs of different kinds of visual systems) to show costs of single trainers and single instructional features.

Engineering colleagues are one of the most important sources of information used by engineers. A problem that faces engineers when attempting to identify colleagues with experience in a particular area is the lack of a central and easily accessible source of information about who has experience in specific subject areas. ET Branch recognizes the importance of colleagues as data sources and is developing an automated data base to help engineers identify colleagues with experience in particular areas. Also, ET branch is beginning to address the need for a training technology database. Under the guidance of ET Branch, the Institute for Simulation and Training (IST) is defining functional requirements for such a database.

Refine CFP Procedures

Engineers presented diverse ideas regarding the need to refine CFP procedures. Some refinements simply involve separating guidance for the training device CFP from guidance for the prime weapon system CFP, since most regulations and other sources of guidance attempt to address both types of efforts with identical guidance. Other refinements involve developing procedures based on the application of systems engineering, refining procedures to make the CFP be more efficient, and developing procedures for applying specific training technologies. Each of these types of ideas for refining procedures is discussed below.

More than one engineer pointed out the fact that most regulations addressing concept formulation are based on the CFP for prime weapon systems rather than training devices. For this reason, among others, there is a lack of regulation-based procedures for developing concepts for training devices. Some engineers also believe that many of the paperwork requirements that make sense when executing the CFP for a prime weapon system are inappropriate for training device CFP.

"There is a need for a systems engineering methodology. Choose a method, establish it, train it, use it on a day to day basis. Otherwise, individuals will vary, will not produce consistent results or will not produce results at all."

Engineers also expressed a need for refining procedures to enhance efficiency. "The acquisition process does not tolerate time pressure. The process must be fixed, and new ways are needed to do things faster." There is a "lack of enough time or personnel to do a job right."

Engineers also presented arguments against further specifying CFP procedures. Some engineers expressed the opinion that project diversity would make it impossible to develop specific procedures that apply to all projects. The net result of further specification of procedures might be a proliferation of unnecessary paperwork requirements. However, careful consideration of the important differences among projects, such as those described in the chapter on baseline CFP, should help to tailor the application of refined procedures to those projects for which they are indeed appropriate.

Another argument against further specification of CFP procedures is in terms of damage to career development, skills and expertise. Certain PM TRADE engineers are of the opinion that any engineer who needs detailed procedures is not qualified to perform his or her job. This outlook is by no means unique to PM TRADE or to the engineering profession. Certain supervisors and job performers consider the use of job aids as an indication that the user lacks critical skills (Chenzoff, Joyce and Nauta, 1985), and Riedel (1988) has noted that this perceived threat to skills, expertise, career or status is a threat to the acceptance of job aids.

Fortunately, the situation within PM TRADE is of a type that bodes well for the acceptance of aids. Post and Price (1973) listed three characteristics of a good work environment that appear to be particularly relevant to the acceptance of decision support systems or other aids. A good aid is one that affords the opportunity to learn skills or knowledge relevant to career advancement, challenges individuals in terms of quantity or complexity of job tasks, and gives individuals a significant role in performing tasks perceived to be critical to the mission of their organization. The size and complexity of many of the PM projects, combined with the need to make rapid decisions, result in CFP ending when time runs out, rather than ending when engineers believe all issues have been addressed. Procedural refinements offer the potential of helping engineers address more of their tasks in a given amount of time.

One engineer made an important point about the relation between refining the CFP and applying automation to CFP.

Automating the current CFP would be inappropriate and result in a decision support system of limited utility. "If we are going to do concept formulation in-house, we will need tools. But first we must refine the process."

Project Integration

There is a "Need for a planning process which provides an opportunity to integrate individual activities and projects into investment strategies which match Army training strategies." Many of the projects addressed by E Division engineers are expected to overlap in terms of functional requirements, suggesting the possibility of integrating these projects to increase their cost-effectiveness. Other projects requiring integration are those resulting in training devices to be used in an integrated fashion. The current workload, combined with other factors (e.g., differences among projects in terms of schedules, funding, and proponents) makes it difficult to take advantage of these possibilities.

In the course of participating in various project meetings within PM TRADE, we observed on-the-spot attempts to integrate projects involving similar functional requirements and/or training devices whose use need to be integrated in schools or units. In one case, PM engineers noted the similarity in requirements between two projects involving instrumented training for Battalion Task Force level field exercises. Engineers expended considerable effort attempting to define the benefits of integrating these projects to proponents concerned with differences between projects in terms of funding sources and milestones. In another case, engineers raised questions about how the application of simulation networking to combined arms training in the form of the Close Combat Tactical Trainer (CCTT) is to be integrated with combined arms training at the National Training Center (NTC). Is there an Army strategy for linking CCTT training and training at NTC that needs to be considered in the design of CCTT?

Training

Engineers were also asked what training they would like to have to help them do a better job. Responses to this question included system engineering training (general or specific to training device development), cost estimation training, training and workshops on the application of new technology, instruction on learning theory, computer training, software training, a course on Army maneuver tasks, and contracting courses.

Conclusions

- Cost, historical, training technology and procedural databases would be useful, but they must be tailored to meet the information needs of engineers in a direct manner. Any attempt to develop databases should include sustained participation by engineers (rather than a one shot needs analysis) to insure that the final product directly meets their information needs.

- Any attempt to automate the CFP procedures should wait until procedural refinements are accomplished, or the automation effort should be conducted in tandem with the effort to refine procedures.

- Any attempt to refine CFP procedures must consider differences among projects in order to support individual engineers more effectively and avoid creating unnecessary paperwork.

Recommendations

- Engineers should be assigned to work with any group attempting to design databases for use by E Division.

- Once again, the five factors identified in the chapter on baseline CFP as influencing CFP procedures should be examined in detail to find out how they influence information needs and job tasks.

- PM TRADE should consider preparing a white paper on how projects might be integrated, the benefits to be gained from project integration, and impediments to project integration.

- The U.S. Army should consider funding policies that provide schools and PM TRADE with greater flexibility to integrate related projects.

Fit of the OSBATS With Training Device CFP

ARI and PM TRADE established a research program to develop methods for designing cost-effective training devices. As part of this program, a decision aid was developed to assist the training device designer in performing TOAs for the training device CFP. This decision aid is called the OSBATS. It is a computer-based model that interactively uses rule-based procedures and databases to support that portion of the concept development of training devices concerned with the TOA (Singer and Sticha, 1987). The goals of OSBATS are to specify the design and use of training equipment to satisfy training requirements at a minimum cost, or to provide the greatest training effectiveness for a given cost (Sticha, Blacksten, et al., 1990).

OSBATS was developed using a top-down approach. That is, an overall goal was specified, the goal was then decomposed into subgoals, and procedures were developed for achieving the subgoals. The developers were not constrained to make OSBATS's procedures compatible with existing device-design practice. The use of the top-down approach, in fact, nearly guaranteed that new device-design procedures would result. The OSBATS developers also were not constrained to limit data requirements for the new model to the data requirements of the current design process.

This chapter is concerned with comparing the functions served by OSBATS with the training device CFP to provide input for an ongoing project to refine the OSBATS. This comparison is necessary, in part, because OSBATS guidance does not explain how it is intended to fit into the CFP, other than indicating that it was designed to support the TOA.

Fit of the OSBATS With Major CFP Tasks

The major CFP tasks are establishing a dialogue between training developers and materiel developers, performing a TOD, performing a TOA, performing a CTEA, developing a BCE, and developing a BTA. A potential problem is that the OSBATS was designed to support only one of these tasks, and yet all of these tasks are inter-related.

Since the scope of the OSBATS is the conduct of a TOA, the model assumes implicitly that all of the information to be derived from the specification of training requirements and the performance of a TOD are available for incorporation within the OSBATS database. The OSBATS model also assumes that all of the issues to be considered in a TOD as input for the TOA are addressed by the database design and algorithms of the OSBATS. Based upon the data collected in this effort, these assumptions are not valid. For example, assessing the technological feasibility of device design options is an important part of the TOD process which is not reflected in the OSBATS. Similarly, defining the minimum fidelity requirements necessary to train a task is outside the scope of OSBATS.

The relationship between a TOA and a CTEA within the OSBATS is unclear. However, as discussed earlier in this report, the relationships between these two types of analyses is unclear generally.

Comments by a senior engineer familiar with OSBATS and the BCE clearly indicate that the procedures used to develop cost estimates within the OSBATS do not match the rigorous procedures used in developing a BCE. Further, the OSBATS is not designed to support the job of developing a BCE.

Developing a BTA involves consideration of detailed functional specifications which may go beyond the level of detail addressed by the OSBATS. For example, an engineer must consider hardware and software variables which can influence the ability of a device to collect, organize and analyze performance data to provide feedback to students.

The Goals of the OSBATS and CFP

Examining the fit between the goal of the OSBATS described in the first paragraph above and CFP as practiced is also provides input for the refinement of the OSBATS. Given the desire of engineers to provide an effective product at the lowest cost possible, engineers would undoubtedly feel comfortable with the goal of OSBATS (i.e., to specify the design and use of training equipment to satisfy training requirements at a minimum cost, or to provide the greatest training effectiveness for a given cost). However, the goal of the OSBATS does not necessarily fit the goals of all schools in training device design. In cases where a TRADOC school is prematurely committed to a particular device, the school's goal is something other than finding the most cost-effective training device option.

Subgoals and Assumptions on Which the OSBATS is Based

To further assess the fit between the OSBATS and CFP practices it is necessary to examine the subgoals of the OSBATS and the manner in which OSBATS attempts to address these subgoals. As described later, the manner in which the OSBATS defines an "effective" training device is not entirely compatible with the engineers' definition of "effective". Further, the OSBATS model does not allow for easy insertion of expanded definitions of "effective."

The goal of optimizing training device design was decomposed into three subgoals (Sticha, Blacksten, et al., 1990);

1) identify tasks that are good candidates for training that uses a training device,

2) design training devices with a level of sophistication and cost appropriate for the tasks that the devices are to train, and

3) minimize costs through the appropriate allocation of training resources among training devices and actual equipment.

As mentioned in Appendix C, an important part of the job of engineers is to work with schools in deciding if a training device is needed or warranted. Would the device make training more cost-effective, or is a device the only reasonable way to conduct the necessary training (e.g., for safety reasons)? Such questions are compatible with the first subgoal listed above. Once the need for a device is established, the next goal of the engineer is to design a device concept that addresses the requirement and costs less than other alternatives would cost. The engineer devotes his or her energies towards attaining this goal throughout the remainder of the CFP. This goal is compatible with the second two subgoals listed above.

Implementation of Subgoals

The development of OSBATS involved breaking subgoals down into functions, breaking functions down into lower level functions, and continuing this process to provide the level of detail needed to implement a software demonstration of the OSBATS. The resulting product provided tools that appear to provide engineers with the capability of performing portions of the CFP better and faster; however, there are portions of the CFP that are not included in the OSBATS.

Software modules were developed to implement the OSBATS models. OSBATS comprises five modules that address a spectrum of critical issues that confront designers of training devices. The modules assist the designer in performing the following tasks;

1) cluster tasks to allow the development of coherent training device configurations,

2) identify optimal instructional features for each task cluster,

3) specify the optimal fidelity levels for each task cluster,

4) select the minimum family of training devices that meet the training requirements, and

5) optimize allocation of training resources in the family of suggested training devices (Singer and Sticha, 1987).

The OSBATS does not address all of the issues considered by engineers in conducting a TOD or TOA, and it does not provide for incorporating additional issues. Examples of these issues include consideration of the technical feasibility of device options and RAM issues associated with device options. The case may be that many of the issues that are not included in the OSBATS do not need to be included. This is a substantial research question that needs to be addressed as the OSBATS concept is integrated with the overall CFP during OSBATS refinement. That is, the current documentation for OSBATS does not include an explanation of how this product fits into the overall CFP. The description of CFP tasks and subtasks provided in Appendix C should assist in preparing such documentation.

As noted earlier, there are at least five factors that can influence the specific procedures used in training device CFP; whether a school specifies that it wants a specific training device; the extent to which the project involves novel applications of training technology; whether the project addresses individual training or collective training; training device policy statements; whether the project addresses school or unit training. The value of a decision support system should be measured in terms of its ability to accommodate necessary procedural diversity. The effort to develop and refine the OSBATS over time appears to be attempting to address procedural diversity, as described below.

The developers of the OSBATS point out that the initial model is intended to apply to institutional individual skills training (Sticha, 1990), and they suggested that different procedures might be required for collective and unit training. For example, the scope of OSBATS was limited to institutional training, because unit training considerations were judged to be too complex to include in the initial development of OSBATS (Sticha, Blacksten, et al., 1990).

The OSBATS accommodates differences among projects in terms of the degree to which a school specifies a particular type of device. Although the OSBATS is capable of generating large numbers of training device configurations for comparison with one another, in terms of cost-effectiveness, the OSBATS also allows the engineer to specify the device options to be considered. This same flexibility allows the engineer to select device options that are compatible with general policy statements.

Engineering Tools Within the OSBATS

Any attempt to describe all of the tools within the OSBATS that might be applied to address existing CFP practices better and faster would be a substantial project in its own right. Therefore, this chapter will highlight one of the most powerful tools within OSBATS, the capability to compare the cost and effectiveness of thousands of potential design options within a brief period of time.

OSBATS, unlike previous aids for training design, is specifically tailored to support the design, rather than the evaluation, of training devices (Sticha, Singer, Blacksten, Morrison, and Cross, 1990). Although evaluation models can be applied to device design, they do not allow convenient comparison of many different device configurations. That is, if a change is made in a device configuration, the evaluation process must be reinitiated from scratch. OSBATS, on the other hand, employs databases and algorithms to compare device configuration alternatives. The only change necessary to compare an additional alternative is a change in a portion of the database contents employed in the comparison, and thus OSBATS makes it possible to compare a new configuration in a few minutes.

The OSBATS is capable of quickly computing changes in cost-effectiveness in response to changes in device configuration because it encompasses models of skill acquisition, retention, and transfer. Assumptions concerning the relation of device fidelity to training effectiveness play a key role in OSBATS. Also, assumptions concerning the contribution of instructional support features to training device efficiency are critical to the OSBATS model. To perform cost/benefit trade-off analysis OSBATS estimates the costs of combinations of fidelity level and instructional feature suites.

The potential applications of the OSBATS tool described above go beyond a TOA. The capability to compute quickly the effects of changes in device configuration on the relative cost-effectiveness of the device might be applied to developing the BTA and subsequent configuration management of the device design. Once again, this tool is only one of the tools within OSBATS that might be applied to device design. Others include an algorithm which organizes task into clusters based on similarities in their "indications for simulation", based on consideration of multiple factors which determine the value of simulation-based training.

Conclusions

- The OSBATS was designed to support a TOA. It was not designed to support two important events which lead up to the TOA; the communication between TRADOC schools and PM

TRADE regarding the training requirements to be addressed by a device, or the conduct of a TOD. The relationship between the TOA and CTEA within the scope of OSBATS is not clear, but the relationship of these analyses is not clear outside the scope of OSBATS either. Similarly, the role of the OSBATS in developing the BTA is not clear. However, engineers make decisions in developing the BTA which go beyond the functions of the OSBATS.

- OSBATS does not address all issues considered by engineers in the training device CFP. This finding is difficult to interpret, because it is not clear as to how the OSBATS is intended to be integrated with the overall CFP.

- The prototype OSBATS does not address embedded training, collective training, or training in units. Therefore, it applies to only a portion of the CFP projects within PM TRADE.

- The OSBATS contains at least one powerful algorithm with potential applications to conducting a TOA, developing a BTA and managing training device configuration. This algorithm might help to link these analyses to one another by providing a common method for comparing the cost-effectiveness of device configurations.

Recommendations

- Ongoing efforts to refine the OSBATS should document how the OSBATS is intended to fit in the overall training device CFP described in Appendix C.

- At a minimum, the OSBATS should be designed to provide greater flexibility in terms of incorporating information developed during the TOD which needs to be included in a TOA.

- Ongoing efforts to refine the OSBATS should document if and how this aid will accommodate procedural diversity influenced by: the extent to which a school specifies that it wants a particular training device; the extent to which the project involves novel applications of training technology; whether the project addresses individual training or collective training; training device policy statements; whether the project addresses school or unit training.

- PM TRADE should consider application of selected OSBATS features as a tool in developing the BTA and managing device configuration.

Summary

From a top level perspective, the CFP as practiced tends to match the CFP described by regulations and other guidance with two exceptions. First, engineers play a more active role in defining training requirements than is implied in regulations. Second, engineers conduct a preliminary TOA to evaluate the quality of their TOD, rather than waiting for schools to initiate the TOA.

CFP guidance is written at a general level and does not discuss in much detail the relationships among a TOD, a TOA, a CTEA, the BTA, and device configuration management. Questions were raised regarding the need for conducting a TOA separate from a CTEA, and a question was raised regarding the continuity between the BTA and device configuration management.

From a lower level perspective, there are at least five factors that influence the specific procedures used by engineers during the training device CFP; whether a school specifies that it wants a specific training device; the extent to which the project involves novel applications of training technology; whether the project addresses individual training or collective training; training device policy statements; whether the project addresses school or unit training. The effects that each of these factors have on CFP procedures need to be examined in greater detail.

Engineers consider the effects that principles of learning have on materiel solutions to training requirements. The extent to which these principles are considered is not standardized, except that all engineers appear to be concerned with defining the minimum fidelity requirements necessary to support training. Differences among projects in terms of the learning principles considered appear to be a function of the engineer (some are more aware of learning principles) and the learning issues or training technology issues unique to projects. To insure the principles of learning are considered along with other training variables, there is a need to develop procedures which link engineering variables with learning variables.

Engineers are generally unhappy about the amount and quality of information that schools provide regarding the training requirements to be addressed by a device. The most critical gaps in information are a failure to describe the tasks to be trained, and a failure to describe the minimum fidelity requirements. Additional gaps in the information provided by schools are dependent upon such factors as the type or scope of training requirements to be addressed. Present guidance for use by schools in preparing training requirements is of the "one size fits all" variety. There is a need to inform schools of engineer information needs associated with various types of training device projects, but PM TRADE and ARI must first identify these information requirements.

The prototype OSBATS decision support system was designed to address the TOA in isolation, and it does not consider the relationships which the TOA has with describing training requirements, performing a TOD, conducting a CTEA, developing a BTA and developing a BCE. One major problem resulting from this lack of consideration is that the OSBATS is unable to accommodate all of the types of issues addressed by engineers in performing a TOD. Another problem is that the OSBATS fails to address the most substantial problem faced by engineers during the CFP, inadequate information regarding the tasks to be trained by a device.

Ongoing efforts to refine the OSBATS must consider that the TOA is not an isolated part of the CFP. The documentation for the OSBATS should clearly explain how this tool is to be integrated with other portions of the CFP, and the OSBATS should be designed to support this integration. For example, if the OSBATS is intended to support the conduct of a TOA, then it should be able to handle all of the types of information generated during a TOD.

Specific targets of opportunity for improving CFP are provided below. It is recommended that an assessment be made of the progress made in addressing these targets at a later point in time.

- Standardize the extent to which engineers consider learning principles in their work in a manner that takes into account important differences among projects (e.g., individual versus collective training).
- Insure that schools are informed of the manner in which information needs of engineers vary as a function of projects.
- Clarify the relationships among a TOA, a CTEA, a BTA and device configuration management.
- Provide engineers with easier access to data on training requirements, training technology, skill acquisition/ retention, training environments, and costs.
- Develop procedures for integrating training device projects.
- Define the scope of activities to be addressed by a refined OSBATS, and explain how the refined OSBATS is to be integrated with any CFP activities outside its scope.

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APPENDIX A
ENGINEERING FUNCTIONS SURVEY

Please look over the entire questionnaire before you begin your answers. If you need additional space to complete an answer please continue on the back of the page.

If you have any questions about the purpose of this questionnaire, or specific items, please call Larry Meliza (4374) or Don Lampton (4368).

A. BACKGROUND INFORMATION

1. Education (Please indicate your major or majors for each degree)

   Some College ______________________________
   B.S ______________________________
   Graduate Degree(s) ______________________________

2. How long have you worked for PM TRADE? ____________

3. How long have you worked in E Division? ____________

4. How many years experience do you have in designing training devices? _________

5. Place a check mark in front of each type of device (or device component) on which you have worked

__ Maintenance Trainers
__ Armor Trainers
__ Gunnery Trainers
__ Procedural Trainers
__ Computer Based Devices
__ Full Mission Simulators
__ Weapons Effects Devices
__ Flat Panel Trainers
__ Collective/Team Trainers
__ Motion Simulation
__ Other (Please list below)
__ Aviation Trainers
__ Driver Trainers
__ Operations Trainers
__ Command and Control Trainers
__ Part Task Trainers
__ Low Fidelity Devices
__ Troubleshooting Training Devices
__ Electronics Maintenance
__ Instructor/Operator Station
__ Interactive Threat Force

6. Please indicate the amount of experience you have had with each category of activity or document listed below.

	No Experience	One Project	Two or More Projects
a. Training device acquisition	( )	( )	( )
b. Weapon system acquisition	( )	( )	( )
c. Non-developmental items	( )	( )	( )
d. Training Device Requirements (TDRs)	( )	( )	( )
e. Commercial Training Device Requirements (CTDR)	( )	( )	( )
f. Systems Training Plan (STRAP)	( )	( )	( )
g. Systems MANPRINT Management Plan (SMMP)	( )	( )	( )
h. Training Development Study (TDS)	( )	( )	( )
i. Concept Formulation Package (CFP)	( )	( )	( )
j. Trade Off Determination (TOD)	( )	( )	( )
k. Trade Off Analysis (TOA)	( )	( )	( )
l. Cost and Training Effectiveness Analysis (CTEA)	( )	( )	( )
m. Best Technical Approach (BTA)	( )	( )	( )
n. Embedded Training	( )	( )	( )
o. Collective/Team Training	( )	( )	( )
p. Broad Agency Announcement (BAA) proposals	( )	( )	( )

7. Which Army schools, and other institutions, have you worked with in designing training devices <u>during the last two years</u>?

8. Place a check mark in front of the formal reviews for which you have helped to prepare input.

__JWG 1
__MARB I
__JWG 2
__MARB II
__AMC MILESTONE I/II Position
__AMC MILESTONE I/III Position
__MILESTONE I/II IPR
__MILESTONE I/III IPR
__Quarterly Reviews
__Monthly Project Screening Committee (PSC)

9. What training have you had in the field of systems engineering?

10. A list of documents which other Army organizations are responsible for producing is provided below. Let us know whether you helped other organizations to prepare these documents, conducted a formal review of these products or use these products in your work. Mark as many situations as apply for each document, and add any documents which have been left out.

	Help Other Organizations to Prepare	Review and Provide Feedback	Use in My Work
a. Systems MANPRINT Management Plan (SMMP)	( )	( )	( )
b. Operational and Organizational (O&O) Plan	( )	( )	( )
c. Systems Training Plan (STRAP)	( )	( )	( )
d. Training Device Requirement (TDR)	( )	( )	( )
e. Commercial Training Device Requirement (CTDR)	( )	( )	( )
f. Trade Off Analysis (TOA)	( )	( )	( )
g. Requirements for Operational Capability (ROC)	( )	( )	( )
h.	( )	( )	( )
i.	( )	( )	( )

11. We would like to know three things about each type of decision listed below. First, do you make this decision in your work on either a formal or informal basis? Second, are there problems in making the decision due to a lack of decision rules or information. Third, were you able to overcome the problem you faced, or do you feel you have considerable knowledge about why a particular decision might be difficult to address.

If there are other training decisions to be made which are not listed below, please add them to the list.

DO YOU HELP DECIDE:	DECISION MADE	PROBLEM FACED	OVERCOME/ KNOWLEDGE
a. If a proposed training device would duplicate an existing device (or device under development)?	( )	( )	( )

b.	If fidelity requirements (e.g. degrees of motion for a flight simulator) are clearly specified?	( )	( )	( )
c.	If fidelity requirements are valid?	( )	( )	( )
d.	How much it will cost to include a particular instructional feature in a training device?	( )	( )	( )
f.	Which instructional support features should be included in a simulator or embedded training application	( )	( )	( )
g.	Which training device options (e.g., full mission simulator, embedded training) or combination of options are the most/least cost-effective	( )	( )	( )
i.	Whether a particular training device is compatible with the institutional and/or unit training environment	( )	( )	( )
k.	If a Trade Off Determination (TOD) adequately defines the issues to be addressed in a Trade Off Analysis (TOA)	( )	( )	( )

12. Have there been any situations where you thought a major error was being made in the design of a training device? If so, were you able to do anything to correct the problem?

13. What software do you use in your work?

14. What databases do you use in your work?

B. ORGANIZATIONAL AND INDIVIDUAL FUNCTIONS

1. List the most important functions performed by E Division, and place a checkmark in front of the functions performed by your branch.

2. Please list your general job functions, and list the major tasks you perform within each function. (Note: Certain tasks may apply to more than one function.)

3. For each function you reported in item 2, describe the input you receive and the expected output.

4. For each function you reported in item 2, list the sources of information you use in addressing the function. Include any guidelines or checklists you have developed as well as people resources (e.g., contractors, HEL, school DOTD staff).

TRAINING AND LEARNING CONSIDERATIONS IN DEVICE DESIGN

1. What types of training or learning issues do you consider in your work?

2. Please list what you consider to be the significant steps or decision points in arriving at the Best Technical Approach (BTA).

3. What are the most significant <u>training</u> decisions that bear upon the BTA?

CAREER DEVELOPMENT AND JOB SATISFACTION

1. What are the major obstacles to performing your job efficiently?

2. What information would assist you in better performing your job duties?

3. Of the tasks that you must perform in your job, which would you most like for someone else to perform? Why?

4. Of the decisions that you must make in your work, which would you most like to have someone else make?

5. Which parts of your job give you the greatest satisfaction?

6. What training would you like to receive that you feel would help you to better perform your duties?

APPENDIX B
EXPERIENCE OF SURVEY PARTICIPANTS

Education. All of the engineers have at least a Bachelors Degree. Over half have a master's degree, and two have doctorates. Roughly three quarters of the engineers have degrees in electrical engineering, and most of the rest have degrees in either math, computer science and physics.

Years of Experience within E Division. The number of years of experience within E Division for individuals involved in concept formulation ranged from nine months to fourteen years with a median of four years of experience. The four engineers from ET Branch had worked for E Division for one, three and one-half, seven and eight years respectively.

Amount and Variety of Experience in Device Design. The number of years of experience in the design of training devices ranged from one year to 22 years with a median of six years. Table B-1 illustrates the variety of experience ED and EC engineers in terms of the types of devices on which they have worked. Table B-2 illustrates the breadth of user groups with which E Division engineers work. Most engineers had worked with more than one school during the two year sample period.

TABLE B-1. NUMBER OF ENGINEERS REPORTING EXPERIENCE WORKING WITH VARIOUS TYPES OF TRAINING DEVICES

TYPES OF TRAINING DEVICES	NUMBER OF ENGINEERS REPORTING EXPERIENCE WORKING WITH DEVICE TYPE
COMPUTER-BASED DEVICES	17
COLLECTIVE/TEAM TRAINERS	12
INSTRUCTOR OPERATOR STATION	12
PROCEDURAL TRAINERS	10
PART TASK TRAINERS	9
MAINTENANCE TRAINERS	9
OPERATIONS TRAINERS	9
GUNNERY TRAINERS	9
FULL MISSION SIMULATORS	9
COMMAND AND CONTROL TRAINERS	8
WEAPONS EFFECTS DEVICES	8
ARMOR TRAINERS	7
ELECTRONICS MAINTENANCE	7
DRIVER TRAINERS	6
FLAT PANEL TRAINERS	5
MOTION SIMULATION	5
INTERACTIVE THREAT FORCE	5
LOW FIDELITY DEVICES	4
TROUBLESHOOTING TRAINING DEVICES	4

TABLE B-2. NUMBER OF E DIVISION ENGINEERS WHO HAVE WORKED WITH SELECTED SCHOOLS AND CENTERS DURING THE PAST TWO YEARS

SCHOOL/CENTER	NUMBER OF ENGINEERS WORKING WITH EACH SCHOOL OR CENTER
AIR TRAFFIC CONTROL SCHOOL	1
ARMOR SCHOOL	6
AVIATION SCHOOL	6
AIR DEFENSE ARTILLERY SCHOOL	3
CHEMICAL SCHOOL	2
COMBINED ARMS TRAINING ACTIVITY	7
COMBAT TRAINING CENTERS	4
COMMAND AND GENERAL STAFF COLLEGE	1
ENGINEER SCHOOL	2
FIELD ARTILLERY	3
INFANTRY SCHOOL	3
INTELLIGENCE SCHOOL	1
INTELLIGENCE SCHOOL AND CENTER	4
LOGISTICS CENTER	2
SIGNAL SCHOOL	1
TRANSPORTATION SCHOOL	2

TABLE B-3 indicates the number of engineers with experience preparing input for the various reviews and decision meetings included in CFP. Tables B-4 and B-5 indicate engineer experience with various documents, activities and content areas in CFP.

TABLE B-3. NUMBER OF ENGINEERS WITH EXPERIENCE PREPARING INPUT FOR THE VARIOUS TYPES OF DECISION MEETINGS AND REVIEWS WITHIN TRAINING DEVICE CFP

REVIEW OR DECISION MEETING	NUMBER OF ENGINEERS WHICH HAVE HELPED TO PREPARE INPUT FOR REVIEW
JWG1	15
MARB1	13
JWG2	10
MARB2	12
AMC MILESTONE I/II POSITION	7
AMC MILESTONE I/III POSITION	4
MILESTONE I/II IPR	10
MILESTONE I/III IPR	7
QUARTERLY REVIEWS	12
MONTHLY PROJECT SCREENING COMMITTEE	11

TABLE B-4. NUMBER OF ENGINEERS WITH EXPERIENCE PREPARING, REVIEWING AND USING SELECTED CFP DOCUMENTS

DOCUMENT	HELP OTHER ORGANIZATIONS TO PREPARE	REVIEW AND PROVIDE FEEDBACK	USE IN MY WORK
SYSTEMS MANPRINT MANAGEMENT PLAN (SMMP)	5	12	5
OPERATIONAL AND ORGANIZATIONAL (O&O) PLAN	4	6	8
SYSTEMS TRAINING PLAN (STRAP)	1	3	3
TRAINING DEVICE REQUIREMENT (TDR)	10	15	15
COMMERCIAL TRAINING DEVICE REQUIREMENT (CTDR)	9	11	11
TRADE OFF ANALYSIS	9	12	11
REQUIREMENTS FOR OPERATIONAL CAPABILITY	3	10	11

TABLE B-5. NUMBER OF ENGINEERS WITH VARIOUS DEGREES OF EXPERIENCE WITH SELECTED TYPES OF CFP DOCUMENTS AND ACTIVITIES

ACTIVITY OR DOCUMENT	NO EXPERIENCE	ONE PROJECT	TWO OR MORE PROJECTS
TRAINING DEVICE ACQUISITION	2	3	13
WEAPON SYSTEM ACQUISITION	9	0	8
NON-DEVELOPMENTAL ITEMS	5	5	8
TRAINING DEVICE REQUIREMENTS (TDRS)			
COMMERCIAL TRAINING DEVICE REQUIREMENTS (CTDRS)	5	4	9
SYSTEMS TRAINING PLAN	12	2	3
SYSTEMS MANPRINT MANAGEMENT PLAN (SMMP)	5	4	8
TRAINING DEVELOPMENT STUDY	4	5	6
CONCEPT FORMULATION PACKAGE	2	5	11
TRADE OFF DETERMINATION (TOD)	2	4	11
TRADE OFF ANALYSIS (TOA)	2	3	11
COST AND TRAINING EFFECTIVENESS ANALYSIS (CTEA)	6	4	7
BEST TECHNICAL APPROACH (BTA)	1	5	11
EMBEDDED TRAINING	8	3	5
COLLECTIVE/TEAM TRAINING	5	4	5
BROAD AGENCY ANNOUNCEMENT (BAA) PROPOSALS	4	5	8

APPENDIX C
E DIVISION TASKS AND SUBTASKS
PERFORMED DURING THE CONCEPT FORMULATION PROCESS

The major tasks performed by engineers during the concept formulation process are listed below with a brief description of the purpose of each task. Subtasks are listed for each task. These descriptions were taken from survey responses and responses to interview questions. The material below describes the range of activities performed by engineers, and it does not necessarily describe the job as performed by every engineer.

The first two tasks described below go beyond E Division's role in concept formulation as specified in regulations, memorandum of instruction and SOPS. These tasks are concerned with defining training requirements in adequate detail to develop engineering solutions. In an effort to be responsive to user requests, E Division engineers aggressively seek out the information required from these users.

<u>Task: Provide Input for Some or all of the Components of a Preliminary Training Development Study (PTDS) and Training Development Need Statement for a Nonsystem Device or a Preliminary Training Effectiveness Analysis for a System Device</u>. The purpose of this task is to provide the initial definition of a training requirement that might be addressed by a training device. Further development of the output of this task should result in the Training Device Requirement (TDR) addressed by the subsequent task.

Subtasks:

- Insure that the training requirement is adequately described to guide device design
  - Encourage the user (e.g., schools and integrating centers) to define the intended scope of the device(s) in terms of duty positions to be trained and the types of tasks to be trained (e.g., trouble shooting electrical problems)
  - Insure that the user has stated an appropriate goal in pursuing the development of a training device (e.g., reduce training costs, provide training on new equipment, increase the effectiveness of training)
  - Encourage the user to conduct job, task and skill analyses or monitor a service support contractor in performing these tasks

- Visit the school to find out more about the tasks to be trained

- Insure performance standards are available for each task

- Maintain a knowledge of school specific and TRADOC-wide training strategies and needs through phone conversations, site visits, attending meetings and reviewing policy documents (e.g., white papers).

<u>For System Devices</u>

- Review documents describing the new weapon system, including: draft Operational and Organizational (O&O) Plan, System Training Plan (STRAP), concept formulation papers and available contractor design documents

- Talk with combat developers to find out how the new weapon system is expected to differ from related or predecessor weapon systems (e.g., new computer-assisted navigation system) and make sure these differences are reflected in the job, task and skill analyses

- Determine when the user expects to field the device (in six months? five years?)

- Determine if and what the funding limits are for a device or devices

- Conduct Media Analysis or review results of school/contractor performed media analysis

  - Identify similar projects and review the results of the media analysis for these projects

  - Insure that fidelity requirements for training each task are specified in adequate detail to drive device design (e.g., if motion is required, are the ranges specified?)

  - Verify/negotiate fidelity requirements

  - Make sure tasks requiring sustainment training and hands on training have been identified

  - Make sure that the results of the analysis specify the location of training (institution or unit)

- Verify/negotiate training device alternatives to be addressed by a Trade-Off Determination (TOD)

  - Make sure that alternative device concepts are present

- Insure that there is an adequate training concept or strategy for each alternative, and make sure that the strategy explains how the alternative is to be used in the total training context (e.g., the device will be used after classroom instruction on the topic and before training is conducted on a full mission simulator)

- Make sure that the alternatives are consistent with the results of a media analysis

- Make sure that the number of individuals or units to be trained have been identified

- Insure that estimates are available regarding the number of devices that will be required

Task: Review TDR (for Nonsystem Devices) or Training Device Requirement Appendix of a ROC Document (for System Devices).

Subtasks:

- Insure that the requirement provides all of the information required of a PTDS or PTEA (see above)

- For system devices, review updates in weapon system design or in planning documents (e.g., O&O Plan) to make sure training requirements defined in the PTEA have not changed or changes have been reflected in a revised PTEA and device requirement

- Review task/skills trained by existing devices, where appropriate to make sure that there is not unnecessary duplication of devices

- Decide if the requirements leave engineers with the flexibility to design cost-effective solutions

Task: Review Commercial Training Device Requirement (CTDR) in Cases where a School Believes an "Off the Shelf" Product Might be Used to Address Training Requirements.

Subtasks:

- Make sure that the CTDR adequately describes the training requirement (see above)

- Make sure that the device can be procured without research, development, test and evaluation.

  - Obtain and review available documentation on the commercial product to identify tasks and skills trained and physical requirements for interfacing the product with the training environment

- Obtain necessary information about the environment in which the user plans to employ the product

- Question current users of the product regarding its effectiveness and RAM characteristics, and ask users about the training environment in which it is used

- Assess whether the training device is compatible with the environment in which it is intended to be used, without modifying the product or the environment

- Conduct a market survey to identify other commercial devices which might the requirements at a lower cost

- Assess the percentage of tasks defined in the training requirement that can be effectively trained with the device, without modifying the device.

- Decide whether the product can be procured on a competitive basis versus sole source

Task: Develop Rough Order of Magnitude (ROM) Estimates for the Life Cycle Costs of Training Device Alternatives. ROM cost estimates are needed to compare the cost-effectiveness of device alternatives and to alert users to potential funding requirements. In certain cases, the cost of a device may preclude further consideration of that device, due to shortages of funds. On occasion, ROM estimates are developed in the absence of any of the documentation described above. For example, a school might decide that it needs some type of training device and ask PM TRADE for a "ball park" estimate of the cost of the device before initiating the concept formulation process. The responses to such requests are based upon the same subtasks performed for all ROM estimates.

Subtasks:

- Identify similar training devices and review Baseline Cost Estimates (BCE) and ROM developmental and life cycle cost estimates for these devices

- Select general method to be used for developing Rough Order of Magnitude (ROM) cost estimates (e.g., costs of developing similar systems, bottom up estimates or cost estimating relationship)

- Conduct a market survey of current prices for developing or buying major components of the device, considering volume discounts, etc.

- Obtain cost data from R and S Division regarding production and support of similar devices

- Obtain estimates of the cost of training on actual equipment

- Prepare a description of the procedures used to develop the cost estimates

Task: Prepare Delivery Order for a Support Service Contract. The scope of this task varies among projects. For example, in cases where training deficiencies and device alternatives have not been defined, the contract may include a task analysis and media analysis.

Subtasks:

- Identify and examine SOWS for similar efforts

- Prepare SOW

- Estimate cost of a concept formulation study (see cost estimation under preparing input for the PSC/JWG1)

- Prepare procurement package

- Review technical proposal

Task: Develop Information for PM TRADE's Project Screening Committee (PSC) and Joint Working Group (JWG) I. Prior to committing itself to a project, PM TRADE must estimate the size of the project and compare this estimate with available resources. Much of the same information developed for this purpose is also needed before JWG I is able to decide whether to proceed with the project.

Subtasks:

- Decide if the training device requirement has been adequately described (e.g., by a TDR or Training Development Need Statement)

  - Make a list of issues to be addressed by the user to clarify the training requirement

  - Obtain an estimate from the school regarding how long it will take to address these deficiencies

- Prepare a rough order of magnitude (ROM) cost estimate for the project

  - Find out if additional work required to adequately define device requirements (see immediately above) is to be performed by the user or by a contractor

- Identify similar past or ongoing projects and find out the costs of these projects

- Estimate feasibility of project

  - Review technologies to insure that they are adequately documented and do not press the state of the art too far

  - Review technological applications to insure the planned applications are not too novel

  - Identify similar past and ongoing projects, find out what problems were encountered and estimate which types of problems might influence the current project

- Estimate how long it would take to complete the project and compare this with the user's time requirements

  - Identify similar projects and find out how long it took to complete these projects

  - Identify problems that delayed similar projects, and decide which problems might influence the current project

- Decide whether work should be done in-house or by contractor

  - Define the tasks to be performed in the project

  - Estimate the various types of expertise required to execute the project, and review the expertise of in-house personnel

Task: Conduct a Trade-Off Determination (TOD). The purpose of the TOD is to develop information about the various training device alternatives to be considered in selecting the Best Technical Approach (BTA).

Subtasks:

- Define issues to be addressed in comparing alternatives and provide information pertinent to these issues

  - Review TOD and TOA documents for comparable systems to identify relevant issues

  - Ask for HEL review of TDR to identify human factors issues relevant to the various alternatives and data requirements for addressing these issues

- Discuss alternatives with user subject matter experts (SMEs) to identify potential strengths and weaknesses of each alternative

- Review relevant state of the art technology and training technology data through literature reviews, attending capabilities briefings and discussions with technical experts

- Consider all of the above information sources in identifying the specific trade-offs to be addressed by the TOD

- Identify data sources to be used in making trade-offs

- Collect data for the TOD

  - Extract relevant information from TODs and TOAs from related projects

  - Collect relevant data from user SMEs, technical experts and reviews of training documents

  - Document data sources used in conducting TOD

- Validate TOD

  - Validate sources of information regarding alternatives

  - Insure that all major alternatives and issues have been addressed

- Prepare TOD document and revise in response to peer/ school review

- Defend TOD before PM TRADE representatives during MARB1 and revise in response to feedback

Task: Conduct a Trade-Off Analysis (TOA). The purpose of the TOA is to analyze the data collected in the TOD to select the best training device alternative or combination of alternatives referred to as the Best Technical Approach (BTA). The goal of the TOA may be to identify the best approach for a given cost, or it may be to identify the most cost-effective approach regardless of cost. According to formal guidance, the TOA is conducted during JWG II; however, as described below a draft TOA document is often prepared by PM TRADE prior to the JWG2 and distributed to participants prior to the meeting.

Subtasks:

- Decide how the trade-offs will be conducted to identify a Best Technical Approach (BTA)

  - Review TOA and BTA for comparable systems to determine the procedures used to conduct TOA in the past

  - Develop a plan for analyzing TOD data to select a BTA and obtain peer review of this plan

- Prepare draft TOA for dissemination to members of JWG2

  - Make sure that procedures used in conducting TOA are well documented

  - Revise TOA in response to peer and school review

- Prepare to defend TOA and BTA selection during MARB2

  - Insure that all procedures used to obtain data have been documented

  - Insure that the method used to select among alternatives are carefully documented

- Revise TOA and BTA is response to MARB 2 feedback

Task: Post Concept Formulaticn.

Subtasks:

- Prepare Technical Portions of RFP for Proof of Principle Effort, etc.

- Participate in the Review of Engineering Change Proposals (ECPs)

Task: Help to Guide Research/Development to Insure that Emerging Technology can be Effectively Applied to Future Concept Formulation/Device Design Efforts. This is an area in which the missions of ED and EC branch overlap with the mission of ET Branch.
Subtasks:

- Keep informed with state of the art technology, including existing and planned applications of the technology

  - Attend contractor presentations within NTSC

  - Read ARI, Navy and AFHRL Research Reports regarding effectiveness of training devices and variables influencing the effectiveness of devices

  - Keep abreast of Navy and AFHRL projects

  - Read technical publications

- Keep informed of current DOD and Army policies regarding training devices (white papers, Simulation Advisory Group, Training Advisory Group)
- Review IRAD project descriptions for pertinent technologies, applications
- Provide input for the PM TRADE/ARI Broad Agency Announcement (BAA)
- Review BAA proposals
- Pass on research concerns to ET, ARI, and HEL
- Serve as members of JCTG subgroups that push or investigate the state of the art for a particular area of endeavor

APPENDIX D

HOW ET BRANCH INFLUENCES FUTURE TRAINING TECHNOLOGY

The mission of ET Branch is to insure that emerging technology can be effectively applied to future concept formulation and device design efforts. Specific tasks and subtasks performed to address this mission are described below.

Task: Keep informed with state of the art technology, including existing and planned applications of the technology.

Subtasks:

- Keep informed of current DOD and Army policies regarding training devices (white papers, Simulation Advisory Group, Training Advisory Group)
- Keep informed of the type of training technology applications and issues facing PM TRADE by attending PSC reviews of proposed training projects
- Read ARI, Navy and AFHRL Research Reports regarding effectiveness of training devices and variables influencing the effectiveness of devices
- Attend contractor presentations within NTSC
- Attend In-Process Reviews (IPRs)
- Read IRAD project descriptions for pertinent technologies and applications
- Attend professional meetings such at the Interservice and Industry Training System Conference
- Conduct site visits

Task: Coordinate with other Services.

Subtasks:

- Represent the Army on Tri-service standardization projects
- Serve as members of JCTG subgroups that push/investigate the state of the art for a particular area of endeavor
- Keep abreast of Navy and AFHRL training device projects

Task: Guide Research Projects Funded by PM-TRADE.

Subtasks:

- Provide input for an Indefinite Quantity Contract (IQC) with the Institute for Simulation and Training (IST)
- Monitor execution of IQC delivery orders
- Provide input for the PM TRADE/ARI Broad Agency Announcement (BAA)
- Review BAA proposals
- Monitor projects funded under the BAA

Task: Guide Research Funded by Organizations Other Than PM TRADE.

Subtasks:

- Review IRAD project descriptions for pertinent technologies, applications
- Review research proposals submitted for funding by the Florida High Technology Research Council
- Pass on research concerns to ARI and HEL
- Keep informed with state of the art technology, including existing and planned applications of the technology
    - Keep abreast of Navy and AFHRL projects
    - Read technical publications
- Who, What, Where, When and Why
- OPTEMPO force on force training in the field versus simulated collective crew training in garrison
- Normal MANPRINT issues: How easy is the device to operate/maintain; can a better or cheaper device be made while still easy to operate
- Defining the integrated training systems for proposed systems (institutional stand alone training devices, weapon system embedded training and weapon system appended training)

- Training issues are almost always related to degree of fidelity provided by the BTA. The school wants to maximize fidelity within dollar constraints, while we want to maximize training effectiveness within schedule and dollar constraints

- If a task and skills analysis is available (I have yet to see one for any training device I have worked on), I would, with the help of others, determine what skills are involved in the various tasks, determine if motor skills and cognitive skills are involved, determine how the operator and maintainer interact with the equipment. Usually there is insufficient data for an analysis of any depth.

- Tailoring device design to training audience, design of user/trainee device interface, matching trainee skill requirements [and] device performance/configuration.

- A requirement/function versus cost of this function/requirement

- Training effectiveness and realistic requirements

- Tactical engagement simulation, scoring, training; precision weapon engagement simulation, scoring and training; After Action Review requirements

- The system engineer needs to have a context perspective of the training objectives(s), training audience and intended use (operational environment) of the device or simulator

- Tasks to be trained, media selection, performance measurement

- Duplication of training, training effectiveness, trade-off of fidelity required, student practice/freeplay

- The [training device] requirements

- Embedded training applications, MANPRINT issues, EIDS CBT, collective/combined arms training (networking), MILES/AGES requirements

- Training by soldiers and officers for army maneuvers in a battle situation

- All types

- The Army overall and we as an organization are woefully delinquent in "productizing" the instructional elements of devices and so I am beginning to think in terms of "teaching machines" opposed to training devices.

- Mission rehearsal

When asked to identity the significant steps or decision points in arriving at the BTA, engineers provided the responses listed below.

- [My] frame of reference is the systems engineering guide provided to all E Division [personnel] in August of 88

- Trade-offs, risks, costs, schedules, army manpower requirement, health, safety, HFE requirements, environment

- Providing an approach and complete training device requirement and systems training plan documents; determining, with the proponent TRADOC agencies, the various trade-offs available to meet the TDR/STRAP requirements; analyzing each of these trade-offs for the optimum alternative, based on updated fiscal and schedule changes

- Selection and coordination of the BTA is accomplished through trade-off determination and TOA which require consideration of cost, risk, and training effectiveness

- A solid, clean TDR; a complete task analysis (most critical); evaluation criteria for assessing the TOD leading to the TOA

- Affordability, training effectiveness, training requirements

- TOD (what are the viable alternatives from the developer's point of view, what tasks need to trained and how, what part task trainers can accomplish this); TOA (which TOD requirements best satisfy the user's needs, what skills can best be accomplished by what method); BTA is a blend of TOD and TOA

- Technically simplest approach that can meet at least 80% of the requirements; cost/training effectiveness; RAM consideration and MANPRINT user friendliness; growth potential; overall training system integration; instrumentation with standardized programmable interchangeable modules (very important)

- List alternatives, apply experience/judgment

- Training device need statement is generated: training device requirement is drafted; JWG1 is held; TOD is performed; TOA is performed

- TOA should give good indication of the BTA. Any media analyses conducted are also helpful. TOD includes cost comparison, risk assessments, etc., all of which are significant

- Cannot answer due to lack of experience

- TOD, TOA, BCE, BTA- a selection of the best alternative that stays within optimum cost efficiency

- JWGS, TOD, TOA, ROMS and MARBS

- TOD, TOA

- TOD, TOA and BCE

- Evaluation, analysis, design, development, implementation

- Satisfy requirements with the best for the Army's techniques