THE DEVELOPMENT OF THE EMBEDDED TRAINING DECISION-AIDING AND RECOMMENDATION TOOL (ET DART)

ABSTRACT

The development of embedded training (ET) guidelines by the Army Research Institute (Witmer and Knerr, 1991a, 1991b) has afforded military planners a systematic method for making critical training decisions related to embedded training systems and other training alternatives. Recent work at NTSC and STRICOM has attempted to expand the use of the guidelines by providing an automated version of the algorithms used in the model. The current study reviews and incorporates those efforts while continuing to expand the capability of an automated version of the guidelines in the areas of:

- user interface;
- making the terminology generic to all services (where necessary);
- user help and instruction;
- decision documentation; and
- decision-aiding for training media cost analysis.

This paper describes the current and future development of a tool (the ET DART) that will fully support decision-making processes related to embedded training.

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INTRODUCTION

Embedded training (ET) research and development has been an important focus of military training for much of the decade of the 80's and into the present. The essentials of defining and implementing ET have been presented in publications such as the Army Research Institute's 10 volume series on Implementing Embedded Training (e.g., Finley et al., Strasel et al. 1988), as well as other work (e.g., Hoskin et al., 1989). Most recently, Witmer and Knerr (1991a) have produced a set of guidelines for making decisions about ET early in the weapon system acquisition process, unlike much of the previous work that tended to focus on the definition of specific ET characteristics and capabilities. What makes the decision guidelines produced by Witmer and Knerr so valuable is that they allow training planners, analysts and developers the opportunity to design-in ET from the earliest stages of system development.

These ET guidelines provide a set of questions that are associated with policy requirements as well as more traditional ET considerations, such as cost (see Witmer and Knerr, 1991b for a full description of the guidelines and their development). By separating the guideline questions into phases that are related to acquisition milestones, the authors have created a set of procedures that can provide an iterative description of the ET requirement for any given weapon system in the current or future Army inventory . With each successive phase or milestone, the additional information provides clarification and additional detail to this description.

The ET decision guidelines are a paper-based set of procedures that require the user to manually track the results (i.e., the recommended media, the ET alternatives, and any suggestions regarding training system requirements). Although the guidelines are not difficult to use as configured, there are additional capabilities that could be added that would expand the efficiency and usefulness of the process, such as sorting and summary routines for reporting. In addition, the process could be made much more efficient through automation. Figure 1 shows a sample decision flow from the ET guidelines. It is apparent from the examination of the guideline procedures that they lend themselves easily to automation.

BACKGROUND

At the Naval Training Systems Center (NTSC), Chatham (1992) developed an automated version of the guidelines as part of an overall multimedia production related to the topic of ET. Using a Windows-based software program called Toolbook, she created a prototype of a program that covered such topics as "Guidance" (containing reference documents), "Actual Systems" (using ET systems), "Research Topics", and "Considerations" (issues to consider when planning for ET); the "Media Selection" topic contained the automated guidelines. This program offered a Windows interface that allowed users to browse through the information alternatives before beginning the media selection process. The media selection itself was the direct incorporation of the Witmer and Knerr guidelines that are found in the original documentation. However, the program contained no capability for creating reports on the recommendations and results of the guided decision process.

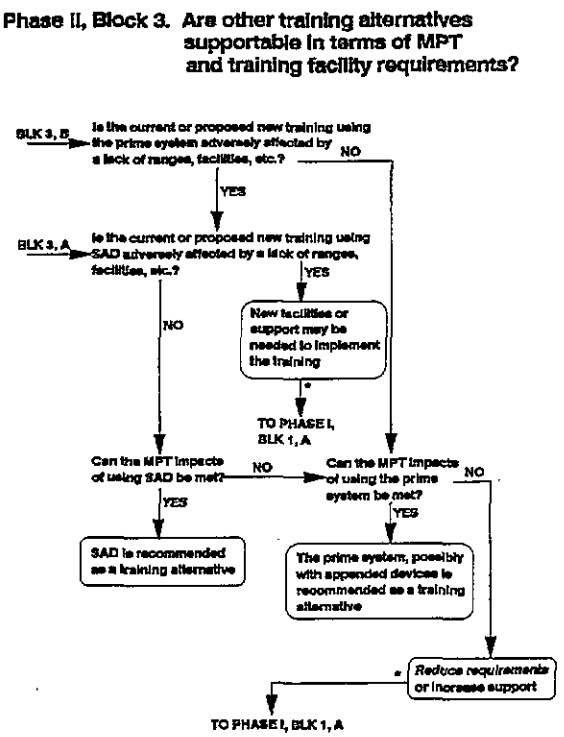

Figure 1: Embedded training guidelines (Witmer and Knerr, 1991a)

This was due to the nature of the program being primarily a demonstration of the kinds of PC applications that could be developed on this and other topics of interest to NTSC personnel.

Work at STRICOM was undertaken by Copeland (1992), and involved the assignment of the guideline decision rules to a forward chaining expert system shell called CLIPS (C Language Integrated Production System). An expert system developed using CLIPS consists of three components: a fact list, a knowledge base, and an inference engine. An individual fact from the ET guidelines fact list might consist of the decision tree node name, verbiage in the node (i.e., a question), type of node, and pointers to the next node (i.e., yes or no path). An individual fact contains all the specifics regarding each node. The STRICOM effort was developed with this in mind so that nodes could be easily added, changed, or deleted without changing the executable CLIPS code. The knowledge base consists of the rules required to execute the ET decision guidelines. A typical knowledge base rule would be the decision node rule which contains the specific executable CLIPS code called when executing a binary (yes/no) decision node. The inference engine is contained in the CLIPS shell and it controls the overall execution and forward chaining reasoning (see Figure 2). For a more detailed explanation of CLIPS, refer to Giarratano & Riley (1989).

The first step of the STRICOM effort consisted of a logic-only knowledge base, which contained basic decision tree logic and very primitive input/output, but which lacked any decision documentation. Also included in this step was the fact list, limited to the facts contained in Phase I of the ET guidelines. The second step of the STRICOM effort consisted of all decision tree logic, a textual input/output capability, and a decision documentation capability. Additionally, all facts associated with Phases I through IV of the ET guidelines were included in the fact list. This second step was completed by three U.S. Military Academy cadets during a summer internship at STRICOM.

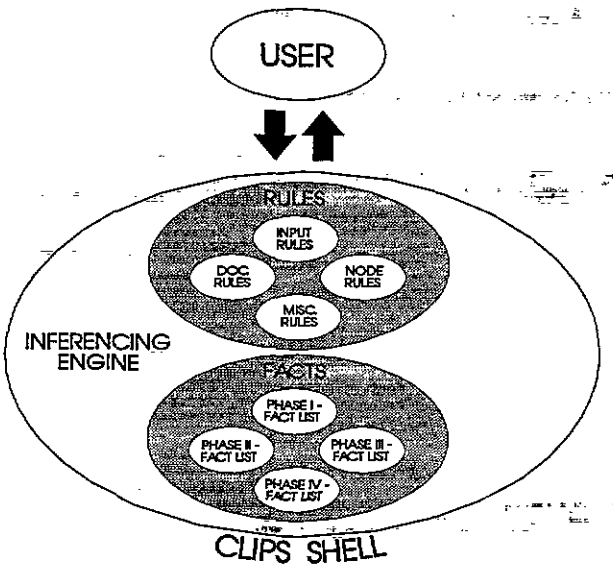

Figure 2: STRICOM program for automated ET guidelines.

The value of the STRICOM effort as an initial step toward automating the guidelines was twofold. First, it demonstrated the usefulness of grouping the fact list (nodes, node names, pointers) into one group, thereby allowing changes to be made without the necessity of changing the code. Second, it provided an area for documenting each decision or answer to the questions contained in the ET guideline documentation. These two features were perceived by the Lockheed developers to be valuable enough to be replicated in the new program that would be created.

The automation of the guidelines has been addressed by the two programs described above. However, the constraints on the resources available to both developers made the scope of the programs' effectiveness

somewhat limited. Creating the decision rules is the most straightforward aspect of ET guideline development; beyond that, however, are the issues of how best to create a program that provides more extensive assistance to training system planners. The Embedded Training Decision Aiding and Recommendation Tool (ET DART) is an attempt to do just that.

ET DART DEVELOPMENT

The ET DART was the first automated tool selected for development as part of the Lockheed Aeronautical Systems Co. (LASC) Independent Research and Development (IRAD) program entitled "Total Training Systems Integration" (TTSI). The intent of the TTSI is to identify which automated tools are needed to make the training development process more efficient, and which tools contribute to making the training system more effective. The current and future needs for training systems will be addressed by the development of additional tools and programs that will: 1) aid in the development and evaluation of training programs, and 2) provide expertise and support to training developers in making decisions that affect the training development process. Since the majority of the logic and underlying principles of the ET guidelines had already been developed by Witmer and Knerr, the remaining work was to focus on what additional capabilities, if any, should be developed as the guidelines were being automated. Figure 3 shows the design elements for the ET DART that were identified early in the planning stages of the program. The inputs for the program are identified in the existing ET guideline documentation, so the remainder of the design elements were the processes that the program would employ and the products users could get as a result. The ET DART development process was divided into three phases,

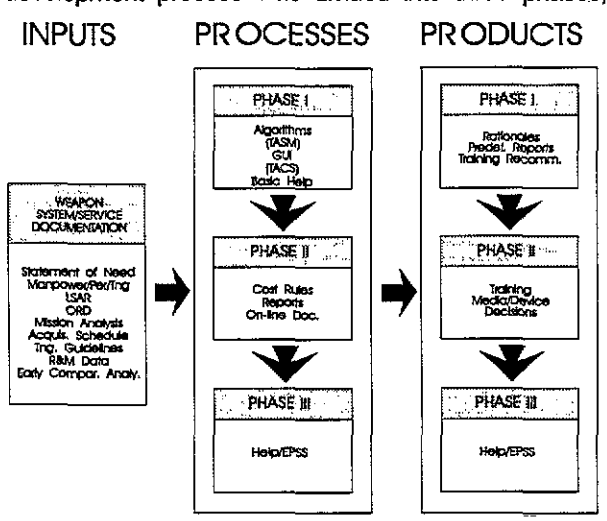

Figure 3: ET DART design elements.

which roughly corresponded to what we considered to be the most likely groups of work that could be accomplished during the year, given any additional work that had to be performed concurrently.

Phase I of the ET DART development process is intended to cover the development and incorporation of:

- the ET decision rules,
- a graphics user interface,
- a context-sensitive help function,
- a means for listing and saving user rationales for each decision made, and
- a Training Alternatives Summary Database, in which the recommendations made throughout each phase and block of the decision process are summarized for review.

Phase II of the program will focus on the development and incorporation of:

- on-line documentation access,
- scenarios for saving data and reports,
- decision rules for selecting media based on costs, and
- a process for making the final decision or selection of the type of ET system or training device to be developed.

The last period of development, Phase III, will focus on the development and refinement of:

- help information for users that includes both content assistance (how to use the guidelines) and program assistance (how to use the software), i.e., an electronic performance support system (EPSS)

Inclusion of Previous Work

At the beginning of Phase I, the programs by Chatham (1992) and Copeland (1992) were reviewed to determine what portions, if any, should be included in the ET DART. It was apparent from these reviews that each version had attributes that should be included in the ET DART, by either direct inclusion of the code or by use of the general principles. The decision concerning the development software to be used (see below), however, dictated that the best features of each predecessor version of the automated ET guidelines be included only in principle. The features to be included were the **graphic user interface (GUI)** from the Chatham program and the **decision documentation** from the Copeland program.

The decision to incorporate these two features was very easy to make. The benefits of a GUI as the means by which users interact with the system are overwhelmingly obvious: the graphic interface provides color, form and an organizational structure that helps users learn about and use the system. In the era of Windows and graphics-intensive programs, these features are the standard means of providing the user interface. The decision documentation feature was a "smart" addition to the program from an administrative and management viewpoint, because it allowed users to provide justification for each decision. This feature allows reviewers of the process an insight into why the decision was made. By making the completion of the documentation for each answer optional, however, we can allow users to easily by-pass the documentation process if desired.

Terminology

As we reviewed the Witmer and Knerr guidelines, we noted that despite the overall applicability of the guidelines to other DoD settings, there were still "Army-isms": terms that were specific to the U.S. Army, such as "soldier", or references to the Army's maintenance practices. There were two ways of dealing with the changes to the terminology: first, we could make the terminology generic across the spectrum of DoD users, or second, we could change the terminology to suit the specific characteristics of each service, and have the service and its associated terminology selectable from the beginning of the program. The decision was made to make the terminology generic in order to avoid the complexity that was expected to occur by creating specific terminology (and possible additional guideline questions) for each service.

Weapon System and Service Documentation

The inputs to the ET guidelines consist primarily of weapon system documentation and policy and doctrine information that governs the specific service user, such as the Army. The ET DART development staff believed that efficiency could be increased if this information could be made available on-line to users. Users could then look up specific weapon system or policy information in order to make or support a decision. Although this capability is possible using programs in a DOS environment, Windows not only allows this feature, but is actually built around it. This Windows capability for allowing quick, on-line access to support information played a major role in the decision of the operating system environment to use for ET DART (see below).

Guideline Questions/Decision Rules

Of all of the aspects that were anticipated by the development staff to be relatively easy, it was the incorporation of the decision rules, i.e., the questions (see Figure 1). However, the rules were designed initially to be used as a paper-based procedure, and were laid out with that method in mind. We quickly found that there was more to the incorporation of the rules than merely typing them in as shown in the Witmer and Knerr document. For example, en route messages that are provided as the decision path is followed in the paper-based version must also appear in a results or summary area if they are to be of value to the user. In other cases, notes and responses marked with an asterisk (suggesting possible cost increases) that are produced in the process of using the guidelines must appear to the user of a computer-based version of the guidelines if they are to be useful. Therefore, the incorporation of the decision rules required the program developers to review the rules and the results to ensure that they would still be complete, meaningful and useful when transferred to the computer database.

Software Development Issues

At the outset of ET DART development, it was necessary to resolve certain software development issues, such as:

- Whether the application would be in DOS or Windows
- What software development tool(s) should be used
- What minimum hardware requirements would be imposed on the user
- How to produce a stand-alone, executable application
- Whether to consider the inclusion of multi-user or network capabilities and/or client-server architecture
- How to work within finite available resources for the development of the application

By analyzing the issue of available resources, it was possible to limit the other issues and choices significantly. Our available programming resources dictated that a software development tool utilizing the Xbase language would be necessary. This narrowed the possible selections, but still allowed several options for user interface:

Option 1. A text-based (DOS) interface utilizing Clipper 5.01 and Nantucket Tools II for programming the application.

Option 2. An intermediate step between a text-based interface and a GUI using Foxpro ver. 2.5 for DOS. (This interface provides pull-down menus, pop-up windows, point and click, click and drag, and other Windows GUI-like features, but runs in DOS and does not require the additional system overhead requirements of Windows.)

Option 3. *The newly released Foxpro for Windows, ver.* 2.5, providing an Xbase development platform while producing a true GUI and, with the additional Distribution Kit, a distributable .EXE file.

Thus, the first major issue became whether to develop the ET DART as a DOS-based tool or as a Windows application. There are several good reasons for each position: DOS can provide a "universal" operating system for the program, and can provide windows-like capabilities; DOS also may provide a faster program operating speed, although this is open to debate. Windows, on the other hand, appears to be the environment of the future, and provides a very attractive and capable means for housing the ET DART. Because Windows seems to be the environment of choice for most users and developers (or soon will be), the decision was made to develop the ET DART as a Windows application.

The next question to be decided was the development software to be used for the ET DART. The software selected for use on the ET DART was Foxpro for Windows; however, due to the need for expanded memory to accommodate the full capability of the software, the programmer staff had to use the DOS version of Clipper initially (Option #1 above), which provided usable code until the memory upgrade was accomplished. To make the ET DART an executable file, the Distribution Kit for Foxpro for Windows was obtained and used to produce the final ET DART products.

Although hardware requirements were somewhat a limiting factor for the development of ET DART, the project staff had to consider what hardware capabilities were likely to be available for ET DART users. For example, since Windows was the development and utilization environment selected, there was "automatically" a requirement for having at least a 386 processor with six megabytes of random access memory (RAM). However, the 486 processor is or will soon be the standard for most users, and greater numbers of Windows programs have mandated even more RAM as requirements for intended users. The decision was therefore pushed toward the higher end of the PC spectrum, as far as both processor speed and RAM requirements.

This is a supportable position as far as high technology organizations and users are concerned: organizations such as ARI and STRICOM often have higher end equipment to use in their jobs. However, users in the line organizations are often not so blessed. Their systems may be lagging somewhat in speed, memory, storage capability, as well as usable software. For this reason, the ET DART staff has reserved the option to create a DOS-based version of the ET DART, using Foxpro ver. 2.5, to ensure that users in the field will have access to a version of ET DART that offers basic decision-aiding capabilities.

In the interest of providing the most efficient, and ultimately, the most useful on-line help system, ET DART developers are incorporating an interim context-sensitive help facility into the ET DART tool. This type of help system will provide users with assistance in the use of incorporated application functions, not the "how to's" associated with embedded training analysis methodologies. An Electronic Performance Support System (EPSS), to be incorporated during a later phase of ET DART development, will provide user assistance with the analysis methodologies, plus all the functions supported by this interim help capability.

At completion of Phase I, the ET DART will offer a standard interface in which the user selects the appropriate "hot key" and is then presented with a window containing help suggestions for the function currently being used. Buttons appearing in the window will allow the user to select "QUIT" or "HELP INDEX". The HELP INDEX feature will present the user with an alphabetized listing of all help topics with standard "point and click" selection capability. If more than one screen is required for the help information, a standard scroll bar will appear on the right side of the window. When the help function is closed, the users are returned to the exact location from where they evoked the help. It must be stressed that this help capability is an interim solution and will be replaced with a more comprehensive EPSS system. In the meantime, ET DART users will have on-line help at their fingertips whenever they need application assistance.

Current Screen Design

The current screen design for the ET DART is represented in Figures 4, 5 and 6, which show:

- a screen showing the training element being evaluated (i.e., mission, function, or task), guideline question, answer, and rationale statement;
- a screen showing the results of a Block and Phase

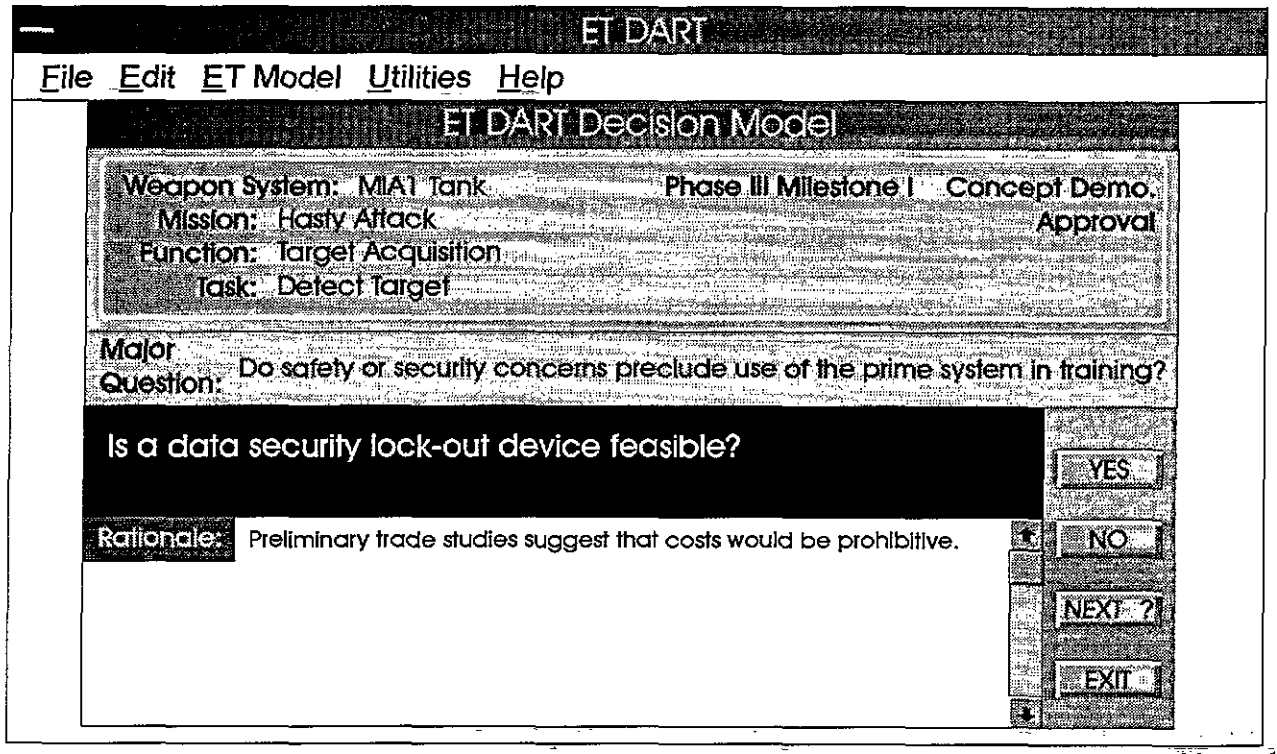

Figure 4: ET DART model guidelines screen.

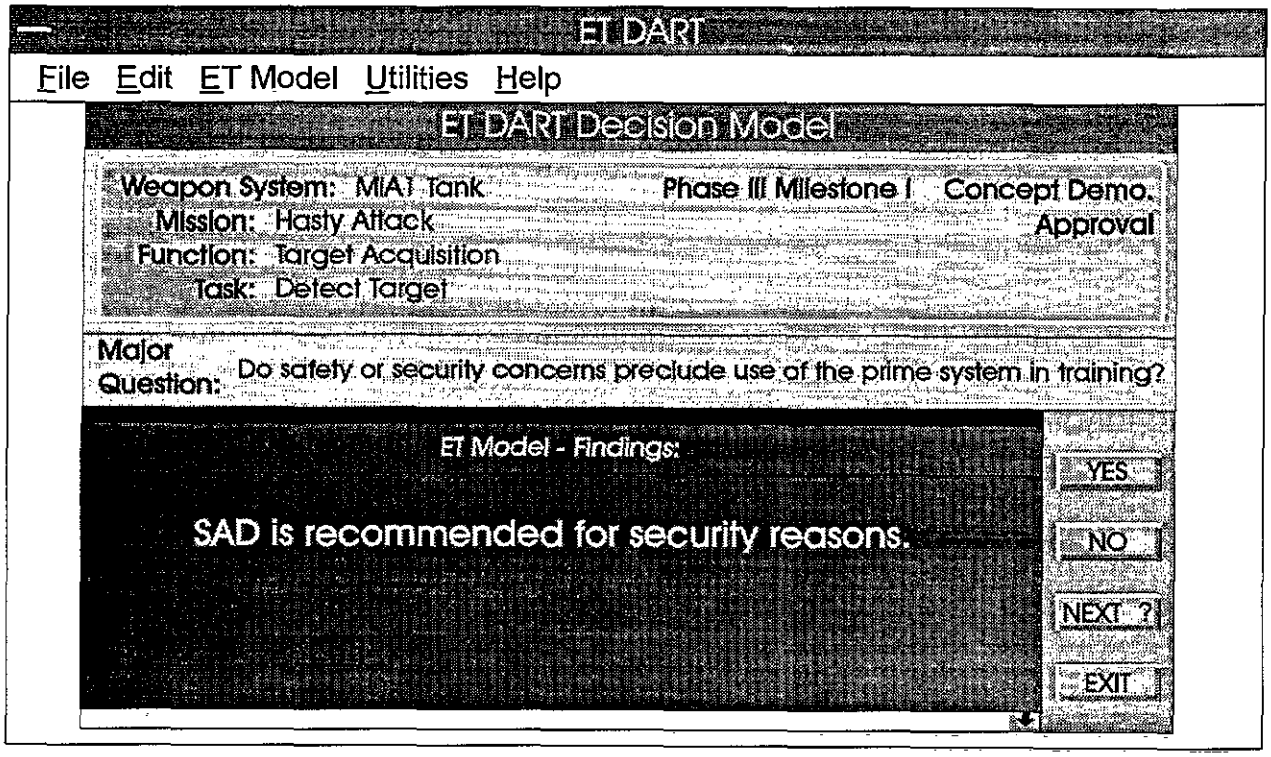

Figure 5: ET DART results screen.

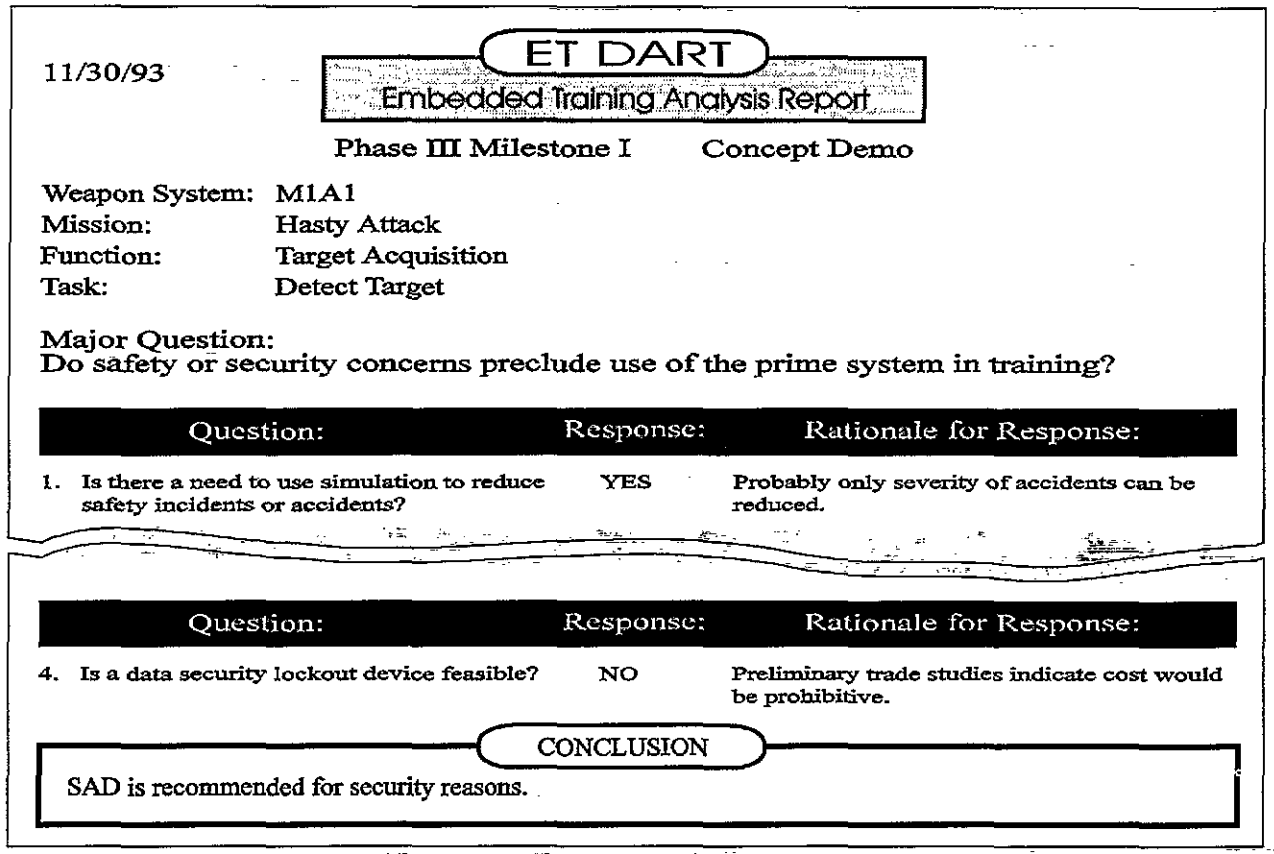

Figure 6: ET DART Block/Phase Report.

analysis;
- and the type of summary that results from the use of the guidelines.

These figures represent the ET DART as it is at this writing, and may evolve over the next few months. Additionally, the figures represent only the level of work that is or will be accomplished during Phase I of the program.

Figure 4 shows the screen used when the appropriate decision guidelines for the designated phase are provided for evaluation of the mission, function or task that has been input. Answers to the questions are provided by the user, along with any rationale that he may wish to provide. Figure 5 shows the results of the analysis. Figure 6 shows a report for a particular mission, function and/or task, and any additional messages encountered along the way.

FUTURE WORK ON ET DART

At this writing, the Phase II development goals will be focused primarily around the determination of the training devices/systems to be developed for the weapon system, using projected costs of the alternatives as the basis for the decision.

The last set of procedures in the Witmer and Knerr guidelines is the estimation of the costs associated with each of the recommended training alternatives identified in earlier steps. The cost estimates reflect non-recurring and recurring costs: design, development and procurement are non-recurring, and operation and maintenance are recurring. However, as Witmer and Knerr have noted, the interpretation of the cost data is the most difficult problem to resolve. The problem occurs when alternatives yield different levels of effectiveness, thus requiring different numbers of devices per alternative. Under these circumstances, the problem is one of cost effectiveness rather than just cost (Witmer and Knerr, 1991a).

The Phase II development of the ET DART should focus on the development of cost decision rules that provide an estimation of cost effectiveness. There are ongoing studies of cost and training effectiveness being conducted at the Institute for Simulation and Training at the University of Central Florida, under the sponsorship of Office of the Assistant Secretary of Defense (Force

Management and Personnel). This effort is directed at the development of a set of cost and training effectiveness methods and standards. In addition, the Aircrew Training Research Division of the USAF's Armstrong Laboratory is studying the cost effectiveness of different types of simulators and training devices in order to determine a standard set of methods for determining cost effectiveness of training. The ET DART project staff will incorporate as much of the results of these studies and other cost information as possible into a set of cost decision guidelines for use in making final training media decisions.

In the longer term (Phase III), the ET DART development staff intends to create and install an enhanced performance support system (EPSS) to replace the interim context-sensitive help system previously incorporated. The EPSS is a step forward in on-line user assistance, an initiative that addresses not only what a user needs to know, but how and at what rate they need to learn. In effect, the EPSS for the ET DART is a learning tool.

The ET DART is, naturally, centered around the determination of embedded training system requirements, and should be used early in the weapon system acquisition process. However, the recommendations and other resulting information that come from the use of the ET DART guidelines include stand alone devices, actual equipment training, and other alternatives as well as embedded training recommendations. In this regard, the ET DART can provide results that are applicable to other media selection processes and programs. However, it should be noted that since most media selection programs are task and/or objective driven (i.e., the medium is determined by the task or objective properties, such as type of learning, etc.) rather than policy, implementation, availability, etc., the results of the ET DART would probably be used mainly either as validation of other media selection program decisions, or as inputs to the media selection program for determination of the specific media type to be used.

SUMMARY AND LESSONS LEARNED

As part of the Total Training Systems Integration IR&D program, the ET DART development staff at Lockheed is creating an automated version of the embedded training decision guidelines developed by Witmer and Knerr (1991a). The development of the ET DART program, based in part upon earlier work by Copeland (1992) and Chatham (1992), will be performed in three phases, each of which will build upon and enhance earlier program capabilities. In addition to the incorporation of the decision algorithms, the ET DART will include a means for documenting each of the decisions made in answering the guideline questions, and a report production capability (Phase I). Later in the development cycle, the program will include the cost effectiveness rules or guidelines that will assist users in making final media decisions, and will contain the capability for using on-line documentation, i.e., the weapon system and service inputs (Phase II). The final phase of development will focus on the inclusion of an EPSS for providing users with both program-related and content-related help.

Finally, in the process of developing the program, we encountered several "learning experiences" that we felt should be passed along.

Lesson # 1. Do the basic version first, then enhance the program if you can, or if it's practical. When the project staff began the design of the program, there was a tendency to want to jump from basic coding to the development of major enhancements. Experience to this point suggests that when the baseline code is completed, it is easier to plan tasks that accurately reflect the scope of effort needed to change the program. For this reason, it was decided to produce the program in phases.

Lesson #2. There is a big difference between paper-based processes and products and computer-based processes and products (and getting from one to another). The nature of computer programs, and our reasons for using them, should suggest that we might not want to simply translate paper-based procedures to a computerized version of the same thing. Our realization of this principle came as we reviewed the decision rules, and the Training Alternatives Summary Matrix of the original Witmer and Knerr guidelines. The matrix is a good representation of the summary of results of the decision-making process, but only for the paper-based version of the guidelines. Computers can present the same information in a variety of user-selected formats, and can present additional information as required. It therefore made no sense, as we discovered, to try to merely replicate the matrix when we could design a much more efficient and effective method for presenting the data.

Lesson #3. Don't assume users know everything about computer programs, or care. As we developed the program, the user interface became an important issue. As a staff who ranged from knowledgeable programmers to mere computer users, we often found ourselves designing and developing a program that assumed too much about the user's familiarity with

Windows or computer programs in general. We therefore had to back off occasionally from the program to evaluate the user friendliness of the interface, and change it, in some cases, to ensure the usability of the program.

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