Evaluation of the Army Maintenance Training and Evaluation Simulation Systems (AMTESS)

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Abstract

AMTESS is the Army's attempt to develop an operational model and framework for acquiring modularized, generic simulation systems for maintenance training. More broadly, the AMTESS program is designed to lead toward a proven, systematized, institutionalized approach to task analysis, training requirements analysis, and fidelity analysis in support of training device acquisition. It is also designed to produce a model hardware configuration which includes a common two-dimensional display subsystem and a unique three dimensional hardware subsystem. Two prototype versions of the hardware model which vary along a number of significant dimensions (e.g., passive vs interactive use of video) are currently being evaluated for their transfer of training effectiveness at Aberdeen Proving Ground, Maryland. Transfer of training is being assessed on operational equipment using specially modified versions of current performance tests, versions designed to provide a rich, detailed data based. The data base will support assessments of overall prototype effectiveness as well as preliminary assessments of the effectiveness of specific prototype features. The results of these efforts will support initial implementation of AMTESS and at the same time will contribute towards a longer range objective of developing an operational model of device acquisition. In this paper, the AMTESS prototypes will be described, along with plans and procedures for their evaluations.

Introduction

The modern Army presently operates in an environment characterized by complex, sophisticated weapon systems with an increasing emphasis on support elements. In other words, the Army is faced with particular challenges in the area of systems maintenance. Major changes, therefore, are needed in maintenance training programs. In response to these changes and needs, the military community is responding by instituting a large scale infusion of training systems. One of these is the Army Maintenance Training and Evaluation System (AMTESS). The Program Manager for Training Devices (PM-TRADE) has been developing this system as a framework and a model for future procurements of maintenance trainers, designed to facilitate entry level training, as well as to sustain and evaluate skill levels in operational units. AMTESS is a modular system which combines two-dimensional displays (i.e., CRT, rear screen projection) with three-dimensional, dynamic equipment mock-ups, all linked to a core computer.

The Army Research Institute (ARI) has been supporting the PM-TRADE in this evaluation of alternative AMTESS prototypes (i.e., breadboards) produced by Grumman and Burtek/Seville, for training in the following MOSs: Self Propelled Artillery Mechanic (63D30) Hawk Firing Section mechanic (24C10) and Wheeled Vehicle Mechanic (63W10). Mini programs of instruction have been developed by Grumman for the 63D30 and 24C10, and by Seville for the 63W10 and 24C10. The purpose of the evaluation is to determine the relative, overall effectiveness of each prototype training system compared to training currently provided as well as to obtain student and instructor reactions. In this paper discussion will be limited to the evaluation for the 63D30 and 63W10 specialities.

AMTESS was envisioned as a means of applying advance simulation technology to a family of "hands-on," "heads-on," low cost, self-paced maintenance trainers for use at installation and unit levels. The AMTESS concept was a system to include: (1) actual "hands-on" maintenance performance training for specific maintenance tasks; (2) integration with existing training programs; and (3) a reduction in cost of ownership, or life cycle cost, for both acquisition and sustained operations.

Requirements

To meet the objectives of AMTESS, four separate tasks were conducted.

1. A Task Commonality Analysis to provide the basis for selecting representative tasks within the automotive maintenance specialities, for use in training system design.

2. A Training Requirements Analysis to develop a mini program of instruction for use in evaluation of AMTESS and to demonstrate the feasibility of integrating the concept into existing Army maintenance training programs.

3. A Fidelity Requirements Analysis to determine the fidelity requirements in a training system.

4. A design effort to develop the concept for AMTESS and to define a preliminary systems engineering design (PSED) for that concept.

Method

Equipment

BURTEK/SEVILLE - WHEEL VEHICLE MECHANIC (63W10)

Based on the above analyses, Burtek/Seville Corporation developed a breadboard model for training specific tasks in the Wheel Vehicle Mechanic (i.e., 63W10) speciality. This system:

- requires a trainee to use and follow (i.e., perform) the activities presented in the technical manuals designated for the selected maintenance tasks.
- permits a trainee to practice maintenance tasks and obtain feedback on performance without instructor supervision.
- accommodates new training materials by software changes and appropriate preparation of new 35mm slides.
- can be adapted to a wide range of MOSs through fabrication of appropriate dynamic equipment mock-ups.
- includes a high physical and functional fidelity equipment mock-up.

GENERAL SYSTEM DESCRIPTION - Burtek/Seville[3]

The Burtek/Seville system includes a student station with CRT, rear projection screen (35mm slide projection), function keyboard and a dynamic equipment mock-up (Cummins Engine). These elements are linked to an instructor's station (CRT, keyboard, printer) through a 16-bit, 32,000 word microprocessor.

Trainees are introduced to particular exercises by the CRT, which then refers them to standard training manuals for detailed procedures. The rear projection screen is used to portray detailed photographs of the Cummins engine with indications of locations where maintenance is to be performed. The bulk of the actual instruction therefore is conducted through hard copy, media (i.e., the TMs and 35mm slides). The CRT does, however, play a critical feedback role since incorrect actions on the Cummins or on the student's response panel (for some simulated actions) are indicated on the CRT.

The instructor station includes the controls and indicators necessary to manage the program of instruction which is delivered at the student station. A video terminal presents information to the instructor, facilitating selection of training problems, selection of systems failures, and malfunctions, and presents records of trainee performance.

Training Management Programs

Programs. The following programs are provided to guide the student through maintenance procedures listed in his technical manuals, provide exercises in trouble shooting, and to monitor his performance:

- Training Exercise Programs
- Failure and Malfunction Programs
- Performance Monitoring Program

Training Exercise Programs. Training exercise programs are provided for the automative maintenance training activities. These programs permit the instructor to initialize particular lessons, introduce the trainee to the lesson, monitor specific steps and their sequence listed in the applicable maintenance TMs for the tasks being performed, and provide feedback to the trainee.

Failure and Malfunction Programs. These programs control failure and malfunction for the system being simulated. They remain in effect until corrected by the trainee or removed by the instructor. The malfunctions affect the performance of the engine components and provide appropriate cues and indicators for the trainee to isolate and identify the faulty component.

Performance Monitoring. This program provides monitoring, sensing and recording of performance errors of procedural steps related to specific tasks included in the simulator. Procedural errors are identified, recorded, and made available to the instructor on CRT or hard copy in an English language text that does not require analysis or interpretation. All performance activities are recorded and recallable by the instructor at the instructor station controls.

Grumman-Self Propelled Artillery Mechanic (63D30)

Conducting an analysis similar to those conducted by Seville/Burtek, Grumman Corporation developed a breadboard model for training specific tasks in the Self Propelled Artillery Mechanic (i.e., 63D30) specialty. This system:

- requires a trainee to use and follow (i.e., perform) the activities presented in the technical manuals designated for the selected maintenance tasks. However, more use is made of tutorial instruction in the Grumman system than in the Seville/Burtek system. The Grumman system employs color video and videodiscs to present explanations and demonstrations, both written and spoken, of how to carry out specific maintenance steps.
- accomodates new training materials by software changes, preparation of new videodisc materials.

- o can be adapted to a wide range of MOS's through fabrication of appropriate simulated equipment components.

- o includes high physical and functional equipment component work-ups. However, components are arranged in test bench fashion, and do not replicate the arrangement on operational equipment.

General System Description--Grumman

The Grumman system includes a student station with a color CRT, CRT touch panel and dynamic equipment components, arranged in test-bench fashion. These elements are linked to an instructor station (CRT, keyboard, printer) through a Motorola 68000 microprocessor. Programs and instructional materials are stored on floppy and videodiscs.

Trainees are led through lesson materials by the color CRT which gives instructions to consult specific pages in the appropriate technical manuals, short explanations on maintenance procedures and diagnostic questions. Explanations are either written or spoken and are supplemented by diagrams or video demonstrations of how to perform specific maintenance tasks. The trainee makes his responses either by touching a menu line on his CRT or performing some action on one of the three-dimensional mock-up components.

Training Management Programs

The information provided for Seville/Burtek is applicable to the Grumman System as well.

Subjects and Design

Subjects were chosen from two locations, the Wheeled Vehicle Maintenance School, in the Edgewood Area of Aberdeen Proving Ground (APG) for the 63W10 MOS and the Ordnance School in APG for the 63D30 MOS. Because of a recent change in the training program it was decided to add additional subjects from the Organizational Maintenance Supervisor (63B30) training program, also at Edgewood Area. A total of 120 subjects were included in the evaluation, with 60 subjects (i.e., 20 in each MOS, 63W10, 63D30, 63B30) assigned to the experimental groups (i.e., training included the AMTESS devices) and 60 subjects assigned to the control groups (i.e., conventional training without AMTESS devices).

An analysis of variance will be conducted,* using the results of a performance test conducted for this study. The dependent variables are number of items (i.e., skills) completed successfully (i.e., measured by number of GO's) and amount of time to complete the tasks and subtasks. An analysis of variance will be conducted using the data collected in the following design (see figure 1, below).

		GROUPS			
		EXPERIMENTAL		CONTROL	
Device	MOS	Average No. of GO's	Time	Average No. of GO's	Time
Grumman	63D30				
Burtek/ Seville	63W10 63B30				

Figure 1: Evaluation Design for AMTESS

Measures

The performance measures typically used in school programs have been expanded to allow for more detailed data collection. In addition to the performance and time measures collected, student, instructor and course developer questionnaires on each task will also be administered and reported.

Performance data will be restricted to those tasks which can be performed on the actual equipment within time and safety constraints. These data will consist of a series of go-no go decisions in a check-list format derived from the appropriate technical manuals for each task. Opinion or user reaction data will also be collected from students and instructors upon completion of training on the devices. In addition, questionnaire data will be collected from instructors and course developers regarding those tasks which can not be observed on the actual equipment because of time or safety considerations. Instructors and course developers will be presented with the entire mini-POI's in order to obtain training efficiency data. This evaluation will also include their reactions to determine if:

- o tasks on each device are also taught in conventional training

- o each of the tasks are necessary

- o each device instructs each task to acceptable levels.

Evaluation Questions

With the evaluation design constructed in the above manner the following evaluation questions are anticipated to be answered by using various subsets of the data.

1. Does a simulator facilitiate performance more than conventional instruction? (data used: the average number of GO's and time for all the experimental subjects versus all the control subjects).**

2. Does a simulator reduce performance time in relation to conventional training (data used: average time for all experimental subjects versus all the control subjects).**

3. Is there greater transfer of training using a simulator than that resulting from conventional training? (data used: average number of GO's for the experimental subjects minus the average number of GO's for the control subjects, divided by average number of GO's for the control subjects).

4. Is there a relation between instructor's and students' opinion about the training devices and students' performance? (data used: instructor and student questionnaire results will be correlated with average number of GO's for the experimental subjects only).**

The above questions were designed to provide insight into the overall effectiveness of the AMTESS devices. The same questions and data indicated will be analyzed for each MOS separately. Because of commonality of the tasks for both experimental and control groups in each MOS generalization of findings is more likely. Restrictions in generalization, therefore, will be a function of the reliability, validity of the performance measures, sample size, etc.

Procedures

All students, regardless of MOS, receive conventional training. Those students selected to receive simulator training (i.e., on AMTESS devices) however, will be directed to their respective training device prior to conventional instruction on the tasks used in this evaluation. The control group will continue with the conventional training and be tested in the same manner as the experimental group (i.e., on the actual equipment). The experimental group upon having conventional training will receive instruction on the device designed to teach skills they have not received before. Both groups will then be tested on the same skills on the actual equipment. The only difference, therefore, between the experimental and control groups will be the use of the training device for the experimental group.

* Complete data has not been collected at the time this paper was prepared, it is assumed, however, all data will be collected and analyzed for the Presentation in November. The remainder of this paper will present the anticipated evaluation which will be presented at the conference.

** Generalization of these findings must be limited because of differences in tasks across MOSs.

Instruction on the AMTESS devices will be conducted by one of the school instructors. The following tasks were selected for this evaluation.

63W10

- o Troubleshoot Engine Malfunction
- o Oil Pump Filter and Pump Removal
- o Oil Pump Filter and Pump Replacement

63B30

- o Adjust Alternator or Drive Belts
- o Starter Motor Removal and Replacement
- o Oil Pump Failure Troubleshooting
- o Inspect Electrical System

63D30

- o Starting System Problem
- o VTM Setup and Checkout
- o Defective Transmission Neutral Position Switch

Conclusion

AMTESS is conceptualized as a program designed to acquire Army training devices by systematic application of front end analyses.[3] The objectives of this program, as delineated by Hofer,[3] include:

o Development of maintenance trainers, utilizing a modular format, for development at both institutional and unit levels.

o Cost-effective assessment methodology development for Army Maintenance training programs.

o Development of Preliminary Engineering models (i.e., breadboard) to demonstrate the effectiveness and validity of the AMTESS concept.

The objectives and effort described here are envisioned to be an initial thrust in advancing Army maintenance training programs. It is recognized, however, that gaps in knowledge still remain to be filled. Example of such information shortcomings include:

- o Generalizability of findings
- o Specific Device Architecture
- o Incorporation of AMTESS into POI
- o Research on Measures of Effectiveness

Generalizability of findings to other instructional modules within the MOSs already under evaluation, to other MOSs, to other applications, such as use in organizational settings or use for skill qualification testing. At the very least, implementation of AMTESS for the MOSs under present evaluation will require the development of additional POI software modules. Software development for

AMTESS has proven to be extremely costly and time consuming, even for relatively minor changes in the prototype mini programs. Extension of program development to other portions of the MOS POIs should therefore be approached with great caution. It may not be necessary or even desireable to apply AMTESS to the entire POI. But in that case decisions must be made about what kinds and amounts of additional software development are needed. The proposed continuing ARI research would directly support this decision making.

Specific Device Architecture, (both software and hardware). This area would focus on such issues as: 2D vs 3D components within AMTESS; AMTESS vs flat panel devices such as (EC-3); and other features such as generalized troubleshooting instruction. The present AMTESS evaluation will not provide much information on the contribution of specific system architecture to training effectiveness. If the prototypes proved to be effective, therefore, specific sources of effectiveness are not likely to be understood. It may be that a relatively low cost feature of a particular prototype system is accounting for most of the training effectiveness and that some relatively high cost feature could be estimated. The converse may also be true, that is, the addition of a low cost feature could dramatically amplify the effectiveness of a particular prototype. For example, evidence is accumulating that generic troubleshooting training may dramatically increase training system effectiveness. Such training could be incorporated into AMTESS as a sub-routine and would lend itself well to presentation on satellite CRTs operating off an AMTESS main frame. This is just one of a number of features which would be studied in further ARI research under the AMTESS umbrella. Front end analysis methodology needs to be examined. Each of the Phase I contractors proposed different breadboard designs for the AMTESS program. A methodology is needed whereby the PM TRADE, TRADOC, and others can evaluate design specifications based on sound guidance for making hardware decisions. That is, there is general agreement in conducting job/task analyses and then training analyses in the development cycle for system acquisition. There is, however, little data on making the conceptual leap from these analyses to device characteristics decisions.

Incorporation of AMTESS into POI. Design and use of AMTESS needs to be related to system variables, such as student characteristics, task characteristics, stage of training, use of other media, and time-based vs performance-based instruction. A number of very serious issues have already been alluded to. To date, for example, little or no analysis has been done on how AMTESS would be incorporated into ongoing POIs. For example, the Missile Maintenance Speciality has been converted from self-paced instruction to lock-step instruction. How will or should this change influence the way in which AMTESS is used? Student flow is yet another issue to be considered in defining appropriate uses of AMTESS. It was emphasized repeatedly at the last Interservice/Industry Conference that high technology solutions to training which do not cope realistically with student flow are not very useful to the military. The anticipated continuing research program will address the utilization issue in a major way and support both near and long term implementation of AMTESS through recommendations to PM TRADE and the TRADOC on how to effectively incorporate AMTESS into ongoing POIs.

Research on Other Measures of Effectiveness such as transfer of training to organizational settings, effectiveness in training "hot" panel repair, and use of analytic tools such as the TRAINVICE model.[4] The current AMTESS evaluation involves measurement of transfer effectiveness within institutional settings. The impact of AMTESS training on transfer of training to job sites will remain unknown.

The present evaluation of the Burtek/Seville and Grumman breadboards is an effort at meeting the AMTESS objectives. Other projects are planned of AMTESS prototypes or in progress which will support this program. A similar evaluation, for example, is under way in HAWK missile maintenance training. At the Air Defense School in Fort Bliss, an evaluation team is already on site collecting data. A supporting program of basic research is under way at ARI, in which the effects of simulation fidelity upon training effectiveness is being explored. This program is described in another presentation at this conference (Hays, 1982). While these activities represent considerable effort and progress in meeting the AMTESS goals, these must be extended further.

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