Technical Report 644

Army Maintenance Training and Evaluation Simulation System (AMTESS) Device Evaluation:

Volume III. Qualitative Assessment of Two Prototype Devices

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Research Institute for the Behavioral and Social Sciences

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Students from several MOS were trained to perform maintenance tasks using one of two prototype AMTESS maintenance training devices. Instructors, course developers, students, and other knowledgeable individuals provided opinion data concerning the adequacy and effectiveness of the devices. These data are reported in this volume of a three-volume series. Opinions generally supported the AMTESS device concept; however, users expressed concern about various specific features of the prototype devices. Results will be used to guide future AMTESS development efforts.

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Training and Simulation

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ARMY MAINTENANCE TRAINING AND EVALUATION SIMULATION SYSTEM (AMTESS) DEVICE EVALUATION: VOLUME III, QUALITATIVE ASSESSMENT OF TWO PROTOTYPE DEVICES

EXECUTIVE SUMMARY

Requirement:

To assess and document user opinions about the usefulness and effectiveness of two breadboard AMTESS devices.

Procedure:

Students, instructors, and course developers from several maintenance MOS and locations provided opinion-based data concerning the effectiveness of two prototype AMTESS devices. The following instruments were used to collect data: initial instructor questionnaire (completed by instructors prior to extensive interaction with the devices), instructor questionnaire (completed by instructors after they had used the devices to train students), course developer questionnaire (completed by course developers following extensive interaction with the devices), structured interviews with various knowledgeable persons, and observations provided by the on-site data collector. Data were compiled in tables and reviewed in order to identify similarities and differences in opinion. The benefits and liabilities of each prototype device were identified.

Findings:

Analysis of responses indicated that the AMTESS concept (i.e., generic, modular maintenance training device) is viable, particularly to train students where use of operational equipment is unsafe or may result in equipment damage. Comments about the utility of specific device features varied with the tasks that the devices trained. In general, students, instructors, and course developers praised a variety of device features including feedback provided to students, the ease with which malfunctions can be inserted into the devices, and the quality of audio and visual stimuli presented to students. The low reliability and durability of the devices detracted from their overall effectiveness.

Utilization of Findings:

Results of this and other reports in this series can support preparations of guidelines on how to design and use generic maintenance training devices. Such devices can increase the efficiency and effectiveness of Army training.

ARMY MAINTENANCE TRAINING AND EVALUATION SIMULATION SYSTEM (AMTESS) DEVICE EVALUATION: VOLUME III, QUALITATIVE ASSESSMENT OF TWO PROTOTYPE DEVICES

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ARMY MAINTENANCE TRAINING AND EVALUATION SIMULATION SYSTEM (AMTESS) DEVICE EVALUATION: VOLUME III, QUALITATIVE ASSESSMENT OF TWO PROTOTYPE DEVICES

INTRODUCTION

The Army has increased its emphasis on maintenance training simulation as the cost and complexity of weapons systems has increased. The Army Maintenance Training and Evaluation Simulation System (AMTESS) program is an example of the Army's emphasis on simulation. Its objective is to provide cost- and training-effective maintenance simulators (Dybas, 1981, 1983). Four maintenance trainer concepts were developed during Phase I of the AMTESS program. Grumman Aerospace Corporation and a consortium of Seville Research Corporation and Burtek, Inc. developed breadboard models of their concepts during Phase II of the program. Each breadboard device was designed so that, by attaching unique software and MOS-specific three-dimensional (3-D) hardware to the core computer system, the device could be used to teach either mechanical or electronic maintenance.

Both the Grumman device and the Seville/Burtek device are composed of four major components: a student station, an instructor station, and two 3-D modules. The Seville/Burtek device presented curricula to students via CRT and a slide projector. Students entered troubleshooting decisions into the device by manipulating a thumbwheel and pushbuttons on the student station. Students trained on the device at the U.S. Army Ordnance Center and School at Aberdeen Proving Ground, Maryland (APG) learned to identify and remove/replace faulty components (starter motor, oil pump, etc.) on a 3-D module that emulated a Cummins NHC-250 diesel engine. Students trained on the device at the U.S. Army Air Defense School at Fort Bliss, Texas were trained to identify faulty components (modulation circuits, noise degeneration circuits, etc.) on a 3-D module that emulated an Improved Hawk High Power Illuminator Radar transmitter.

The Grumman device presented curricula to students with an interactive video disc system. Students entered troubleshooting decisions by pressing a touch panel on a CRT. Students trained with this device at APG learned to identify faulty components on a 3-D module that emulated the starting and charging system of an M110A2 self-propelled howitzer. At Fort Bliss, students learned to identify faulty components (modulation circuits, noise degeneration circuits, etc.) on a 3-D module that emulated the Improved Hawk High Power Illuminator Radar transmitter.

The results of a 1982 and 1983 evaluation of these devices are presented in a three-volume series of documents. Volume I is an Executive Overview. Volume II summarizes an evaluation of the devices' capability to provide transfer of training to operational equipment. (Students were trained using either conventional methods or using one of the two versions of the AMTESS simulator and were then tested on ability to perform actual maintenance tasks on operational equipment.) Volume III (this report) summarizes user opinions about the usefulness and effectiveness of the devices. Other reports also address the AMTESS program. Front-end analysis procedures were discussed by Woelfel, Duffy, Unger, Swezey, Hays, and Mirabella (1984) and specific device features were addressed by Criswell, Unger, Swezey, and Hays (1983).

The AMTESS devices were evaluated in six experiments at two locations (APG and Fort Bliss) with soldiers from eight Military Occupational Speciality areas (MOSs). Volume II explains the need for six experiments. Experiments 1 and 2 addressed the Seville/Burtek simulator at APG while Experiments 3 and 4 addressed the Grumman simulator at APG. Experiment 5 addressed the Seville/Burtek simulator at Fort Bliss while Experiment 6 addressed the Grumman simulator at Fort Bliss (see Table 1).

This volume describes the device users' opinions which were collected as part of the transfer-of-training evaluation (Volume II). The studies in this volume will be refered to as experiments in order to maintain consistency with Volume II. Table 1 shows an overview of the evaluation which used the following data collection instruments:

- Initial instructor questionnaire. These forms were filled out by instructors after they were trained to use the simulators but prior to using the devices to train students.
- Instructor questionnaire. Instructors provided detailed information about the simulators after they had used the devices to train students.
- Course developer questionnaire. Course developers responded to questions about the lessons presented on the simulators after they had extensive experience with the devices.
- Trainee questionnaire. After students completed training with the simulator and testing on operational equipment, they responded to a series of questions concerning their opinions about the simulator.
- Structured interview. Various individuals who were knowledgeable about the simulators responded to a series of 13 questions about the devices.
- Data collector observations. During the transfer-of-training evaluation, data collectors recorded various types of information about specific device features and lessons. They also assessed the reliability of the devices and various aspects of trainee-simulator interactions.

This volume is divided into three major sections. Following this introduction, the second section presents and discusses data collected in each of the six experiments shown in Table 1. The final section provides an overall discussion of the results obtained from these experiments.

Table 1

AMTESS Field Evaluation Studies Qualitative Data

	Experiment					
	1	2	3	4	5	6
DEVICE	S/B[a]	S/B	G[b]	G	S/B	G
MOS	63B30	63W10	63H30	63D30	24C10	24E, G, R
LOCATION	APG	APG	APG	APG	BLISS	BLISS
SAMPLE SIZE:						
Initial Instructor Questionnaire	2	3	5	-	11	2
Instructor Questionnaire	1	1	6	-	1	-
Course Developer Questionnaire	2	-	3	-	-	1
Trainee Questionnaire	20	67	15	15	10	10
Structured Interviews	4	1	5	-	2	5
OTHER DATA	DCO[c]	-	DCO	-	DCO	DCO

[a]Seville/Burtek

[b]Grumman

[c]Data Collector Observations

RESULTS OF EXPERIMENTS

Experiment 1

Forty (40) students from the 63B30 MOS (Organizational Maintenance Supervisor) were trained to perform four tasks on a Cummins NHC-250 diesel engine. The tasks included adjustment of alternator belts, removal/replacement of the starter motor, troubleshooting an oil pump failure, and inspection of the electrical system. Students were trained with either conventional methods (20 students) or the Seville/Burtek simulator (20 students). They were then tested on their ability to perform these tasks on operational equipment. Data consist of responses to questionnaires and structured interviews, as well as observations made by the on-site data collector during the course of the experiment.

Method

Subjects. Characteristics of subjects who provided data are presented below:

- Initial instructor questionnaire. Two Noncommissioned Officers (NCOs) who were instructors for the 63B30 MOS completed the questionnaire.

- Instructor questionnaire. One of the instructors described above completed this questionnaire.

- Course developer questionnaire. Two civilians responsible for creating and modifying curricula for the 63B30 MOS completed this questionnaire.

- Trainee questionnaire. Twenty (20) MOS 63B30 students who had received training with the Seville/Burtek simulator completed this questionnaire after they had been tested on their ability to perform troubleshooting tasks on the operational equipment.

- Structured interview. Interviews were conducted with the two instructors described above, one of the course developers described above, and the data collector involved in the transfer-of-training study (Volume II).

Materials. Four questionnaires and one structured interview form (see Appendix A) were used to collect qualitative data about the Seville/Burtek device. The Initial Instructor Questionnaire assessed instructor opinion about the simulator after instructors had been trained to use the simulator, but before they had used the device to train students. Respondents were asked to rate (on a 5-point scale ranging from "very easy" to "very hard") the difficulty involved in learning to use the simulator. They were also asked to rate (on a 5-point scale ranging from "like it very much" to "dislike it very much") the extent to which they liked or disliked the simulator. Two other questions asked respondents to comment on their ratings while a final question asked respondents to make other comments they felt were appropriate.

The Instructor Questionnaire assessed opinion about the Seville/Burtek device after they had trained students on the simulator. Respondents were asked to rate (on a 5-point scale ranging from "very well" to "very poorly") how well the device trained students to perform tasks addressed by the lessons. [See Table 2 for a description of the 22 tasks (numbered 4-13 and 17-28) that were rated.] They were also asked to explain why they made this rating and to comment on specific device features involved in each lesson. A final question asked them to make other comments they felt were appropriate.

The Course Developer Questionnaire assessed opinions concerning the appropriateness of the curriculum which supported the Seville/Burtek device. For each of 21 lessons in the curriculum that were evaluated, the respondents noted if the task addressed by the lesson was critical and if the lesson was currently taught with conventional methods (using operational equipment). Course developers were asked to rate (on a 5-point scale ranging from "very difficult" to "very easy") the difficulty of performing each task involved in the lessons. They were also asked to rate (on a 5-point scale ranging from "novice" to "expert") the skill level at which trainees would perform each task after the trainees had completed training. A final question asked them to make other comments they felt were relevant.

The Trainee Questionnaire assessed student opinion about the device after students had completed training and had been tested on their ability to perform troubleshooting tasks on operational equipment. Trainees were asked to rate (on a 5-point scale ranging from "like it very much" to "dislike it very much") how they felt about the simulator. Subsequent questions asked them to explain why they made this rating and to comment on specific device features they liked or disliked. A final question asked students to make other comments they felt were relevant.

The Structured Interview (13 questions) addressed a variety of topics about the simulator, its features, and the lessons that support the simulator. After respondents answered the questions, they were asked to rate (on a 7-point scale ranging from "none" to "greatest") the simulator features (or lessons) for their training value in the current setting. They were also asked to rate (on a 7-point scale ranging from "none" to "greatest") the simulator features (or lessons) for their potential training value.

Procedure. Prior to filling out the questionnaires or participating in the structured interviews, subjects were briefed on the purpose of the questionnaires (or interview) and the types of questions they would be asked.

Initial Instructor Questionnaires were completed in a group setting after instructors had completed a training course on simulator operation.

One instructor and one MOS 63B30 student worked together to complete 22 of the 28 lessons presented by the simulator. Responses judged to be redundant were combined with responses to other lessons in order to save time. The instructor filled out an instructor questionnaire upon completing each of the 22 lessons in which he participated.

Course Developer Questionnaires were completed as two course developers and one MOS 63B30 student worked together to complete 21 of the 22 lessons

Table 2

Seville/Burtek Tasks Rated by Instructors and Course Developers (Experiment 1)

Task Number	Description
4	Remove and replace oil pump
5	Perform an oil pressure test using STE/ICE
6	Remove and replace thermostat
7	Remove and replace water pump
8	Remove and replace alternator
9	Perform a DC voltage test using STE/ICE
10	Remove and replace starter motor
11	Perform a DC current test using STE/ICE
12	Remove and replace fuel pump
13	Perform a resistance test using STE/ICE
17	Troubleshoot and repair engine (oil pump failure-low pressure)
18	Troubleshoot and repair the cooling system (thermostat failure-low temperature)
19	Troubleshoot and repair the cooling system (water pump failure-high temperature)
20	Troubleshoot and repair fuel system (fuel pump failure-engine stalls)
21	Troubleshoot and repair electrical system (starter motor failure-slow start)
22	Troubleshoot and repair electrical system (alternator failure-high charge)
23	Troubleshoot and repair electrical system (loose alternator belt-low charge)
24	Troubleshoot and repair electrical system (alternator failure-BG point low)
25	Troubleshoot and repair electrical system (fuel pump failure-hard start)
26	Troubleshoot and repair electrical system (battery switch failure)
27	Troubleshoot and repair electrical system (front harness failure)
28	Troubleshoot and repair NHC-250 Diesel (protective control box failure)

that were completed by the instructor described above. Upon completion of each lesson, the course developers independently completed a questionnaire.

Twenty (20) MOS 63B30 students completed Trainee Questionnaires after they had completed training and they had been tested on their ability to perform troubleshooting tasks on the operational equipment. Trainees completed their questionnaires independently.

Two instructors, one course developer, and one data collector completed the Structured Interview after all transfer-of-training data had been collected. Interviews were conducted on an individual basis. One interview was self-administered. For the remaining three interviewees, the interview protocol was as follows:

- o The interviewer asked the interviewee a question.
- o The interviewer prompted the interviewee for specific comments about the simulator if the interviewee was initially unresponsive.
- o The interviewer asked the interviewee to rate simulator features (for questions 1, 3, 4, 8, 9, 10, 11, and 13).
- o The interviewer reviewed comments with the interviewee to ensure correctness of recorded responses.

Results[1]

Several of the questionnaires asked respondents to comment on specific device features. In order to clarify these comments, brief descriptions of the major features of the Seville/Burtek device are presented in Table 3.

Initial Instructor Questionnaire. Results of the initial instructor questionnaire are summarized below.

QUESTION 1: How easy or hard is it to learn to use the simulator?
RATINGS: 1 = very hard, 5 = very easy
N = 2

Response	Number of Responses
VERY EASY	2
FAIRLY EASY	0
AVERAGE	0
FAIRLY HARD	0
VERY HARD	0
TOTAL	2

[1]Data presented in this section for each of the six experiments reported are available in raw form from the U.S. Army Research Institute.

Table 3

Description of Seville/Burtek Device Features

Feature	Description
Remove/replace capability	Components of the 3-D module could be removed and replaced by students.
Student CRT unit	Text presented on this CRT directed student actions and provided feedback.
Student responder unit	Students turned a thumbwheel and pushed buttons to enter their decisions (i.e., inspect hoses) into the training device.
Instructor CRT unit	Instructors were able to monitor student actions on this CRT unit.
Hardcopy printout	A record of student performance could be printed as the student performed the lesson or after the lesson was completed.
Lesson arrangement	The sequence in which students participated in lessons could be controlled by the instructor.
Editing system	Text, graphics, and all procedures involved in a lesson could be modified by instructors.
Malfunction insertion	Numerous faults could be inserted into the simulator by manipulating two controls on the instructor station.
Random malfunction insertion	This feature randomly selects a malfunction and inserts it into the simulator.
Slide projector unit	Photographs, diagrams, and other visual aids were presented via slide projector.
Sound effects	Various equipment sounds were simulated.

Note: The 3-D module of the Seville/Burtek device for the 63B30 and 63W10 MOSs (Experiments 1 and 2) is a full-scale reproduction of a Cummins NHC-250 diesel engine. The 3-D module is composed of engine components (i.e., starter motor, batteries, etc.), controls, displays, and test equipment.

The 3-D module of the Seville/Burtek device used by the 24C10 MOS students (Experiment 5) is a full-scale reproduction of an Improved Hawk High Power Illuminator Radar transmitter unit. The 3-D module is composed of a cabinet, interior components (i.e., cables, power supplies, etc.), controls, displays, and test equipment.

When asked to rate the difficulty involved in learning to use the Seville/Burtek device, two instructors indicated that it was very easy to learn to use the device.

QUESTION 2: Why did you answer Question 1 as you did?

Instructors indicated that it was very easy to learn to use the simulator because the manufacturer had provided detailed instructions for operating the device.

QUESTION 3: How do you feel about the simulator?
RATINGS: 1 = dislike it very much, 5 = like it very much
N = 2

Response	Number of Responses
LIKE IT VERY MUCH	2
LIKE IT SOMEWHAT	0
NO STRONG FEELINGS ABOUT IT	0
DISLIKE IT SOMEWHAT	0
DISLIKE IT VERY MUCH	0
TOTAL	2

QUESTION 4: Why did you answer Question 3 as you did?

The instructors rated the device highly because they felt it would be a useful training device and that it was easier to induce malfunctions in the simulator than in operational equipment.

QUESTION 5: Please make any additional comments you feel are appropriate.

Additional comments made by the instructors indicated that they felt the device would be useful for Skill Qualification Tests (SQTs). They also stated that it would be useful to place the device at the battalion level.

Instructor Questionnaire. Data reported for the instructor questionnaire are based on the responses of one instructor.

QUESTION 1: How well does the simulator train this task?
RATINGS: 1 = very poorly, 5 = very well
N = 1

Response	Number of Responses
VERY WELL	7
MODERATELY WELL	13
FAIRLY	2
POORLY	0
VERY POORLY	0
TOTAL	22

One questionnaire was complete[illegible] each of 22 tasks included in the simulator curriculum. When asked [illegible] rate how well the simulator trains each of the 22 tasks, the instructor i[illegible]dicated that most tasks were trained moderately well. The mean rating for all tasks was 4.23 (standard deviation = 6.1). Raw data are presented in Table B-1.

QUESTION 2: Why did you answer Question 1 as you did?

Instructor comments indicated that "fair" ratings were given to tasks that were poorly documented; that is, directions provided to students on the student CRT or in the student guidebook (provided by Seville/Burtek to help students complete lessons) were unclear and did not match directions provided in TMs. The instructor did not indicate why certain tasks were given a rating of "very well" and other tasks were given a rating of "moderately well."

QUESTION 3: What specific features of the simulator (involved in this task) do you like or dislike?

Specific features of the simulator that appealed to the instructor were: 1) high fidelity of the alternator component, 2) ease of inserting malfunctions into the simulator, and 3) feedback provided to the student. The instructor disliked the low fidelity representation of the starter motor remove/replace task, and the sensitivity of the 3-D module during this task.

QUESTION 4: Why do you like or dislike these features?

The instructor disliked the low physical fidelity of components involved in the starter motor remove/replace task because it made the task too simple to perform. He stated that obstacles to removing this component (propeller shaft and frame) are not represented in the simulator. He also felt that the sensitivity of the 3-D module resulted in a student performance record that included an inflated number of errors.

QUESTION 5: Please make any additional comments you feel are appropriate.

The instructor indicated that the student guidebook provided little useful information for tasks 6 and 9. He also stated that he liked the way tasks 27 and 28 were presented on the simulator.

Course Developer Questionnaire. Two course developers completed a questionnaire for each of 21 tasks included in the simulator curriculum.

QUESTION 1: Is this a critical task which needs to be trained?
RESPONSES: Yes, No.
N = 2

Response	Number of Responses
YES	8
NO	34
TOTAL	42

One course developer indicated that all of the rated tasks were critical, while a second course developer indicated that only 13 of the 21 rated tasks were critical. Respondents made no comments about their decisions concerning task criticality. Raw data are presented in Table B-2.

QUESTION 2: Is this task currently trained on operational equipment?
RESPONSES: Yes, No
N = 2

Response	Number of Responses
YES	40
NO	2
TOTAL	42

Course developers agreed that nearly all of the tasks included in the simulator curriculum were currently included in conventional training. Raw data are presented in Table B-3.

QUESTION 3: How difficult is it to perform this task?
RATINGS: 1 = very easy, 5 = very difficult
N = 2

Response	Number of Responses
VERY DIFFICULT	0
SOMEWHAT DIFFICULT	25
ABOUT AVERAGE IN DIFFICULTY	9
SOMEWHAT EASY	8
VERY EASY	0
TOTAL	42

When asked to rate the difficulty of performing tasks included in the simulator curriculum, the course developers concurred that, on average, the tasks were somewhat above average in difficulty. The mean rating for all tasks was 3.4 (standard deviation = .8). Raw data are presented in Table B-4.

QUESTION 4: At what skill level should a trainee perform this task at the end of training?
RATINGS: 1 = novice, 5 = expert
N = 2

Response	Number of Responses
EXPERT	0
LESS THAN EXPERT	18
APPRENTICE	24
BETTER THAN NOVICE	0
NOVICE	0
TOTAL	42

When asked to rate the skill level at which trainees should perform a task upon completion of training, course developers indicated that, on average, trainees would perform somewhat better than apprentice level. The mean rating for all tasks was 3.43 (standard deviation = .5). Raw data are presented in Table B-5.

QUESTION 5: Please make any additional comments you feel are appropriate.

The course developers made several additional comments. They both noted that the simulator curriculum would have been better if it had included set-up and check-out procedures for the Simplified Test Equipment/Internal Combustion Engine (STE/ICE) kit. The course developers also agreed that it may be more appropriate to provide training for remove/replace tasks using operational equipment since physical fidelity is more important for remove/replace tasks than it is for troubleshooting tasks. One course developer made several comments identifying erroneous diagrams, procedures, etc. associated with the simulator curriculum. Another course developer noted the ease of inserting malfunctions into the simulator and the decreased risk of student injury associated with the simulator.

Trainee Questionnaire. Trainees completed questionnaires after they had been trained with the simulator and had been tested on their ability to perform four troubleshooting tasks on operational equipment.

QUESTION 1: How do you feel about the simulator?
RATINGS: 1 = dislike it very much, 5 = like it very much
N = 20

Response	Number of Responses
LIKE IT VERY MUCH	16
LIKE IT SOMEWHAT	4
NO STRONG FEELINGS ABOUT IT	0
DISLIKE IT SOMEWHAT	0
DISLIKE IT VERY MUCH	0
TOTAL	20

Trainees rated the simulator highly. The mean rating for all students was 4.8 (standard deviation = .41).

QUESTION 2: Why did you answer Question 1 as you did?

Many students indicated that they rated the simulator highly because they felt they were well-trained.

QUESTION 3: What specific features of the simulator do you like or dislike?

Two students stated that they liked all device features. Specific features that students liked include feedback, hands-on capability, simplicity of operation, and the hardcopy printout of student performance. Several students disliked the fact that the simulator was so sensitive to vibration during remove/replace tasks that it recorded minor movements as deviations from normal procedures.

QUESTION 4: Why do you like or dislike these features?

There were no relevant responses to this question.

QUESTION 5: Please make any additional comments you feel are appropriate.

Many students commented that they enjoyed working with the simulator.

Structured Interview. Responses to the 13 questions posed during the structured interview are summarized below.

QUESTION 1: What were the instructional features of the simulator that were applicable to the school's training course?

Four interviewees stated that the 3-D module was applicable to the school's training course. These interviewees criticized the 3-D module, however, because it lacked the required degree of physical or functional fidelity for components such as the STE/ICE kit, oil dipstick, propeller shaft, and radiator fan.

Opinions were mixed concerning the applicability of feedback provided on the student CRT unit. One interviewee felt that the feedback helped students complete lessons. Another interviewee, however, felt that the feedback confused students at times. This confusion resulted when the students performed tasks in an order that was considered acceptable by school personnel, but the simulator provided feedback that indicated that the order was inappropriate.

Three interviewees stated that the hardcopy printout of student performance is applicable to the school's training course. One interviewee, however, felt that the printout was too detailed. He noted that detailed performance records were unnecessary at APG.

Three interviewees stated that the flexible arrangement of lessons was useful. One interviewee indicated that a simulator that did not incorporate this feature would be of limited value.

All interviewees stated that the ability to insert malfunctions into the simulator was highly useful. One interviewee noted that it was very easy to insert several malfunctions at a time into the simulator.

While interviewees thought that the remove/replace feature was applicable, they noted several deficiencies: 1) components are not durable and cannot withstand normal wear and tear, and 2) since components are easily accessed, much of the difficulty associated with remove/replace tasks is eliminated.

Opinions concerning the simulator's editing feature varied considerably. Two interviews thought it would be highly useful to be able to change lesson content and arrangement. Others, however, stated that the editing system was of little value.

Three individuals indicated that the random malfunction selection feature was moderately useful while one stated that it was of little value. One individual noted that this feature may be more appropriate for SQT than for training 63B30 students. Another interviewee noted that selection of malfunctions did not seem to be random. Rather, the same subset of malfunctions were consistently selected by the simulator.

Interviewee assessment of the slide projector unit ranged from "good" to "poor." The interviewee who liked this feature praised it for presenting illustrations that could not normally be shown during training (i.e., leaking oil lines). Another interviewee, however, felt that the projector unit was of little value because most of the material it presented came from existing technical manuals (TMs).

Two interviewees stated that they liked the self-paced lesson format. They also noted that a self-paced format did not remove the requirement for an instructor's presence during training.

Ratings made by the interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	4	4	.82
Rate the potential training value of these features as a whole.	4	5.5	.58

QUESTION 2: What were the instructional features of the simulator that were not applicable to the school's training course?

Interviewees indicated that few of the instructional features were not applicable. Rather, they described some of the less desirable aspects of the applicable features described in Question 1. Features that were described as inapplicable include the hardcopy printout of student performance, the editing system, random malfunction selection, and the slide projector unit. Each of these features was thought to be inapplicable by one of the four interviewees.

QUESTION 3: Which features of the lesson presentation helped make the simulator lessons interesting to the students?

The interviewees generally agreed that students enjoyed troubleshooting the 3-D module because it faithfully reproduced symptoms of a malfunctioning engine. Interviewees also felt that the simulator's sound effects played an important part in maintaining student interest in the lessons. Additionally, most of the interviewees stated that the materials presented on the slide projector unit held students' attention.

Ratings by the interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	4	4.5	1.29
Rate the potential training value of these features as a whole.	4	5.25	.5

QUESTION 4: Of the lessons taught by the simulator, which ones did you feel were particularly effective?

One interviewee (an instructor) indicated that the lessons involving troubleshooting (identifying faulty components) were more effective than lessons involving removal and replacement of components. He stated that the effectiveness of certain remove and replace tasks (i.e., starter motor) was reduced because the physical fidelity of the simulator was somewhat less than optimal. He also noted that lessons dealing with components that were represented in the simulator (oil pump) were more effective than lessons dealing with components that were not represented in the simulator (i.e., the driver's compartment).

Ratings made by the interviewees are presented below:

RATING (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these lessons as a whole.	4	4.75	.5
Rate the potential training value of these lessons as a whole.	4	4.5	.58

QUESTION 5: Of the lessons taught by the simulator, which ones did you feel were ineffective?

Several interviewees stated that the lessons dealing with the STE/ICE kit were ineffective. They stated that lessons involving STE/ICE did not include the "set-up and check-out" procedures that are normally presented during conventional training.

QUESTION 6: Were there any occasions when you felt that the difficulty level of the material being presented by the simulator was above the students?

None of the interviewees felt that any of the material presented to students was too difficult for the students to understand.

QUESTION 7: Were there any occasions when you felt that the difficulty level of the material being presented by the simulator should be increased?

Interviewees identified three areas where the difficulty level of the presented material should be increased. First, interviewees stated that the materials presented on the slide projector unit were too simplistic. They felt that materials presented on the projector would be more useful if they illustrated aspects of the engine that are not normally seen on operational equipment (i.e., leaking oil lines). Second, the interviewees indicated that certain remove/replace tasks were presented in a simplistic manner. One interviewee noted that the remove/replace starter motor lesson was too easy for students because the 3-D module provided easy access to this component. Another interviewee noted that remove/replace tasks on the simulator were too simplistic because these lessons did not require students to apply appropriate levels of torque when tightening bolts. The third area mentioned by interviewees concerns the use of TMs. Several interviewees stated that tasks were simplified because simulator lessons indicated precise TM page and paragraph numbers. They felt that training would have been improved if the students had been trained to find the correct TM pages for themselves.

QUESTION 8: What hardware features of the simulator made it more effective than conventional training?

Interviewees generally agreed on the features of the simulator that made it more effective than conventional training. They indicated that malfunctions could be inserted into the simulator much more easily than they could be inserted into operational equipment. One interviewee noted that certain malfunctions inserted into the simulator could not be inserted into the operational equipment without considerable damage to the equipment (e.g., an oil pump failure).

The interviewees also agreed that the low voltages present in the simulator significantly reduced the possibility that students would injure themselves during training. The hardcopy printout was another feature that interviewees mentioned. One interviewee stated that it was effective to use this printout when debriefing students. Consistent presentation of material to students was also mentioned as a feature of the simulator that made simulator training more effective than conventional training.

Ratings made by the interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	4	4.25	.5
Rate the potential training value of these features as a whole.	4	4.75	.5

QUESTION 9: What were the features that made this simulator easy for the instructors to operate?

Several interviewees stated that training sessions conducted with the simulator were simplified because of the easy access to components of the 3-D module. They noted that when training sessions are conducted with operational equipment, components may not be clearly seen or reached by students.

The interviewees who felt that the editing system was applicable to the school's training course (Question 1) felt that the system made the simulator easy to operate. They noted that lessons could be easily changed with this system. The instructor CRT and instructor panel were also cited by the interviewees as facilitating operation of the simulator.

Ratings made by the interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	4	5.5	.58
Rate the potential training value of these features as a whole.	3	5.3	.58

QUESTION 10: What were the features that made this simulator easy for students to operate?

There were very few responses to this question. Interviewees had many comments on the features that made the simulator difficult for the students to operate (see Question 12), but few comments on features that facilitated student performance. When responses were made, the interviewees agreed that students' interaction with the simulator was facilitated because the module allowed easy access to components, it faithfully represented the physical and functional characteristics of the operational equipment, and it was not a safety hazard.

Interviewees also felt that the student guidebooks helped students complete lessons successfully. This statement contrasts with the instructor who felt that student guidebooks were not useful for tasks six and nine (see Question 5, page 10).

Ratings made by the interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	4	4.25	.96
Rate the potential training value of these features as a whole.	4	5.25	.5

QUESTION 11: What aspects of the device would be appropriate for substituting for actual equipment?

The interviewees agreed that the 3-D module could be substituted for operational equipment. Several of them also stated that the question was difficult to answer since they felt it would be impossible to substitute specific features of the device for the operational equipment without substituting the entire device. It appeared that the interviewees then interpreted the question to read "What aspects of the device make it appropriate for substituting for actual equipment?". Bearing this interpretation in mind, the interviewees indicated that the ability to insert a variety of malfunctions into the simulator, the accessibility of simulator components, and the decreased probability of student injury on the simulator made the device substitutable for actual equipment.

Ratings made by the interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	4	4.25	.96
Rate the potential training value of these features as a whole.	4	5.25	.5

QUESTION 12: What types of problems did the students have?

One of the interviewees did not respond to the question as he did not work with students. The remaining interviewees listed a variety of problems experienced by students.

The slide projector unit was seen as unreliable by several interviewees. One interviewee stated that numerous delays in training were caused by this unit's tendency to overheat and melt slides. The interviewees felt that students were confused by the variety of materials that required their attention. One interviewee noted that students had to attend to the student CRT, the slide projector unit, the 3-D module, the student responder panel, TMs, a student guidebook, and a list of potential malfunctions. Interviewees felt that the student responder panel was difficult for students to understand. They indicated that students spent too much time trying to enter their responses into the device. Interviewees indicated that during lengthy troubleshooting procedures, little feedback was provided to students. Consequently, students did not know if they were following procedures correctly. Another interviewee noted that when feedback was present it provided too little information to be of value to students. One interviewee noted that some sections of the student guidebook did not follow the information presented in TMs or information presented on the student CRT and the slide projector unit. The interviewee went on to say that when students were confused, the simulator did not afford them the opportunity to repeat a step without seeking the assistance of an instructor. As was noted previously, the interviewees stated that students experienced difficulty with lessons involving STE/ICE because these lessons did not include procedures required to set up and check out this equipment.

QUESTION 13: How would you employ the simulator in order to gain maximum benefit from it?

Several interviewees stated that the highly skilled 63B30 students would not benefit from the remove/replace lessons as much as students who were less skilled. They stated that remove/replace tasks are more appropriate for "10" level students and less appropriate for "30" level students. The interviewees stated that the "30" level students should only use the simulator for refresher training or for testing purposes.

Several interviewees stated that the simulator should be used in conjunction with operational equipment in order for students to experience the increased difficulties associated with removing and replacing components from the operational equipment.

Ratings made by the interviewees for the simulator as a whole are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of the simulator as a whole.	4	4.75	.5
Rate the potential training value of the simulator as a whole.	4	5.25	.5

Data Collector Observations. During the transfer-of-training experiment, the data collector was able to make a variety of observations about the operation of the simulator. These observations are summarized below:

- o Electrical sensors on the 3-D engine module enabled the computer to assess the student's progress through a remove/replace lesson. These sensors were overly sensitive, however, and produced erroneous data on the student's performance record. Students were confused by such errors on their performance record.

- o The slide projector unit frequently overheated, jammed, and melted slides. Problems with this unit caused numerous delays in the training program.

- o Instructors repeatedly warned students that nuts and bolts could only be hand tightened because the device was delicate. Despite this warning, students occasionally stripped threads when attempting to remove or replace a component on the 3-D module.

- o In general, the 3-D module is a high fidelity representation of a diesel engine. Certain components, however, are not represented in the simulator and, in some cases, the absence of these components seriously affected training. For example, students can remove/replace the starter motor on the simulator much more easily than they can on operational equipment because certain obstacles (the propeller shaft, frame) are not represented on the simulator. Students trained to perform this task using the simulator experience difficulty performing the task on operational equipment.

- Sound effects present during training sessions helped to maintain students' motivation.

- The editing system is very flexible. Instructors could have completely reorganized simulator lessons if they had desired to do so.

- Students find the student responder panel difficult to operate.

- Students were frequently confused by the considerable number of stimuli to which they were required to attend. Students attended to the CRT, slide projector unit, 3-D module, responder panel, TMs, and student guidebook.

Discussion

Although the quantity of data reported for Experiment 1 is considerable, analysis of this data is .implified since many of the comments made by different individuals in response to different questions are quite similar. The data can be summarized by the four positive statements and the five negative statements about the simulator that are discussed below.

Positive Statements. Instructors, course developers, and trainees hold favorable opinions of the Seville/Burtek simulator. Instructors indicated that they had little difficulty learning to operate the simulator. They also felt that students trained with the simulator would be able to perform quite well on operational equipment. Course developers indicated that the tasks addressed by the simulator curriculum were critical and that students trained with the simulator would perform well on operational equipment. Trainees indicated that they enjoyed working with the simulator, and they felt well-prepared to perform troubleshooting tasks on operational equipment.

Ease of inserting malfunctions is a valuable device feature. Instructors and course developers appreciated the fact that a variety of malfunctions could be inserted into the simulator with minimal effort. Further, they praised the device for its ability to simulate faults that could not be induced in operational equipment.

Performance monitoring is a valuable device feature. Instructors and trainees indicated that training was facilitated because they could identify student errors as they were being committed. Instructors also praised the hardcopy printout of student performance for its value when debriefing students.

The simulator is safer than operational equipment. Both instructors and course developers noted that students were less likely to injure themselves on the simulator than on operational equipment because low voltages are present in the simulator.

Negative Statements. Students were confused by the materials to which they must attend. Instructors, course developers, and the data collector indicated that students did not always attend to the correct stimulus during training because there were numerous potential sources of information.

Physical fidelity of the 3-D module is too low for certain remove/replace tasks. Instructors, course developers, and the data collector felt that while the easy access to components found on the 3-D module was beneficial, certain remove/replace tasks were too simplistic because students did not have to maneuver around obstacles that are present on operational equipment.

The reliability and durability of the simulator should be improved. Many individuals noted that the slide projector unit failed repeatedly and that components of the 3-D module could not withstand with rigors of normal use.

Lessons should have included procedures for set up and check out of the STE/ICE kit. Although several lessons contained minor procedural errors, statements made by instructors, students, course developers, and the data collector indicated that the exclusion of the STE/ICE set-up and check-out procedures from the simulator curriculum significantly decreased the training value of the simulator.

The 3-D module is too sensitive. Instructors, students, and the data collector indicated that minor vibrations that normally accompany remove/replace operations are recorded as errors.

Experiment 2

Forty-one (41) students from the 63W10 MOS (Direct Support Vehicle Repairman) were trained to troubleshoot, remove, and replace an oil pump using either conventional methods (20 students) or the Seville/Burtek simulator (21 students). Students were then tested on their ability to perform this task on operational equipment. Data consist of responses to questionnaires and structured interviews, as well as various observations made by the on-site data collector during the course of the experiment.

Method

Subjects. Characteristics of subjects who provided data are as follow:

- o Initial instructor questionnaire. Three NCOs who were instructors for the 63W10 MOS completed the questionnaire.
- o Instructor questionnaire. This questionnaire was completed by one of three instructors described above.
- o Trainee questionnaire. Twenty-one (21) MOS 63W10 students who had received training with the Seville/ Burtek simulator completed this questionnaire after

they had been tested on their ability to perform a troubleshooting task on operational equipment. The questionnaire was also completed by 46 students who had been trained with the simulator, but had not been tested on their ability to perform a troubleshooting task on the operational equipment due to constraints encountered during the course of the experiment.

- Structured interview. An interview was conducted with a 63W10 MOS instructor. In addition, three of the individuals interviewed in Experiment 1 (two course developers and the on-site data collector) made comments that were applicable to the 63W10 MOS. Relevant comments made by these individuals are reported in this experiment.

Materials. The questionnaires and structured interview form used in this experiment were identical to those used in Experiment 1 (see Appendix A).

Procedure. The procedure used in Experiment 2 was highly similar to that used in the first experiment. It can be summarized as follows:

- Subjects were briefed before responding to questionnaires or interview questions.

- Initial instructor questionnaires were completed in a group setting after instructors were familiar with the simulator.

- An instructor questionnaire was completed for each of 22 tasks addressed by simulator lessons.

- Course developer questionnaires were not completed.

- Trainees responded to questionnaires after training sessions were completed (for trainees who were not subsequently tested on operational equipment) or after training and testing were completed.

- Structured interviews were conducted on an individual basis after transfer-of-training data had been collected.

Respondents commented on specific features of the Seville/Burtek device- These features are described in Table 2. The 3-D module on which the MOS 63W10 students were trained was identical to the 3-D module on which the 63B30 students were trained.

Results

Initial Instructor Questionnaire. As indicated by the responses to Question 1, 63W10 instructors experienced few problems learning to operate the simulator.

QUESTION 1: How easy or hard is it to learn to use the simulator?
RATINGS: 1 = very hard, 5 = very easy
N = 3

Response	Number of Responses
VERY EASY	1
FAIRLY EASY	2
AVERAGE	0
FAIRLY HARD	0
VERY HARD	0
TOTAL	3

The mean rating for all instructors was 4.33 (standard deviation = .58).

QUESTION 2: Why did you answer Question 1 as you did?

One instructor stated that the training sessions conducted by representatives of Seville/Burtek were very helpful. The other instructors felt that the procedures for operating the simulator could be learned easily since these procedures were not complicated.

QUESTION 3: How do you feel about the simulator?
RATINGS: 1 = dislike it very much, 5 = like it very much
N = 3

Response	Number of Responses
LIKE IT VERY MUCH	1
LIKE IT SOMEWHAT	2
NO STRONG FEELINGS ABOUT IT	0
DISLIKE IT SOMEWHAT	0
DISLIKE IT VERY MUCH	0
TOTAL	3

The mean rating for all instructors was 4.33 (standard deviation = .58).

QUESTION 4: Why did you answer Question 3 as you did?

All instructors liked the simulator because it was easy to operate.

QUESTION 5: Please make any additional comments you feel are appropriate.

One instructor was initially skeptical about the device, but after completing the operator's training course, he had a favorable opinion of the simulator because it was simple to operate.

Instructor Questionnaire. One instructor and one student worked together to complete 22 lessons presented on the Seville/Burtek simulator. The instructor filled out a questionnaire after each lesson had been completed. Responses to the five questions that appeared on the 22 questionnaires are summarized below.

QUESTION 1: How well does the simulator train this task?
RATINGS: 1 = very poorly, 5 = very well
N = 1

Response	Number of Responses
VERY WELL	19
MODERATELY WELL	1
FAIR	2
POORLY	0
VERY POORLY	0
TOTAL	22

The mean rating for all tasks was 4.77 (standard deviation = .61). Raw data are presented in Table C-1.

QUESTION 2: Why did you answer Question 1 as you did?

Other than indicating that the exercises were "very good," the instructor made no specific comments about why tasks were rated so highly. He indicated that lower ratings were given to tasks that were redundant or too simple.

QUESTION 3: What specific features of the simulator (involved in this task) do you like or dislike?

The instructor found it easy to follow the lessons and liked the clean work environment (i.e., no oil, dirt, etc.).

QUESTION 4: Why do you like or dislike these features?

QUESTION 5: Please make any additional comments you feel are appropriate.

The instructor made no relevant responses to these questions.

Trainee Questionnaire. Responses of the 21 students who were tested on operational equipment are reported separately from the responses of the 46 students who were not tested on operational equipment.

QUESTION 1: How do you feel about the simulator?
RATINGS: 1 = dislike it very much, 5 = like it very much

Response	Number of Responses	
	Students Tested (N = 21)	Students Not Tested (N = 46)
LIKE IT VERY MUCH	10	31
LIKE IT SOMEWHAT	8	10
NO STRONG FEELINGS ABOUT IT	1	3
DISLIKE IT SOMEWHAT	2	0
DISLIKE IT VERY MUCH	0	2
	TOTAL 21	TOTAL 46

The mean rating for students who were tested was 4.24 (standard deviation = .94). The mean rating for students who were not tested was 4.48 (standard deviation = .96).

QUESTION 2: Why did you answer Question 1 as you did?

Students who were tested on operational equipment and rated the simulator highly did so for a number of reasons. Step-by-step instructions for completing lessons and performance feedback were features most frequently noted. Students also liked the simulator because it was easy to use, safe, fun to operate, and clean. One student who did not rate the simulator highly felt that it was not appropriate for use with entry level soldiers. Other students who indicated that they disliked the simulator provided no specific explanation for their opinions.

The 41 students who were not tested on operational equipment, and who rated the simulator highly, liked the device because it was faster, cleaner, safer, and easier to operate than actual equipment. They also liked the device because it provided feedback and useful illustrations on the slide projector unit. The two students who gave the simulator a poor rating stated that they did not understand how to operate the device.

QUESTION 3: What specific features of the simulator do you like or dislike?

Students who were tested on their ability to troubleshoot a task on operational equipment liked the hardcopy printout, feedback, and the slide projector unit. These students did not like the sensitivity of the 3-D module, the low fidelity representation of certain (unspecified) components, and the confusion that results from trying to attend to many sources of information.

Students who were not tested on operational equipment responded to this question in a manner similar to students who were tested. They liked the hardcopy printout, feedback, and the slide projector unit. These students also liked the fact that the 3-D module looked, sounded, and functioned like a diesel engine. Two students liked the fact that the simulator was simple to operate. Students disliked the sensitivity of the 3-D module.

QUESTION 4: Why do you like or dislike these features?

Students in both groups liked the hardcopy printout and feedback because these features allowed them to determine when they were committing errors. Students liked the slide projector unit because the diagrams and photographs presented on this unit were superior to the materials presented in the TMs. The sensitivity of the 3-D module was disliked by students because its sensors recorded minor movements and vibrations as student errors.

QUESTION 5: Please make any additional comments you feel are appropriate.

Many students (both tested and untested) enjoyed working with the simulator. They also stated that they desired additional training with the simulator.

Structured Interview. Responses to the 13 questions that were posed during the structured interview are presented below.

QUESTION 1: What were the instructional features of the simulator that were applicable to the school's training course?

The 63W10 MOS instructor stated that the 3-D module was applicable to the school's training course since it allowed students to gain hands-on experience during training. He stated that the ability to quickly insert malfunctions into the 3-D module was one of the outstanding features of this simulator.

He also felt that feedback provided to students and instructors was very useful since these features allowed students to complete lessons with minimal instructor intervention. This comment contrasts with the statement of the interviewee in Experiment 1 (page 13) who felt that feedback confused students at times.

Other features of the simulator that the instructor found to be applicable include flexible arrangement of lessons, remove/replace capability, editing system, slide projector unit, self-paced method of instruction, and random malfunction selection. Most of the interviewees in Experiment 1 did not think the random malfunction selection feature was applicable.

Ratings made by the instructor are presented below:

RATINGS (1 = None, 7 = Highest)	N	RATING
Rate the training value of the features as a whole.	1	6
Rate the potential training value of the features as a whole.	1	7

QUESTION 2: What were the instructional features of the simulator that were not applicable to the school's training course?

The instructor stated that the lessons involving the STE/ICE kit were inapplicable because they did not include instructions for set up and check out of this equipment. He noted that it was particularly important for MOS 63W10 students to learn the set-up/check-out procedure because they had no previous experience with STE/ICE.

Two individuals interviewed during Experiment 1 made responses to this question that are appropriate for inclusion in this experiment. The on-site data collector felt that the 3-D module was not applicable to the 63W10 MOS because the module simulated an engine that was not addressed in the curriculum of conventionally trained students. A course developer stated that the remove/replace capability was of limited value to 63W10 students since they are primarily involved with troubleshooting tasks.

QUESTION 3: Which features of the lesson presentation helped make the simulator lessons interesting to the students?

The instructor indicated that there were several features that maintained students' interest in the lesson. He stated that students found the 3-D module (and associated sound effects) very interesting. The instructor felt that high physical and functional fidelity and low probability of student injury were factors that contributed to the students' interest in the 3-D module. Information presented on the student CRT was seen as maintaining student interest since this information directed students to perform specific actions, and it provided them with feedback about these actions. The instructor felt that students were interested in the materials presented by the slide projector. He added, however, that students lost interest in lessons when this unit malfunctioned. Self-paced lesson presentation was an additional feature mentioned by the instructor. He noted that in conventional training, students lose interest in lessons when instructors present material to a group of students at a rate suited only to the most advanced student. The instructor felt that this problem would not occur with the self-paced lessons presented on the Seville/Burtek device.

Ratings made by the instructor are presented below:

RATINGS (1 = None, 7 = Greatest)	N	RATING
Rate the training value of these features as a whole.	1	7
Rate the potential training value of these features as a whole.	1	7

QUESTION 4: Of the lessons taught by the simulator, which ones did you feel were particularly effective?

Although the instructor had completed most of the lessons presented by the training device, he stated that he did not recall the details of the lessons well enough to identify those that were particularly effective.

Ratings made by the instructor are presented below:

RATINGS (1 = None, 7 = Greatest)	N	RATING
Rate the training value of these lessons as a whole.	1	7
Rate the potential training value of these lessons as a whole.	1	7

QUESTION 5: Of the lessons taught by the simulator, which ones did you feel were ineffective?

The instructor stated that lessons involving the STE/ICE kit need improvement. He also indicated that certain (unspecified) lessons would be more effective if they were more detailed.

QUESTION 6: Were there any occasions when you felt that the difficulty level of the material being presented by the simulator was above the students?

The MOS 63W10 instructor felt that students experienced difficulty using TMs. He indicated that many of the problems students experienced in this area were due to the students' poor reading skills. This same comment about MOS 63W10 students was made by one of the individuals interviewed in Experiment 1. Another individual interviewed in Experiment 1 stated that the material presented by the simulator was more appropriate for students with more advanced skills (MOS 63B30) than it was for students with basic skills (MOS 63W10).

The 63W10 instructor also stated that the students found it difficult to operate the simulator. He indicated that problems experienced by students operating the device arose because students were provided too brief an orientation to the simulator. This orientation was abbreviated because School administrators required students to complete training in the least amount of time feasible.

QUESTION 7: Were there any occasions when you felt that the difficulty level of the material being presented by the simulator should be increased?

The instructor felt that students would become confused if any of the lessons were more difficult.

QUESTION 8: What hardware features of the simulator made it more effective than conventional training?

Four hardware features were mentioned by the instructor. The 3-D module was thought to be more effective than operational equipment because students have easy access to components, and because students can learn to troubleshoot the electrical system without fear of receiving an electrical shock. The instructor did not indicate that the benefits of easy access to components may have been offset by the low physical fidelity of the 3-D module (as was indicated by the interviewees in Experiment 1).

The process of entering decisions into the student responder panel was described as more effective than conventional training methods because simulator-trained students are forced to enter their decisions into this unit, whereas students trained conventionally may not be cognizant of the specific decisions they make when troubleshooting. This comment does not indicate that the student responder panel is easy to use. Rather it indicates that this unit requires students to think about the troubleshooting process and make troubleshooting decisions in order to progress through a lesson. Students may progress through conventional training without giving much thought to the troubleshooting process. The instructor felt that the information provided by the instructor CRT and the hardcopy printout made the simulator more effective than conventional training since they allowed the instructor to monitor actions performed by the student.

Ratings made by the instructor are presented below:

RATINGS (1 = None, 7 = Greatest)	N	RATING
Rate the training value of these features as a whole.	1	4
Rate the potential training value of these features as a whole.	1	5

QUESTION 9: What were the features that made this simulator easy for the instructor to operate?

The instructor stated that the simulator could be operated easily by entering commands on the instructor panel. He felt that malfunctions could be inserted easily into the 3-D module and that the device allowed great flexibility in the sequence in which lessons were presented. He noted that the limited durability of remove/replace components, and the poor reliability of the slide projector unit made the simulator difficult to operate.

Ratings made by the instructor are presented below:

RATINGS (1 = None, 7 = Greatest)	N	RATING
Rate the training value of these features as a whole.	1	6
Rate the potential training value of these features as a whole.	1	7

QUESTION 10: What were the features that made this simulator easy for the students to operate?

The instructor felt that the student guidebook and the accessibility of components on the 3-D module made the simulator easy for students to operate.

Ratings made by the instructor are presented below:

RATINGS (1 = None, 7 = Greatest)	N	RATING
Rate the training value of these features as a whole.	1	5
Rate the potential training value of these features as a whole.	1	4

QUESTION 11: What aspects of the device would be appropriate for substituting for actual equipment?

The instructor felt that the 3-D module could be substituted for actual equipment. The ease of inserting malfunctions into this module was mentioned as being one of its most valuable features. The instructor stated that substitution of the 3-D module for operational equipment should not be complete. He felt that students also needed exposure to operational equipment during training.

Other features that the instructor felt were substitutable for operational equipment include the hardcopy printout, slide projector unit, and flexible lesson presentation.

Ratings made by the instructor are presented below:

RATINGS (1 = None, 7 = Greatest)	N	RATING
Rate the training value of these features as a whole.	1	6
Rate the potential training value of these features as a whole.	1	7

QUESTION 12: What types of problems did students have?

The instructor felt that the most serious problem experienced by students was the fragile nature of components that were removed/replaced from the 3-D module. He indicated that students were not trained to apply appropriate amounts of force when removing/replacing components. Further, he noted that time required to repair damaged helical coils, bolts, electrical contacts, and fittings decreased the amount of time available to train students.

QUESTION 13: How would you employ the simulator in order to gain maximum benefit from it?

The instructor stated that the Seville/Burtek simulator would be maximally effective if it were used in conjunction with operational equipment to train 10, 20, and 30 level students. He felt that the student/instructor ratio should be no greater than two to one. The instructor indicated that the device would be appropriate for the direct support and organizational levels of maintenance, but not for the general support and depot levels of maintenance.

Ratings made by the instructor for the device as a whole are presented below:

RATINGS (1 = None, 7 = Greatest)	N	RATING
Rate the training value of the simulator as a whole.	1	6
Rate the potential training value of the simulator as a whole.	1	6

Data Collector Observations. Information about the operation of the simulator recorded by the data collector is identical for 63W10 and 63B30 students. Since this data has been reported for 63B30 students in Experiment 1, it will not be reported for 63W10 students.

Discussion

A series of positive and negative statements about the Seville/Burtek device are presented in light of the data presented above.

Positive Statements. Instructors and trainees hold favorable opinions of the Seville/Burtek device. Instructors indicated that the device was easy to operate and that it did a very good job of training students to perform troubleshooting tasks. Students stated that they enjoyed working with the simulator and that they desired additional training with the simulator.

Students and the instructor liked a number of device features. Students repeatedly stated that they enjoyed working on the simulator because it provided performance feedback, step-by-step instructions for accomplishing tasks, and a slide projector unit that helped them to identify engine components. The 63W10 instructor liked many features, in particular, the device's performance feedback and the ease of inserting malfunctions into the 3-D module.

Negative Statements. Lessons should have included procedures for set up and check out of the STE/ICE kit. The 63W10 instructor felt that the lack of set-up and check-out procedures for STE/ICE impaired student performance because students had no prior experience with STE/ICE.

The 3-D module is too sensitive. Students and the instructor disliked the fact that minor vibrations that normally accompany remove/replace tasks were recorded as errors.

The durability of the simulator is low. The 63W10 instructor felt that the device could not withstand rigorous use.

Experiment 3

Twenty-two (22) students from the 63H30 MOS (Direct Support Maintenance Supervisor) were trained to troubleshoot the starting and charging system of an M110A2 self-propelled howitzer using either conventional methods (12 students) or the Grumman simulator (10 students). Students were then tested on their ability to perform this task on operational equipment. Data consist of responses to questionnaires and structured interviews, as well as observations made by the on-site data collector during the course of the experiment.

Method

Subjects. Characteristics of subjects who provided data are as follows:

- Initial instructor questionnaire. Five NCOs who were instructors for the 63H30 and 63D30 MOSs completed the questionnaire.

- Instructor questionnaire. Questionnaires were completed for each of the lesson segments presented by the device. See Table 4 for a description of lesson segments. Four NCOs who were instructors for the 63H30 and 63D30 MOSs completed questionnaires. In order to collect additional data, two other individuals knowledgeable about the device (a civilian training specialist and the project liaison officer) also completed the questionnaire.

- Course developer questionnaire. This form was completed by an individual responsible for creating and modifying curricula for the 63H30 and 63D30 MOSs. In order to collect additional data, this form was also completed by two other individuals knowledgeable about the device (a civilian training specialist and the project liaison officer).

- Trainee questionnaire. Ten 63H30 students who received training with the Grumman device completed this questionnaire after they were tested on their ability to perform a troubleshooting task on operational equipment. The questionnaire was also completed by five students who were trained with the simulator, but were not tested on their ability to perform a troubleshooting task on operational equipment.

- Structured interview. Three instructors for the 63H30 and 63D30 MOSs, the project liaison officer, and the on-site data collector were interviewed.

Materials. The questionnaires and structured interview form used in this experiment were identical to those used in Experiments 1 and 2. (See Appendix A.)

Table 4

Grumman Simulator Lessons and Segments

Lesson	Segments
Introduction	0: Introduction, Part 1
	1: Introduction, Part 2
1	2: Vehicle Test Meter (VTM) Set-up and Check-out Tutorial
	3: VTM Set-up and Check-out Exercise
2	4: Introduction to the Starting System
	5: Starting System Problem, Part 1 (VTM Set up and Check out)
	6: Starting System Problem, Part 2 (Troubleshooting a Defective Transmission Neutral Position Switch)
3	7: Charging System Problem 1 (Defective Lead 1)
	8: Charging System Problem 2 (Defective Voltage Regulator)
	9: Charging System Problem 3 (Defective Generator)

Procedure. The procedure followed for Experiment 3 was similar to the procedure reported for the first two experiments. The procedure is summarized below:

- Subjects were briefed before responding to questionnaires or interview questions.
- Initial instructor questionnaires were completed in a group setting after instructors were familiar with the simulator.
- Subjects were asked to complete an instructor questionnaire for each of the nine segments listed in Table 4.
- Subjects were asked to complete course developer questionnaires for each of the nine segments listed in Table 4.
- Trainees responded to questionnaires after training sessions were completed (for trainees who were not subsequently tested on operational equipment) or after training and testing were completed.
- Structured interviews were conducted on an individual basis after transfer-of-training data had been collected.

Several questions asked respondents to comment on specific features of the Grumman simulator. In order to clarify responses to these questions, brief descriptions of the major features of the Grumman device are presented in Table 5.

Results

Initial Instructor Questionnaire. Responses to this questionnaire are summarized below.

QUESTION 1: How easy or hard is it to learn to use the simulator?
RATINGS: 1 = very hard, 5 = very easy
N = 5

Response	Number of Responses
VERY EASY	2
FAIRLY EASY	0
AVERAGE	3
FAIRLY HARD	0
VERY HARD	0
TOTAL	5

The mean rating for all instructors was 3.8 (standard deviation = 1.1).

Table 5

Description of Grumman Device Features

Feature	Description
Video disc system	Still frames, motion frames, and computer-generated text were presented by this system on the student CRT unit in order to direct student actions and provide feedback.
Touch panel	Students entered their decisions into the training device by touching certain locations on the student CRT that display words (yes, no, etc.), pictures (master switch, instrument switch, etc.) or schematics.
Request help	Many frames presented by the video disc player allow students to request help by touching the CRT. Help is presented in the form of audio and/or visual cues.
Repeat lesson	At certain predetermined points in the training program, students may choose to repeat segments, or parts of segments.
Call instructor	When students make two consecutive errors, the device ceases to accept student input and the student receives a message to call an instructor.
Sound effects	Various engine sounds (cranking, idle, shut-down) were simulated in the M110A2 howitzer configuration.
Hardcopy printout	A record of student performance could be printed after a lesson was completed.
Automated pre-lesson check	Prior to starting a lesson, the device checks to ensure that all switches, cables, etc. of the 3-D module are in the correct configuration. Instructions for correcting erroneous configurations are presented on the student CRT.
Lesson arrangement	Students normally complete lessons in a fixed sequence. The training device keeps track of the segments that a student has completed, presenting the appropriate segment each time a student works with the device.
Universal instructor	This feature allows instructors to present segments in any sequence; however, no record of student performance is kept when this feature is enabled.
Instructor CRT	Information about the video disc system is presented on the instructor CRT when students participate in lessons on the simulator.

Note: The 3-D module of the Grumman simulator for the 63H3D and 63D30 MOSs (Experiments 3 and 4) consists of controls, displays, test equipment, and components of the starting and charging system for the M110A2 self-propelled howitzer.

The 3-D module of the Grumman device used by MOSs 24E, 24G, and 24R (Experiment 6) is a full-scale reproduction of an Improved Hawk High Power Illuminator Radar transmitter unit. The 3-D module is composed of a cabinet, interior components (cables, power supplies, etc.), controls, displays, and test equipment.

QUESTION 2: Why did you answer Question 1 as you did?

Instructors indicated that although procedures for operating the device were not complicated, device malfunctions detracted from instructor training sessions.

QUESTION 3: How do you feel about the simulator?
RATINGS: 1 = dislike it very much, 5 = like it very much
N = 5

Response	Number of Responses
LIKE IT VERY MUCH	0
LIKE IT SOMEWHAT	2
NO STRONG FEELINGS ABOUT IT	1
DISLIKE IT SOMEWHAT	1
DISLIKE IT VERY MUCH	1
TOTAL	5

The mean rating for all instructors was 2.8 (standard deviation = 1.3).

QUESTION 4: Why did you answer Question 3 as you did?

The instructors generally agreed that the lessons presented on the simulator were too simple for the 63H30 students. They suggested that it may be more appropriate to use the simulator to train entry level students. One instructor disliked the simulator very much because the lessons did not adequately describe how to use the STE/ICE kit during troubleshooting tasks.

QUESTION 5: Please make any additional comments you feel are appropriate.

Most of the instructors indicated that the lessons did not adequately describe how to use the STE/ICE kit when troubleshooting. They indicated that the lessons showed students how the STE/ICE kit could be used as a volt/ohm meter, but they did not describe the other capabilities of this equipment.

<u>Instructor Questionnaire</u>. Data reported for the instructor questionnaire are based on the responses of instructors and other individuals knowledgeable about the Grumman simulator and the 63H30 MOS. The tasks rated by instructors are refered to by simulator lesson segments.

QUESTION 1: How well does the simulator train this task?
RATINGS: 1 = very poorly, 5 = very well
N = 6

Response	Number of Responses
VERY WELL	7
MODERATELY WELL	12
FAIR	9
POORLY	13
VERY POORLY	4
TOTAL	45

The mean rating for all lesson segments was 3.1 (standard deviation = 1.25). Raw data are presented in Table D-1.

QUESTION 2: Why did you answer Question 1 as you did?

Respondents provided low ratings for those segments (6, 7, 8, and 9) in which the simulator repeatedly "locked up" (would not register student actions or advance to the next step). Respondents gave low ratings to segments that presented incorrect procedures and segments that progressed at a slow rate. The first few segments (0-3) were rated relatively highly because they were well-prepared.

QUESTION 3: What specific features of the simulator (involved in this task) do you like or dislike?

Respondents liked the instructor station, the 3-D module, the color video displays, the audio track that accompanied the video presentation, the fact that students could make errors without damaging equipment, and the interaction between the student and simulator. Respondents disliked the frequency with which the device malfunctioned, the low fidelity of the 3-D module, the rate at which lessons were presented, the inability to skip parts of a lesson, the inability to repeat lessons, and various procedural errors in the lessons.

QUESTION 4: Why do you like or dislike these features?

One respondent liked the interaction between the student and the simulator because it promoted learning. Respondents who liked the 3-D module indicated that it was realistic and gave students "hands-on" troubleshooting experience. Other respondents, however, disliked aspects of the 3-D module. One respondent felt that the W5 cable of the STE/ICE kit was not a high fidelity representation of the operational equipment. Another respondent stated that it was difficult to understand the interrelationship of components found on the simulator. Other (unspecified) features were disliked because they wasted time and did not promote learning.

QUESTION 5: Please make any additional comments you feel are appropriate.

One respondent noted that in Segment 2, students were not instructed to visually inspect the VTM (a STE/ICE component) prior to hook-up. This respondent also stated that the simulator needed to be completely revised. Another respondent felt that students accepted the lessons because they could interact with the simulator. One respondent stated that the simulator was a very poorly designed piece of equipment. One respondent felt that, for Segment 7, the task was taught incorrectly and would confuse students. Another respondent stated that students were not taught how to start the engine in Segment 1.

Course Developer Questionnaire. Responses were made by one course developer and two other individuals who were knowledgeable about the Grumman device.

QUESTION 1: Is this a critical task which needs to be trained?
RESPONSES: Yes, No
N = 3

Response	Number of Responses
YES	15
NO	4
TOTAL	19

Respondents indicated that all segments, except Segments 0 and 6, addressed critical tasks that should be trained. Segment 0 is an introduction to AMTESS, while Segment 6 addresses troubleshooting a defective transmission neutral position switch. Raw data are presented in Table D-2.

QUESTION 2: Is this task currently trained on operational equipment?
RESPONSES: Yes, No
N = 3

Response	Number of Responses
YES	13
NO	6
TOTAL	19

Respondents agreed that Segment 0 (Introduction to AMTESS) and Segment 9 (Charging System Problem 3) were not taught on operational equipment. Respondents did not agree on whether Segments 6 and 7 were taught on operational equipment. Raw data are presented in Table D-3.

QUESTION 3: How difficult is it to perform this task?
RATINGS: 1 = very easy, 5 = very difficult
N = 3

Response	Number of Responses
VERY DIFFICULT	0
SOMEWHAT DIFFICULT	2
ABOUT AVERAGE IN DIFFICULTY	6
SOMEWHAT EASY	6
VERY EASY	5
TOTAL	19

The mean rating for all tasks was 2.26 (standard deviation = .99). Raw data are presented in Table D-4.

QUESTION 4: At what skill level should a trainee perform this task at the end of training?
RATINGS: 1 = novice, 5 = expert
N = 3

Response	Number of Responses
EXPERT	7
LESS THAN EXPERT	4
APPRENTICE	4
BETTER THAN NOVICE	3
NOVICE	1
TOTAL	19

The mean rating for all tasks was 3.68 (standard deviation = 1.29). Raw data are presented in Table D-5.

QUESTION 5: Please make any additional comments you feel are appropriate.

One respondent made five comments about Segment 5:

- o Form DA 2404 (Equipment Inspection and Maintenance Worksheet) appears on the student CRT and indicates that the engine will not crank. However, the 3-D module can be cranked by students.
- o Electrical wiring on the 3-D module, including STE/ICE, should be labeled clearly.
- o The lessons should be updated to reflect a new TM (9-4910-571-12&P).
- o The lessons should require students to check battery connections prior to using STE/ICE.
- o The instructor's CRT does not provide sufficient information.

Another respondent felt that Segment 6 presented appropriate troubleshooting procedures, but did not present underlying troubleshooting concepts. He also stated that the illustrations presented on the student CRT in Segment 4 helped students to learn about components of the electrical system.

Trainee Questionnaire. Responses of the ten students who were tested on operational equipment are reported separately from the responses of the five students who were not tested on operational equipment. Students who were not tested participated in all lessons presented by the simulator, while students who were tested only participated in a subset of these lessons (Segments 0, 1, 2, 3, and 8).

QUESTION 1: How do you feel about the simulator?
RATINGS: 1 = like it very much, 5 = dislike it very much

Response	Number of Responses	
	Students Tested (N = 10)	Students Not Tested (N = 5)
LIKE IT VERY MUCH	6	1
LIKE IT SOMEWHAT	3	0
NO STRONG FEELINGS ABOUT IT	0	1
DISLIKE IT SOMEWHAT	0	0
DISLIKE IT VERY MUCH	1	3
	TOTAL 10	TOTAL 5

The mean rating for students who were tested was 4.3 (standard deviation = 1.25). The mean rating for students who were not tested was 2.2 (standard deviation = 1.79).

QUESTION 2: Why did you answer Question 1 as you did?

Many students who were tested on operational equipment gave the Grumman simulator high ratings because they thought the device was a good training tool. One student who was tested disliked the simulator very much because error messages appeared on the student CRT when correct troubleshooting procedures had been followed.

In general, students who were not tested on operational equipment did not rate the simulator as highly as students who were tested. Students disliked the simulator very much because it malfunctioned frequently and because the lessons were too simple. One student rated the simulator highly because he felt it helped him understand troubleshooting procedures.

QUESTION 3: What specific features of the simulator do you like or dislike?

Students who were tested on operational equipment liked the "hands-on" experience with the 3-D module, the proceduralized instruction presented in the lessons, feedback provided to students about the correctness of their actions, and video frames that identified the engine components to which students should attend. These students did not like simulator malfunctions, the requirement to press "next" on the touch screen in order to progress through a lesson, wires on the 3-D module that were not labeled, and lessons that required the use of the M110A2 howitzer TM and the STE/ICE TM.

One student who was not tested liked the audio and video stimuli presented on the student monitor. Another student liked feedback and the simplicity of the device, but disliked the fact that students could input data faster than the device could accept it. Other students who were not tested did not like any of the features of the simulator.

QUESTION 4: Why do you like or dislike these features?

Two students who were tested and who liked proceduralized instruction felt that it was simple to follow and helped them to identify malfunctions. One student (tested) liked feedback because it identified student errors and reduced training time. Another student (tested) felt that unmarked cables were confusing and that the simulator was too time-consuming. No other comments about specific features were made by students who were tested.

Students who were not tested reiterated their dislike of the simulator because it malfunctioned frequently. One student disliked the lessons because they were too simple, while another student liked the information presented on the student monitor because it was simple.

QUESTION 5: Please make any additional comments you feel are appropriate.

In general, students who were tested indicated that they enjoyed working with the simulator. One student, however, felt that the Grumman simulator was worthless. Another student stated that the simulator wasted time and money. Other students stated that conventional lecture methods were as effective as the simulator and that the simulator should be drastically redesigned before it is accepted by the Army. One student indicated that students should receive training for additional tasks on the simulator.

Structured Interview. Responses to the 13 questions that were posed during the structured interview are presented below.

QUESTION 1: What were the instructional features of the simulator that were applicable to the school's training course?

Four interviewees felt that the 3-D module was applicable to the School's training course. One of these interviewees noted that components of the 3-D module looked and functioned like components found on the operational equipment. Another interviewee, however, stated that the STE/ICE component of the 3-D module did not perform as many functions as an operational STE/ICE kit.

Most interviewees felt that the video feedback presented on the student CRT was applicable. One interviewee indicated that the feedback allowed students to understand what they were doing, while another interviewee noted that the frequency of feedback decreased as students progressed through lessons. One interviewee criticized feedback because of the delay between students' actions and the arrival of feedback. Another interviewee criticized the feedback because students were not always provided a cue to attend to the student CRT when feedback was presented. This interviewee stated that instructors frequently had to tell students to attend to the CRT in order to receive feedback.

Three interviewees stated that audio feedback provided to students was "good." One of these respondents elaborated on his comment when he indicated that audio feedback allowed students to understand the results of their actions without having to read the student CRT.

Three respondents indicated that diesel engine sound effects were applicable. Two of these respondents stated that the sound effects added to the realism of the 3-D module. One respondent noted that additional sound effects were warranted (an engine cranking, but not starting).

Four interviewees felt that the hardcopy printout of student performance was applicable to the School's training course. One interviewee indicated that this feature provided instructors the capability to collect data on student performance. Another interviewee, however, indicated that while the printout was an excellent idea, it was of minimal value because it did not identify specific errors that students committed.

One interviewee stated that the editing capability of the Grumman device was applicable; however, he noted that none of the instructors who operated the device were trained to use the editing system (few were aware of its existence).

Three interviewees felt that the universal instructor feature was applicable because it allowed instructors to access different lessons in the simulator's curriculum. Two of these interviewees, however, felt that the utility of this feature was diminished because a printout of student performance is not provided when this feature is operational.

Three interviewees felt that the video disc system was applicable. One of these individuals felt that the combination of still and motion frames, computer-generated text, and an audio track were effective in maintaining students' motivation. One interviewee criticized this feature for the length of time required to search for frames. Another individual stated that the student CRT was too small and that instructors had to assume an awkward position in order to turn the video disc player on and off.

Three individuals agreed that the automated pre-lesson check was useful because it saved time for instructors and guaranteed that the device was in the correct configuration to present a lesson.

The "call instructor" feature was felt to be applicable by two interviewees. One interviewee felt that this feature was similar to the "tilt" feature of a pinball game, while another interviewee indicated that this feature helped students to follow correct troubleshooting procedures.

Three interviewees felt that self-paced lessons were applicable. One of these interviewees stated that this was one of the better features of the device. These same three individuals also felt that the request help feature was applicable.

Ratings made by interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	5	3	1
Rate the potential training value of these features as a whole.	5	4.4	1.14

QUESTION 2: What were the instructional features of the simulator that were not applicable to the school's training course?

Two respondents noted that the STE/ICE manual used in the simulator curriculum was obsolete.

The lessons addressing the generator and starter motor were seen as inapplicable by two interviewees because these lessons train students to perform troubleshooting procedures that are not used in conventional training sessions and are not used by soldiers in the field.

Four interviewees felt that the manner in which the lesson were arranged was inappropriate. Several interviewees stated that the sequence in which lessons were presented was inflexible.

One interviewee felt that the instructor CRT was inapplicable because he did not understand the information that was presented on the CRT when students were participating in lessons. Another interviewee indicated that the call instructor feature was not useful because it required an instructor to spend too much time clearing student errors. This interviewee felt it would be more appropriate for the device to handle all errors without requiring instructor intervention.

QUESTION 3: Which features of the lesson presentation helped make the simulator lessons interesting to the students?

Three interviewees felt that the self-paced nature of the lessons and the request help feature helped to maintain student interest. One interviewee stated that these features allowed students to ask for help, something they would not normally do during conventional training sessions.

Three interviewees stated that the video frames presented by the video disc system were interesting to students, while two interviewees stated that the audio track that accompanied the video presentation was of interest to students. The video presentation was fun to watch, while the audio presentation allowed students to learn troubleshooting procedures without requiring them to read.

Other features mentioned by interviewees included feedback to students, touch panel, request help, and the 3-D module.

Ratings made by interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	5	3.6	1.14
Rate the potential training value of these features as a whole.	5	5.4	.55

QUESTION 4: Of the lessons taught by the simulator, which ones did you feel were particularly effective?

Three interviewees felt that the introduction to AMTESS and Lesson 1 (set-up and check-out of the STE/ICE kit) were effective. One interviewee indicated that parts of all three lessons were effective because they provided students hands-on experience with the 3-D module.

Ratings made by interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these lessons as a whole.	5	3.2	.84
Rate the potential training value of these lessons as a whole.	5	4.8	1.1

QUESTION 5: Of the lessons taught by the simulator, which ones did you feel were particularly ineffective?

Interviewees generally agreed that the lessons that addressed troubleshooting the starting and charging system (Segments 4, 5, 6, 7, 8, and 9) were ineffective. Three interviewees felt that Segments 6 and 9 were particularly ineffective because these segments present troubleshooting procedures that students cannot use in the field.

One interviewee commented that the lessons should have trained students to use a multimeter rather than the STE/ICE kit. This interviewee also stated that the request help feature allowed students to complete troubleshooting lessons too easily since students could request correct procedures from the simulator rather than trying to complete exercises on their own. One interviewee felt that the first two segments were ineffective because they were advertisements for AMTESS.

QUESTION 6: Were there any occasions when you felt that the difficulty level of the material being presented by the simulator was above the students?

None of the interviewees felt that material presented by the simulator was too difficult for students.

QUESTION 7: Were there any occasions when you felt that the difficulty level of the material presented by the simulator should be increased?

All of the interviewees identified instances in which the difficulty level of material presented to students should be increased. Generally, interviewees felt that the rate at which material was presented to students was too slow. (Although lessons were self-paced, all students were required to complete each step of a lesson. Further, the rate at which students performed procedures on the 3-D module was frequently limited by the simulator's ability to process student input.) Three interviewees felt that the lessons did not address the full capability of the STE/ICE kit. All five interviewees felt that the lessons should have placed more emphasis on the use of TMs (especially the vehicle operator's manual for starting and stopping the engine). Three interviewees felt that students should have experienced troubleshooting more difficult problems on the 3-D module, while two interviewees felt that the difficulty level of the troubleshooting procedures was adequate. One interviewee felt that the lessons should have addressed the deductive reasoning process involved in troubleshooting instead of simply presenting troubleshooting procedures.

QUESTION 8: What hardware features of the simulator made it more effective than conventional training?

Statements made by four of the interviewees indicated that they felt that the 3-D module was of value because it provided easy access to components, it did not pose a safety hazard to students, and it could not be damaged as easily as operational equipment. One interviewee disliked the fact that the 3-D module provided students with access to components that were not easily accessible on operational equipment. Other features mentioned by interviewees include the video disc system, the request help feature, and the touch panel.

Ratings made by interviewees are presented below:

RATING (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	5	3.6	.55
Rate the potential training value of these features as a whole.	5	4.4	.89

QUESTION 9: What were the features that made this simulator easy for the instructors to operate?

Several interviewees stated that the touch panel and the automated pre-lesson check of the 3-D module made the simulator easy to operate. Interviewees stated that they did not understand some features of the simulator (editing system, instructor CRT) and they also felt that the device was difficult to operate when certain other features malfunctioned (3-D module, video disc system) or provided useless information (instructor CRT).

Ratings made by interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	5	3.4	.55
Rate the potential training value of these features as a whole.	5	4.6	.89

QUESTION 10: What were the features that made this simulator easy for the students to operate?

The interviewees generally agreed that the touch panel enabled students to enter responses into the device quickly and easily. One interviewee, however, noted that the touch panel did not always record students' responses correctly.

All of the interviewees indicated that the audio track of the video disc player helped to make the device easy for students to use. Several interviewees felt that students were able to process auditory stimuli much better than written stimuli.

Three interviewees felt that the accessibility of components on the 3-D module made the device easy to operate, while one interviewee felt that such accessibility confused students. One individual noted that students became frustrated when the 3-D module malfunctioned.

Ratings made by interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	5	4.2	.45
Rate the potential training value of these features as a whole.	5	4.4	.89

QUESTION 11: What aspects of the device would be appropriate for substituting for actual equipment?

Interviewees experienced difficulty answering the question and appeared to reinterpret the question as "What aspects of the device made it appropriate for substituting for actual equipment?". Four interviewees stated that the 3-D module made the device appropriate for substitution for operational equipment. They noted that malfunctions are easily inserted into the 3-D module, the module is safer than operational equipment, and the probability of damaging the 3-D module is low. These same four interviewees also indicated that presenting self-paced lessons with a video disc player was valuable because students were able to view detailed video frames at a rate that they selected.

Ratings made by interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	5	3	1
Rate the potential training value of these features as a whole.	5	3.8	.84

QUESTION 12: What types of problems did students have?

All five interviewees indicated that there were frequent hardware and software problems with the device. These problems are summarized below:

- Simulator recorded correct student actions as errors or recorded student errors as correct actions.
- System would "lock-up," i.e., would not record student responses or advance to the next lesson.
- System "lock-ups" required students to repeat lessons that were in progress when the failure occurred.
- Simulator failed to record the responses of students for lessons that had been completed.
- Cables and connectors for the 3-D module shorted out.
- Components of the 3-D module could not withstand normal student use.
- Material presented by the video disc player was not synchronized with events that occurred on the 3-D module.

Other problems mentioned by the interviewees are summarized below:

- The student CRT was too small to be seen by more than one student at a time.
- Students found it difficult to look down at the student CRT when they were working with the 3-D module in a standing position.
- Students did not know if they should attend to the 3-D module, the student CRT, or a TM.
- Students could not review the frame that preceded the current frame presented by the video disc player.
- Many students entered responses at a rate that was faster than the system could accommodate, causing students to wait for the system to "catch up" with them.
- The student guidebook was difficult to read and the information it provided was elementary.

QUESTION 13: How would you employ the simulator in order to gain maximum benefit from it?

All of the interviewees felt that the device should be used to train entry level students because the tasks addressed by the simulator are relatively simple and because the material is presented at a slow rate. In addition, most of the interviewees stated that training with the simulator should be supplemented by training with operational equipment in order to familiarize students with the location of components on operational equipment.

Ratings made by the interviewees for the simulator as a whole are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of the simulator as a whole.	5	3	1
Rate the potential training value of the simulator as a whole.	5	4.2	.84

Data Collector Observations. The observations made by the data collector during the transfer-of-training study are summarized below:

- The system malfunctioned frequently. System failures resulted in a loss of student data and a decrease in student and instructor desire to work with the device.
- Segments 6 and 9 are of little value to 63H30 students. In these segments, students are trained to connect leads directly to the generator and starter motor. However, on operational equipment, this procedure is rarely performed because it requires the engine to be removed from the vehicle. Conventionally trained students learn to identify a faulty generator or starter motor through deductive reasoning, a process which does not require the engine to be removed from the vehicle.
- Few individuals were aware of the existence of an editing system. Those familiar with the system found it awkward and time consuming because it was too heavily oriented towards inflexible, repetitive menus. Greater emphasis should be placed on direct edit commands.
- The record of student performance is of little value since it does not identify specific actions the student performs. Total time required to complete a lesson, total number of errors committed, and an overall performance index are the only values that appear on the printout for each lesson.
- When students make two consecutive errors, a "call your instructor" message appeared on the student CRT. If the image that was on the CRT immediately prior to these errors was computer-generated text, then the CRT became blank after the student errors were cleared. Since

instructors were given no cue about the next step to perform, they spent considerable amounts of time attempting to find the next appropriate step. Frequently, the correct step could not be identified and the segment would have to be started from the beginning, resulting in a loss of student data.

- An audio cue (chirp) emitted from the 3-D module indicated that students should look at the CRT. One of two types of messages appeared on the CRT in conjunction with the audio cue, a message indicating that an error was committed or a message indicating that a procedure should be performed. Students were frequently confused because they assumed that the audio cue could only mean that they had committed an error. The use of two different cues seems warranted.

- Students frequently performed troubleshooting procedures on the 3-D module faster than the rate at which the simulator could record student input. Consequently, students were provided error messages when, in fact, they had not committed any errors.

Discussion

The preceding section presented a wide range of opinions about various aspects of the Grumman training device. Several common themes that appeared throughout the data are summarized below in the form of positive and negative statements about the device.

Positive Statements. The ability to perform troubleshooting tasks on the 3-D module is a valuable device feature. Students stated that they enjoyed working on the 3-D module. Instructors and course developers felt that "hands-on" experience with the module helped students understand troubleshooting procedures.

The video disc system is an effective and motivating device feature. Students stated that they enjoyed the audio and video material presented on the video disc system. Instructors felt that material presented on this system helped students to identify and troubleshoot engine components.

Negative Statements. The Grumman device frequently malfunctions. All of the individuals who provided questionnaire data or interview data felt that the effectiveness of the Grumman device was diminished because of its low reliability. The device exhibited many different types of malfunctions that caused numerous delays in training sessions.

Lessons are inflexible. Students did not like the fact that they could not skip segments (or parts of segments), nor could they repeat segments (or parts of segments) on request. Instructors did not like the fact that they could not manipulate the order in which segments are presented to students.

Some lessons are too simple while others are inappropriate. Students, instructors, and course developers commented that the lessons were more appropriate for entry level students than they were for advanced students (63H30) because they were relatively simple. Instructors and course developers stated that Segments 6 and 9 were inappropriate because they present troubleshooting procedures that cannot be used by soldiers in the field.

The student performance record is of little value. Although many individuals thought that a printout of student performance was conceptually appropriate, they felt that the information presented by the Grumman device was inadequate because it was not presented in sufficient detail.

System response time is too slow. Both students and instructors commented that the simulator could not accept and process student input at a rate of speed that was commensurate with typical student performance. This resulted in training delays and a decreased desire (by students and instructors) to work with the device.

Experiment 4

Twenty-three (23) students from the 63D30 MOS (Self-propelled Field Artillery Systems Mechanic) were trained to perform a task (identical to the task in Experiment 3) using either conventional methods (11 students) or the Grumman simulator (12 students). Students were then tested on their ability to perform this task on operational equipment. Data consist of responses to the trainee questionnaire only. Individuals responsible for training MOS 63D30 students were also responsible for training MOS 63H30 students. Individuals responsible for creating and modifying curricula for the 63D30 MOS were also responsible for the 63H30 MOS. Since data obtained from these individuals has already been reported in Experiment 3; it will not be reported in this experiment.

Method

Subjects. Characteristics of subjects who provided data are as follows:

- Trainee questionnaire. Twelve (12) 63D30 students who were trained with the Grumman simulator completed this questionnaire after they were tested on their ability to perform a troubleshooting task on operational equipment. The questionnaire was also completed by three students who were trained with the simulator, but were not tested on their ability to perform a troubleshooting task on operational equipment.

Materials. The trainee questionnaire used in this experiment was identical to the questionnaire used in previous experiments. (See Appendix A.)

Procedure. The procedure used in administering the trainee questionnaire was highly similar to the procedure used in previous experiments. Trainees responded to the questionnaire after training sessions were completed (for trainees who were not subsequently tested on operational equipment) or after training and testing were completed. Trainees were briefed before responding to the questionnaire.

Responses of the 12 students who were tested on operational equipment are reported separately from responses of the three students who were not tested on operational equipment.

Results

QUESTION 1: How do you feel about the simulator?
RATINGS: 1 = dislike it very much, 5 = like it very much

Response	Number of Responses: Students Tested (N = 12)	Number of Responses: Students Not Tested (N = 3)
LIKE IT VERY MUCH	5	2
LIKE IT SOMEWHAT	3	0
NO STRONG FEELINGS ABOUT IT	2	1
DISLIKE IT SOMEWHAT	1	0
DISLIKE IT VERY MUCH	1	0
	TOTAL 12	TOTAL 3

The mean rating for students who were tested was 3.83 (standard deviation = 1.34). The mean rating for students who were not tested was 4.33 (standard deviation = 1.15).

QUESTION 2: Why did you answer Question 1 as you did?

Several students who were tested and who gave the device a high rating liked the feedback provided by the simulator. Other students who were tested stated that the device would be a useful training tool for entry level students.

One of the students who was not tested gave the simulator a high rating because simulator lessons made it easy for him to learn to use STE/ICE. Another student who was not tested gave the simulator a neutral rating because it did not function properly.

QUESTION 3: What specific features of the simulator do you like or dislike?

Students who were tested liked the fidelity of the 3-D module, the video disc system, the request help feature, feedback, the requirement to think about troubleshooting procedures, the absence of an instructor, and proceduralized self-paced lessons. One of these students stated that the device recorded correct student actions as errors and that the device operated too slowly.

None of the students who were not tested made specific comments about features they liked or disliked.

QUESTION 4: Why do you like or dislike these features?

One student who was tested liked proceduralized self-paced lessons because they make it easy to learn. No other students made relevant responses.

QUESTION 5: Please make any additional comments you feel are appropriate.

Students who were tested made the following comments: 1) the simulator is not as good as conventional training; 2) the simulator is preferable to an instructor; 3) students should be trained to use STE/ICE before using the simulator; and 4) the simulator should be used by one student at a time. Students who were not tested did not respond to this question.

Discussion

Only data collected from 63D30 trainees has been reported in this experiment (other data concerning the Grumman device at APG is presented in Experiment 3). This data can be summarized by one positive and one negative statement.

Positive Statement. Students liked the simulator and a number of specific features. Specific features that students liked include feedback, lessons addressing STE/ICE, the 3-D module, the request help feature, the video disc system, and proceduralized lessons.

Negative Statement. The simulator frequently malfunctioned and operated too slowly. These comments were also made by 63H30 students (Experiment 3).

Experiment 5

Twenty-two (22) students from the 24C10 MOS (Hawk Missile Firing Section Mechanic) were trained to perform troubleshooting tasks using either conventional methods (12 students) or the Seville/Burtek simulator (10 students). These students were then tested on their ability to perform troubleshooting tasks (identification of faulty components) on operational equipment. Data consist of responses to questionnaires and structured interviews, as well as observations made by the on-site data collector during the course of the experiment.

Method

Subjects. Fewer subjects were available to complete questionnaires and participate in interviews in Experiment 5 than in previous experiments. Characteristics of subjects who provided data are as follows:

- Initial instructor questionnaire. Four civilian and seven military instructors completed the questionnaire.

- Instructor questionnaire. One of the civilian instructors described above completed the instructor questionnaire.

- Course developer questionnaire. No course developers were available to complete this questionnaire.

- Trainee questionnaire. Ten MOS 24C10 students who were trained with the Seville/Burtek device completed this questionnaire after they were tested on their ability to perform troubleshooting tasks on operational equipment.

- Structured interview. The civilian instructor described above and the on-site data collector for the transfer-of-training study completed structured interviews.

Materials. The questionnaires and structure interview form used in Experiment 5 were identical to those used in the previous experiments. (See Appendix A.)

Procedure. The procedure followed in administering the questionnaires and interviews was highly similar to the procedure described for previous experiments.

Respondents commented on specific features of the Seville/Burtek device. These features are described in Table 6.

Results

Initial Instructor Questionnaire. Responses to this questionnaire are summarized below.

QUESTION 1: How easy or hard is it to learn to use the simulator?
RATINGS: 1 = very hard, 5 = very easy)
N = 11

Response	Number of Responses
VERY EASY	6
FAIRLY EASY	0
AVERAGE	1
FAIRLY HARD	4
VERY HARD	0
TOTAL	11

The mean rating for all instructors was 3.73 (standard deviation = 1.49).

QUESTION 2: Why did you answer Question 1 as you did?

Instructors who gave the simulator neutral and high ratings agreed that the training course conducted by Seville/Burtek was valuable and that the written instructions for operating the simulator were clear and easy to understand. These instructors also stated that their previous experience with the Hawk radar unit and with computers helped them understand how to operate the simulator. The instructors who stated that it was fairly hard to learn to use the simulator said that there were too many problems with the simulator. They stated that they did not like learning to use a simulator that was not operating correctly.

QUESTION 3: How do you feel about the simulator?
RATINGS: 1 = dislike it very much, 5 = like it very much
N = 11

Response	Number of Responses
LIKE IT VERY MUCH	1
LIKE IT SOMEWHAT	3
NO STRONG FEELINGS ABOUT IT	0
DISLIKE IT SOMEWHAT	6
DISLIKE IT VERY MUCH	1
TOTAL	11

The mean rating for all instructors was 2.73 (standard deviation = 1.27).

QUESTION 4: Why did you answer Question 3 as you did?

The instructors who liked the simulator indicated it provided them the opportunity to train tasks (high voltage procedure) that were impossible to train on operational equipment. In addition, these instructors felt that the simulator was more reliable than the operational equipment (which frequently malfunctions). Instructors who disliked the simulator indicated that they did not trust the device because it was not operating properly. (The simulator malfunctioned frequently for this group of instructors.) These individuals disliked the simulator because it was not realistic. They noted that components were missing or not true to life (i.e., degraded fidelity of the cabinet, components, switches, and dials), and that troubleshooting procedures presented by the simulator were different (in an unspecified manner) from the procedures normally presented to students.

QUESTION 5: Please make any additional comments you feel are appropriate.

Several respondents noted that the cost of the simulator was too high, and that its use could not justify its cost since the Hawk radar was scheduled for significant hardware and software modifications in the near future. (Since no accurate cost projections for the device were available, these comments were apparently based on rumor.)

Instructor Questionnaire. Data reported for the instructor questionnaire are based on the responses of a single instructor. Rather than completing a questionnaire for each of the 50 exercises taught by the simulator (see Table 6), the instructor grouped the exercises and completed a questionnaire for each of the following six content areas:

1. introduction to the transmitter

2. master oscillator and power amplifier high voltage circuits

3. modulator bias and arc detection circuits

Table 6

Exercises Presented by the Seville/Burtek Simulator in the Radar Transmitter Configuration

Exercise Number	Description
1	Normal Operations
2	Table 3-16
3	Monthly Check
4	Remove and Replace High Voltage Regulator
5	Remove and Replace Master Oscillator (MO) Filament Power Supply (PS) A4
6	Remove and Replace Power Amplifier (PA) Filament PS A3
7	Remove and Replace MO
8	Remove and Replace PA Tube
9	Remove and Replace HI/LO Frequency Amplifier
10	Adjust MO Frequency
11	MO Filament Test
12	PA Filament Test
13	PA High Voltage Test
14	MO High Voltage Test
15	Degeneration Intermediate Frequency (IF) Amplifier Test
16	High Voltage Regulator (PA) Failure [A][a]
17	High Voltage Regulator (PA) Failure [B][a]
18	High Voltage Regulator (PA) Failure [C][a]
19	High Voltage Regulator (PA) Failure [D][a]
20	MO High Voltage PS A1 Failure [A]
21	MO High Voltage PA A1 Failure [D]
22	PA PS A2 Failure [A]
23	PA PS A2 Failure [D]
24	PA Filament PS A3 Failure [A]
25	PA Filament PS A3 Failure [D]
26	PA Filament PS A3 Failure [D]
27	MO Filament PS A4 Failure [A]
28	MO Filament PS A4 Failure [B]
29	MO Filament PS A4 Failure [C]
30	MO Filament PS A4 Failure [D]
31	PA Tube Failure [A]
32	PA Tube Failure [D]
33	MO Failure [A]
34	MO Failure [E][a]
35	Ferrite Switch Failure [A]
36	Ion Probe Failure [A]
37	Ferrite Switch Control and PS Failure [A]
38	Ferrite Switch Control and PS Failure [D]
39	Range and Coding Amplifier Oscillator Failure [A]
40	Range and Coding Amplifier Oscillator Failure [D]
41	Monitor Amplifier Failure [A]
42	Degeneration IF Amplifier Failure [A]
43	Degeneration IF Amplifier Failure [D]
44	Bridge Null and Cavity Tuning Control Amplifier Failure [A]
45	Bridge Null and Cavity Tuning Control Amplifier Failure [D]
46	Ferrite Phase Controller (Degen) Failure [A]
47	High and Low Frequency Amplifier Failure [A]
48	High and Low Frequency Amplifier Failure [B]
49	Klystron Tuning Control Amplifier [A]
50	Weekly Check

[a][A], [B], [C], [D], and [E] denote exercise variations.

4. noise degeneration circuits

5. radio frequency generation circuits

6. modulation circuits

QUESTION 1: How well does the simulator train this task?
RATINGS: 1 = very poorly, 5 = very well
N = 1

Response	Number of Responses
VERY WELL	3
MODERATELY WELL	2
FAIRLY	0
POORLY	1
VERY POORLY	0
TOTAL	6

The mean rating for all tasks was 4.17 (standard deviation = 1.17). Raw data are presented in Table E-1.

QUESTION 2: Why did you answer Question 1 as you did?

Certain tasks were given the rating "very well" because these tasks could not be trained using operational equipment. The instructor did not indicate why some tasks were given a rating of "moderately well" or "poorly."

QUESTION 3: What specific features of the simulator (involved in this task do you like or dislike?

Specific features of the simulator that appealed to the instructor were: 1) the overall high fidelity of the 3-D module, 2) the ability to insert malfunctions without damaging equipment, and 3) the ability to demonstrate the built-in test equipment. The instructor disliked: 1) the low fidelity of certain (unspecified) components of the 3-D module, and 2) the cable connectors.

QUESTION 4: Why do you like or dislike these features?

The instructor liked the 3-D module because it allowed him to demonstrate concepts and normal operations of the transmitter without the distraction and complexity present in the operational equipment. He found the simulator to be easy to set up, reliable, and friendly to both instructors and students.

The instructor indicated that the ability to train high voltage procedures, radio frequency generation tasks, and modulation bias and arc detector tasks was the outstanding capability of the Seville/Burtek device. He noted that malfunctions in these circuits could be inserted into the simulator but not the operational equipment because the malfunction would damage the operational equipment.

The instructor noted that simulator-trained students are trained to use the high voltage test set to isolate complex problems. However, students trained on operational equipment are not taught to use this equipment since insertion of high voltage malfunctions damages the equipment.

The instructor noted that the simulator provided poor training for the noise degeneration circuits. He noted that since many of the details of these circuits were not represented in the simulator, students experienced difficulty troubleshooting these circuits on the operational equipment. The instructor disliked the cable connectors since they were difficult to use.

QUESTION 5: Please make any additional comments you feel are appropriate.

The instructor indicated that the simulator was superior to conventional training methods for five of the six content areas (see page 54) addressed by the simulator. (Noise degeneration circuits were trained poorly.) He stated that he could depend on the simulator to function correctly.

Trainee Questionnaire. Responses of the 10 students who were trained with the simulator are summarized below.

QUESTION 1: How do you feel about the simulator?
RATINGS: 1 = dislike it very much, 5 = like it very much
N = 10

Response	Number of Responses
LIKE IT VERY MUCH	5
LIKE IT SOMEWHAT	5
NO STRONG FEELINGS ABOUT IT	0
DISLIKE IT SOMEWHAT	0
DISLIKE IT VERY MUCH	0
TOTAL	10

The mean rating for all students was 4.5 (standard deviation = .53).

QUESTION 2: Why did you answer Question 1 as you did?

Students indicated that they were comfortable and confident working on operational equipment because the simulator helped them overcome their fear of the operational equipment. They also felt that the self-paced lessons helped them to learn troubleshooting procedures.

QUESTION 3: What specific features of the simulator do you like or dislike?

Students liked the variety of malfunctions that could be inserted into the simulator, the lack of noise generated by the cooling system of operational equipment, feedback, the self-paced lesson presentation, and the hardcopy printout. Students disliked the low fidelity of certain 3-D module components and the lack of time spent training on the operational equipment.

QUESTION 4: Why do you like or dislike these features?

Students liked troubleshooting realistic problems and symptoms that could not be placed into the operational equipment (e.g., high voltage problems). They felt prepared to troubleshoot these types of problems in the field after they were trained on the simulator. The lack of usual radar noise helped students to hear the instructor clearly. Several stated that feedback provided by the simulator was useful, while one felt that feedback should be reduced as students become more proficient troubleshooters.

All students preferred self-paced training and the last good-first bad method of troubleshooting presented in the simulator lessons, rather than lockstep training and Fault Isolation Procedures (FIP) used in conventional training.

The hardcopy printout was helpful since the printout enabled them to see which of their actions were correct and which were incorrect. They disliked the low fidelity of the 3-D module (tuning motors, crystals, switches, and meters were missing or were low fidelity representations of the operational equipment). It was difficult to understand how certain circuits worked since components of these circuits were not represented in the simulator. Also it was difficult to remember to check certain meters on the operational equipment since the simulator's low fidelity meter always indicated that the meter was providing a "good" reading.

QUESTION 5: Please make any additional comments you feel are appropriate.

Many students indicated that training could have been improved if more time had been provided for practice on the operational equipment since certain tasks (remove/replace certain components) could not be practiced on the simulator.

Structured Interviews. Responses to the 13 questions that were posed during the interviews are summarized below.

QUESTION 1: What were the instructional features of the simulator that were applicable to the school's training course?

Both interviewees stated that the 3-D module was applicable and that it could be substituted for operational equipment. They also agreed that the malfunction insertion feature was useful because it allowed students to troubleshoot many different problems and because it eased the burden of the instructor. Both interviewees noted that feedback provided to the student and the instructor was useful. The on-site data collector felt that the sequence of simulator lessons was applicable since it was flexible and could be inserted into existing self-paced materials. The other interviewee liked the flexibility of the editing system.

Ratings made by the interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	2	5.5	.71
Rate the potential training value of these features as a whole.	2	6.5	.71

QUESTION 2: What were the instructional features of the simulator that were not applicable to the school's training course?

Both of the interviewees thought that the random malfunction selection feature was not applicable to the school's training course. They noted that a specific subset of malfunctions need to be inserted in the simulator when training certain tasks, but this degree of control was not provided by the random malfunction feature. The interviewees also agreed that the hard-copy printout of student performance was inappropriate since the school does not require permanent records of student performance. The on-site data collector thought that the slide projector unit was not applicable since most of the diagrams displayed by the projector were also available on student handouts. This interviewee also indicated that self-paced lessons were not applicable since the school typically uses a lockstep method of instruction.

QUESTION 3: In your opinion, which features of the lesson presentation helped make the simulator lessons interesting to the students?

Both interviewees agreed that feedback provided to the students on the CRT helped to maintain student interest. The student responder unit was also seen as useful for maintaining student interest. The interviewees concurred that self-paced lessons maintained student interest since the students were allowed to determine how much time to devote to any one task. The on-site data collector stated that students' hands-on experience with the 3-D module helped make the lessons interesting to students.

Ratings made by the interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	2	5	0
Rate the potential training value of these features as a whole.	2	5.5	.71

QUESTION 4: Of the lessons taught by the simulator, which ones did you feel were particularly effective?

The interviewees agreed that the monthly and weekly check procedures were very effective. They stated that students trained on the simulator performed these tasks very well on the operational equipment, in part, because simulator training had reduced students' fear of the operational equipment. The on-site data collector indicated that the high voltage lessons presented on the simulator were highly effective since students normally receive no training for these tasks.

Ratings made by the interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these lessons as a whole.	2	6	1.41
Rate the potential training value of these lessons as a whole.	2	7	0

QUESTION 5: Of the lessons taught by the simulator, which ones did you feel were ineffective?

The on-site data collector felt that none of the lessons were ineffective. The training specialist felt that the lessons involving the noise degeneration circuits were ineffective because low fidelity representations of components involved in these circuits were included in the simulator.

QUESTION 6: Were there any occasions when you felt that the difficulty level of the material being presented by the simulator was above the students?

Both interviewees felt that the lessons involving the noise degeneration circuits were too difficult for the students. The training specialist stated that the low fidelity representation of components involved in these circuits made it difficult for students to understand these lessons.

QUESTION 7: Were there any occasions when you felt that the difficulty level of the material being presented by the simulator should be increased?

The on-site data collector stated that none of the material presented by the simulator was too easy for students. The training specialist felt that the high voltage lessons were too simple for the following two reasons: 1) the lessons did not simulate malfunctions for all high voltage components (cables and high voltage test set were assumed to be operating correctly), and 2) the lessons led students to believe that a specific set of bad readings could only be caused by one malfunction when, in reality, any given set of bad readings could be caused by a number of malfunctions.

QUESTION 8: What hardware features of the simulator made it more effective than conventional training?

The interviewees agreed that the simulator was more effective than conventional training because a variety of realistic problems can be easily inserted into the simulator, while it is very time consuming to insert the small number of minor problems that can be inserted into operational equipment.

The interviewees also concurred that feedback provided to students made the simulator more effective than conventional training.

The on-site data collector felt that the physical layout of the 3-D module enhanced performance because students could stand upright while troubleshooting (students must maintain awkward positions when working on operational equipment). This interviewee also felt that the low voltages present in the 3-D module allowed the students to work on lessons without fear of injuring themselves or damaging equipment (potentially lethal voltages are present in the operational equipment).

Ratings made by the interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	2	6.5	.71
Rate the potential training value of these features as a whole.	2	7	0

QUESTION 9: What were the features that made this simulator easy for the instructors to operate?

The interviewees agreed that the instructor panel was simple to operate, and that it allowed the instructors to exercixe great flexibility in the way that lessons were presented to the students. Both interviewees felt that the reliability of the device was good (except for the slide projector unit); instructors did not spend a lot of time repairing the simulator. The on-site data collector stated that the editing system was easy to operate. She note that this system allowed instructors to make various changes to lessons which expedited student progress.

Ratings made by the interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	2	5.5	.71
Rate the potential training value of these features as a whole.	2	6	1.41

QUESTION 10: What were the features that made this simulator easy for the students to operate?

The interviewees agreed that the student responder unit facilitated operation of the simulator.

Ratings for this feature are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	2	4.5	.71
Rate the potential training value of these features as a whole.	2	5	1.41

QUESTION 11: What aspects of the device would be appropriate for substituting for actual equipment?

Interviewees interpreted the question as "What aspects of the device made it appropriate for substituting for actual equipment?". Both interviewees felt that the ease of inserting realistic malfunctions made the simulator appropriate for substituting for operational equipment. The training specialist stated that the reliability of the device and its high fidelity also made it substitutable for actual equipment, while the on-site data collector felt that the self-paced lessons and the lack of dangerous voltages made the simulator appropriate for substituting for actual equipment.

QUESTION 12: What types of problems did students have?

Interviewees agreed that students experienced problems troubleshooting the local oscillator tuning motor, the cavity tuning motor, and the arc detector crystals on the operational equipment because these components were represented on the simulator with low physical and functional fidelity. The training specialist felt that students experienced problems troubleshooting the operational equipment because a great deal of prompting and feedback was present throughout training on the simulator but no feedback was present when troubleshooting the operational equipment.

QUESTION 13: How would you employ the simulator in order to gain maximum benefit from it?

Both interviewees felt that the simulator should be used in a school setting. The training specialist felt that training on the simulator should be supplemented by training on operational equipment. The on-site data collector stated that the simulator could be used for both initial training and refresher training.

Ratings made by the interviewees for the simulator as a whole are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of the simulator as a whole.	2	6	1.41
Rate the potential training value of the simulator as a whole.	2	7	0

Data Collector Observations. A variety of observations about the simulator were made by the data collector during the transfer-of-training experiment. These observations are summarized below:

- The slide projector unit did not function properly. Slides frequently appeared at the wrong time or did not appear at all.

- On several occasions, the simulator "locked-up," i.e., the device did not accept inputs from the student station, instructor station, or 3-D module. When this problem occurred, the device had to be turned off and restarted.

- The device was too sensitive to movements of the 3-D module. A fair amount of vibration and movement is usually involved in removing or replacing a component. These minor movements were regarded as errors by the simulator when, in fact, they are a normal part of remove/replace procedures.

- On two occasions, the simulator ended an exercise before the student had finished performing required actions.

- Students were confused when correct troubleshooting procedures (verified by instructors) were entered on the student responder panel and they received a message indicating that their actions were incorrect.

- Students always received feedback on the student CRT when they entered correct decisions on the student responder panel. However, feedback was not always provided when students entered incorrect decisions. Students were confused because they did not know if their decision was correct or incorrect.

- Students were required to enter a troubleshooting procedure on the student responder panel before performing the procedure on the 3-D module. However, they frequently attempted to work on the 3-D module without entering a decision on the student responder panel. Some type of cue for students to enter decisions on the responder panel may be appropriate.

- Instructors were able to use the editing system effectively. They modified messages that were presented to students and modified the lessons so that different student actions were accepted as correct.

- The "free play" mode of the simulator was useful because it allowed students to experiment with controls, cables, etc. The instructor used this feature to demonstrate the capability of the device to students.

- Instructors were able to start (or restart) a training session at any point in a lesson by entering a few commands on the instructor station. This feature was valuable to instructors since training sessions were frequently interrupted. If this feature had been unavailable, students (or instructors) would have been forced to repeat the entire lesson that had been interrupted.

- The simulator contained a "halt on student errors" feature that stopped students' troubleshooting activities after they had committed three consecutive errors, and a "continue on student errors" feature that allowed students to troubleshoot regardless of the number of errors that were committed. These features can be activated by instructors very easily. Although the "continue on student errors" feature was always used during the transfer-of-training study, instructors indicated that the "halt on student errors" feature could be very useful.

Discussion

Comments made by instructors, students, and the on-site data collector can be summarized as follows:

Positive Statements. Instructors and students hold favorable opinions of the device. In general, instructors thought that the device was easy to learn to use. They also indicated that the device did a good job of training students to perform troubleshooting tasks. Students indicated that they enjoyed working with the device.

"Hands-on" troubleshooting experience is a highly valued device feature. Respondents repeatedly stated that the simulator was valuable because it allowed students to gain "hands-on" experience troubleshooting high voltage components. Students are not provided the opportunity to troubleshoot the high voltage components of operational equipment because lethal voltages are present in these components and because inserting a malfunction into high voltage components of operational equipment seriously damages the equipment. Respondents also noted that it is much easier to insert malfunctions into the simulator than it is to insert malfunctions into operational equipment.

Negative Statement. Low fidelity representations of certain components of the 3-D module reduced the effectiveness of the simulator. Respondents stated that they disliked the low fidelity representation of the tuning motors, arc detector crystals, and certain controls and displays. They felt that these low fidelity components detracted from the training effectiveness of the simulator.

Experiment 6

Three students from the 24E MOS (Improved Hawk Fire Control Mechanic), four students from the 24G MOS (Improved Hawk Information and Coordination Control Mechanic), and three students from the 24R MOS (Improved Hawk Master Mechanic) were trained to perform troubleshooting tasks using the Grumman simulator. These students were then tested on their ability to perform troubleshooting tasks on the simulator and on operational equipment. Data reported in this document for Experiment 6 consist of responses to questionnaires and structured interviews as well as observations made by the on-site data collector during the course of the experiment.

Method

Subjects. Characteristics of subjects who provided data are as follow:

- o Initial instructor questionnaire. Two Non-commissioned Officers (NCOs) who were instructors for the 24 C10 MOS completed the questionnaire.

- o Course developer questionnaire. One civilian course developer for the 24C10 MOS completed this questionnaire.

- o Trainee questionnaire. Ten students from three MOSs who had received training on the Grumman simulator completed this questionnaire after they had been tested on their ability to perform troubleshooting procedures on the simulator and on the operational equipment.

- o Structured interviews. Interviews were conducted with a course developer, three civilian training specialists, and the on-site data collector.

See Table 7 for a listing of simulator segments that were evaluated.

Materials. The questionnaires and structured interview forms used in this experiment were identical to those used in previous experiments. (See Appendix A.)

Procedure. Prior to filling out a questionnaire or participating in an interview, subjects were briefed on the purpose of the questionnaire (or interview) and were informed of the types of questions they would be asked.

Initial instructor questionnaires were completed by two instructors after they completed two and a half days of a five-day operator training course. This course could not be completed by instructors because the device malfunctioned repeatedly.

Table 7

Simulator Lesson Segments Included in the Evaluation of the Grumman Device at Fort Bliss

Segment Number	Description
1	Introduction to AMTESS
2	Introduction to High Voltage Circuits (Games)
3	Introduction to Weekly High Voltage Checks for High Voltage Circuits
4	Indicator Relationships (Meter Responses to the Conditions of Components)
5	Last Good/First Bad Method of Troubleshooting
6	Introduction to High Voltage Power Supply Test Set
7	High Voltage Power Supply Test Set Procedures
8	Problem #1 - Failed Master Oscillator Filament Power Supply A4
9	Problem #2 - Failed Power Amplifier High Voltage Power Supply A2
10	Introduction to Troubleshooting
11	Troubleshooting the High Voltage Regulator
12	Troubleshooting (no feedback): Fault 11 - Failed Master Oscillator High Voltage Power Supply A1 Fault 10 - Failed High Voltage Regulator Fault 12 - Failed Power Amplifier Filament Power Supply A3
13	Weekly Check Procedures

The course developer was asked to complete a questionnaire for each of the 41 non-redundant lesson segments presented by the simulator. (See Table 8; although the table lists 59 lesson segments, 18 of these are redundant.) However, when the course developer was available to review simulator segments, the device was not working correctly, and when the device was working correctly, the course developer was not available to evaluate the device. Thus, the course developer completed only two questionnaires for the 13 simulator segments that were involved in the transfer-of-training study. One questionnaire was completed for 11 segments that addressed high voltage procedures while another questionnaire was completed for the segment that addressed weekly check procedures. No questionnaire was completed for the segment that involved an introduction to AMTESS.

Ten students from three MOSs completed trainee questionnaires after they completed training and after they were tested on their ability to perform troubleshooting tasks on the simulator, and weekly check procedures on operational equipment. Trainees completed questionnaires independently.

Five individuals completed the structured interview after all transfer-of-training data had been collected. Interviews were conducted on an individual basis. One interview was self-administered. For the remaining four interviewees, the protocol was as follows:

- o The interviewer asked the interviewee a question.
- o The interviewer prompted the interviewee for specific comments about the simulator if the interviewee was initially unresponsive.
- o The interviewer asked the interviewee to rate simulator features (for questions 1, 3, 4, 8, 9, 10, 11, and 13).
- o The interviewer reviewed comments with the interviewee to ensure correctness of recorded responses.

Certain questions ask respondents to comment on specific features of the Grumman device. These features are described in Table 5.

Results

Initial Instructor Questionnaire. Results of the initial instructor questionnaire are summarized below.

QUESTION 1: How easy or hard is it to learn to use the simulator?
RATINGS: 1 = very hard, 5 = very easy
N = 2

Response	Number of Responses
VERY EASY	1
FAIRLY EASY	0
AVERAGE	1
FAIRLY HARD	0
VERY HARD	0
TOTAL	2

Table 8

Lesson Segments Presented by the Grumman Simulator in the Radar Transmitter Configuration

Segment Number	Description
0	Introduction to AMTESS
1	Introduction to High Voltage (HV) Circuits
2	Introduction to Weekly Checks for High Voltage Circuits
3	Indicator Relationships (Meter Responses to the Conditions of Components)
4	Last Good/First Bad Method of Troubleshooting
5	Introduction to High Voltage Power Supply Test Set (HVPSTS)
6	HVPSTS Procedures
7	Problem #1: Failed Master Oscillator Filament Power Supply A4
8	Problem #2: Failed Power Amplifier High Voltage Power Supply A2
9	Introduction to Troubleshooting Problem
10	Problem #3: Failed High Voltage Regulator (HVR)
11	Problem #4: Failed Master Oscillator High Voltage Power Supply (MOVHPS) A1
12	Problem #5: Failed Power Amplifier Power Supply (PAPS) A3
13	Introduction to Troubleshooting Problem
14	Problem #3 Repeated (Failed HVR)
15	Problem #4 Repeated (Failed MOHVPS A1)
16	Problem #5 Repeated (Failed PAPS A3)
17	Introduction to Troubleshooting Problem
18	Problem #3 Repeated (Failed HVR)
19	Problem #4 Repeated (Failed MOHVPS A1)
20	Problem #5 Repeated (Failed PAPS A3)
21	Conclusion to High Voltage Circuits
22	Introduction to Radio Frequency (RF) Circuits
23	RF Circuits/Arc Detection Circuits Relationships
24	RF Circuits Problem #1
25	RF Circuits Problem #2
26	Introduction to Troubleshooting Problem
27	RF Circuits Problem #3
28	RF Circuits Problem #4
29	RF Circuits Problem #5
30	Introduction to Truubleshooting Problem
31	RF Circuits Problem #3 (Repeated)
32	RF Circuits Problem #4 (Repeated)
33	RF Circuits Problem #5 (Repeated)
34	Introduction to Troubleshooting Problem
35	RF Circuits Problem #3 (Repeated)
36	RF Circuits Problem #4 (Repeated)
37	RF Circuits Problem #5 (Repeated)
38	Conclusion to RF Circuits
39	Introduction to Arc Detection Circuits
40	Arc Detection Circuits Problem #1
41	Arc Detection Circuits Problem #2
42	Weekly Check Procedure
43	Noise Degeneration Circuits Problem #1
44	Noise Degeneration Circuits Problem #2
45	Introduction to Troubleshooting Problem
46	Noise Degeneration Circuits Problem #3
47	Noise Degeneration Circuits Problem #4
48	Noise Degeneration Circuits Problem #5
49	Introduction to Troubleshooting Problem
50	Noise Degeneration Circuits Problem #3 (Repeated)
51	Noise Degeneration Circuits Problem #4 (Repeated)
52	Noise Degeneration Circuits Problem #5 (Repeated)
53	Introduction to Troubleshooting Problem
54	Noise Degeneration Circuits Problem #3 (Repeated)
55	Noise Degeneration Circuits Problem #4 (Repeated)
56	Noise Degeneration Circuits Problem #5 (Repeated)
57	Credits
58	Seventeen (17) Practice Problems Available

[a]Since evaluation of the device required a revision of the sequence in which lesson segments were presented, lesson segment numbers do not match those presented in Table 7.

The mean rating for all instructors was 4.0 (standard deviation = 1.41).

QUESTION 2: Why did you answer Question 1 as you did?

One instructor stated that it was very easy to learn to use the simulator because the briefing provided by representatives of Seville/Burtek was thorough and because he had several years of experience with the Hawk system. The other instructor stated that the simulator malfunctioned when he worked with it. He indicated that the computer malfunctioned when he attempted to skip certain troubleshooting procedures.

QUESTION 3: How do you feel about the simulator?
RATINGS: 1 = dislike it very much, 5 = like it very much
N = 2

Response	Number of Responses
LIKE IT VERY MUCH	0
LIKE IT SOMEWHAT	2
NO STRONG FEELINGS ABOUT IT	0
DISLIKE IT SOMEWHAT	0
DISLIKE IT VERY MUCH	0
TOTAL	2

QUESTION 4: Why did you answer Question 3 as you did?

One instructor stated the simulator added a new dimension to learning and to teaching. He felt that the device saved time, energy, and manpower. The other instructor felt that the symptoms for certain malfunctions were inaccurate and that this could be misleading to students.

QUESTION 5: Please make any additional comments you feel are appropriate.

One instructor felt that the simulator was too expensive. (Since accurate cost projections for the device were not available, this comment was apparently based on rumor.) He also felt that instructors should be trained not only to operate the simulator, but also to program it, repair it, and perform maintenance on it. The other instructor felt that the simulator needed to be "de-bugged" before students used it.

Course Developer Questionnaire. One course developer completed two questionnaires. One questionnaire addressed 11 segments involving high voltage procedures while the other questionnaire addressed one segment involving weekly check procedures.

QUESTION 1: Is this a critical task which needs to be trained?
RESPONSES: Yes, No
N = 1

Response	Number of Responses
YES	2
NO	0
TOTAL	2

The course developer indicated that both the weekly check procedures and the high voltage tasks were critical tasks which needed to be trained. The respondent made no comments about his decisions concerning task criticality.

QUESTION 2: Is this task currently trained on operational equipment?
RESPONSES: Yes, No
N = 1

Response	Number of Responses
YES	50
NO	50

The weekly check procedures were taught at the School. The respondent stated the Air Defense School was unable to train high voltage tasks using operational equipment.

QUESTION 3: How difficult is it to perform this task?
RATINGS: 1 = very easy, 5 = very difficult
N = 1

Response	Number of Responses
VERY DIFFICULT	0
SOMEWHAT DIFFICULT	0
ABOUT AVERAGE IN DIFFICULTY	1
SOMEWHAT EASY	1
VERY EASY	0
TOTAL	2

The course developer indicated that the weekly check procedures were somewhat easy to perform and that the high voltage procedures were about average in difficulty.

QUESTION 4: At what skill level should a trainee perform this task at the end of training?

Response	Number of Responses
EXPERT	0
LESS THAN EXPERT	2
APPRENTICE	0
BETTER THAN NOVICE	0
NOVICE	0
TOTAL	2

QUESTION 5: Please make any additional comments you feel are appropriate.

The course developer felt that students were well-prepared to perform the complex task of troubleshooting high voltage problems on operational equipment after they completed the high voltage lessons on the simulator. Providing "hands-on" training for high voltage problems was one of the most important features of the simulator. It may not be cost-effective or training-effective to use the simulator to train a fixed procedure, such as the weekly checks procedure. He also noted that the simulator malfunctioned often, and that students concluded that training is more effective on operational equipment than it is on the Grumman simulator.

Trainee Questionnaire. Responses of the 10 students who were trained with the simulator are summarized below.

QUESTION 1: How do you feel about the simulator?
RATINGS: 1 = dislike it very much, 5 = like it very much
N = 10

Response	Number of Responses
LIKE IT VERY MUCH	5
LIKE IT SOMEWHAT	4
NO STRONG FEELINGS ABOUT IT	0
DISLIKE IT SOMEWHAT	1
DISLIKE IT VERY MUCH	0
TOTAL	10

The mean rating for all students was 4.3 (standard deviation = .95).

QUESTION 2: Why did you answer Question 1 as you did?

Several students liked the simulator because training sessions with the device were more interesting than conventional training sessions. They also liked the device because it was easier to understand information presented by the simulator than it was to understand information presented by an instructor, and because lessons were self-paced. Many students disliked the fact that the simulator malfunctioned frequently. Other students did not like self-paced lessons.

QUESTION 3: What specific features of the simulator do you like or dislike?

The lesson that was presented in the form of a game (identification of high voltage components) was liked by most students. The safety of the 3-D module, lessons involving high voltage circuits, the touch panel, the request help feature, the block diagrams that appeared on the CRT, the 3-D module, the lack of noise generated by the 3-D module, and the cue (chirp) to attend to the CRT were other features that students liked. The wide variety of problems experienced due to device malfunctions was disliked by students. They also did not like: the request help feature, specific hardware components such as the high voltage cables, the touch panel, the quality of photographs presented in Segment 1, and the inability to complete a lesson without instructor intervention after they have made several consecutive errors.

QUESTION 4: Why do you like or dislike these features?

Students who stated that they liked the lesson that was presented as a game felt that this lesson was interesting, challenging, and effective. Respondents indicated that they liked the safety of the 3-D module (low voltages) because it allowed them to stop worrying about injuring themselves. One student stated that the safety of the 3-D module created a relaxed atmosphere in which students could concentrate on their work. Students liked lessons involving high voltage circuits because they must work on these components in the field. Conventionally trained students do not receive "hands-on" experience with high voltage problems at the Air Defense School. The touch panel feature was described by students as interesting and easy to use. Students who liked the request help feature indicated that this feature was easy to use, and presented useful information. Other students, however, did not like this feature. One student stated that information provided by this feature did not always provide precise information (i.e., location of components), while another student did not understand how to use this feature.

Many students disliked simulator features because these features malfunctioned frequently. Students indicated that 1) correct procedures performed on the 3-D module were recorded as errors or were not recorded at all, 2) the audio cue to attend to the student CRT did not function properly, and 3) the touch panel did not record student responses reliably. Other students indicated that certain controls on the 3-D module were not in correct locations, that the high voltage cables were difficult to attach, that the audio cue to attend to the student CRT was annoying, and that the quality of photographs presented in Segment 1 was poor. One student stated that the flow diagram presented in Segment 1 was backwards.

QUESTION 5: Please make any additional comments you feel are appropriate.

Several students stated that training with the simulator was fast and more interesting than conventional training. Students stated that the simulator could be used for refresher training as well as for advanced individual training. One student felt that the device would be useful for training radar operators as well as mechanics. Many students indicated that there are many problems with the device that need to be corrected. One student stated that his concentration was broken whenever problems developed with the device. Another student felt that the simulator was difficult to use because device malfunctions required him to repeat certain training segments. Several students felt that although "hands-on" experience with high voltage troubleshooting procedures was beneficial, some of these procedures were simplified. They felt that more complex high voltage procedures are necessary. One student stated that it was easy to transfer skills from the simulator to operational equipment.

Structured Interview. Responses to the 13 questions posed during the structured interview are summarized below.

QUESTION 1: What were the instructional features of the simulator that were applicable to the school's training course?

Three of the four interviewees who responded to the question stated that the 3-D module was applicable to the school's training course. They felt that the device could be substituted for operational equipment. Interviewees felt that performance feedback was applicable. The on-site data collector noted that more feedback was provided at the beginning of the lesson while less feedback was provided at the end of a lesson. The repeat lesson feature was applicable since students could repeat a lesson if they did not understand it. Other features interviewees found to be applicable included the self-paced lessons, the universal instructor, the instructor CRT, the call instructor feature, automated malfunction insertion, the video disc system, lesson arrangement, and the hardcopy printout of student performance.

Ratings made by the interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	4	4.5	.58
Rate the potential training value of these features as a whole.	4	5.5	1

QUESTION 2: What were the instructional features of the simulator that were not applicable to the school's training course?

Two interviewees felt that the "chirp" used as a cue to attend to the student CRT was inapplicable because it confused students. One of these interviewees felt that the "chirp" was annoying. These comments contrast with students' responses (page 71) indicating that the "chirp" was helpful.

Several interviewees felt that the automated pre-lesson check was not applicable. One interviewee stated that it was an awkward way of establishing communication between the student CRT and 3-D module, while another felt that this feature was time consuming. Two interviewees felt that the instructor CRT was not applicable. One interviewee indicated that the CRT was useful only when entering commands for enrolling students, repeating a lesson, or skipping lessons. They felt that the information presented on this CRT was not useful. These interviewees also felt that the "call instructor" feature was not applicable. One interviewee stated that this feature slowed the lesson presentation and involved the instructor unnecessarily. Another interviewee noted that students could not "experiment" with meters, switches, and controls because the call instructor message would appear on the student CRT and the lesson would stop if the student attempted to "experiment." Interviewees felt that the editing system was not applicable because it was difficult for an instructor to use this system. They felt that only expert programmers could use the system. Other features described as inapplicable include self-paced lessons, the video disc system, and the universal instructor feature.

QUESTION 3: Which features of the lesson presentation helped make the simulator lessons interesting to the students?

Most interviewees agreed that self-paced lessons were interesting to students. The interviewees also felt that the request help feature made the lessons interesting to students. The course developer stated that this feature provided students with information shortly after it was requested. One interviewee stated that students were interested in lessons in which they were required to locate components on the 3-D module. One interviewee stated that performance feedback made lessons interesting to students since the variety of feedback provided by the device allowed students to know when they were following correct procedures and when they were commiting errors. Other features mentioned by interviewees include the games in Segment 1, high voltage test set procedures, preprogrammed malfunctions, the 3-D module, and the video disc system.

Ratings made by the interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	4	4.75	.96
Rate the potential training value of these features as a whole.	4	5.75	.5

QUESTION 4: Of the lessons taught by the simulator, which ones did you feel were particularly effective?

Two interviewees indicated that Segment 2 (introduction to high voltage) was effective because students were taught nomenclature, parts location, and function. They also stated that Segment 7 (High Voltage Power Supply Test Set procedures) was effective because 1) test procedures were presented in a step-by-step manner, 2) students received "hands-on" experience performing the procedures, and 3) feedback was provided throughout the segment. Two interviewees felt that Segment 8 (troubleshooting the Master Oscillator Filament Power Supply A4) was effective because the student was able to use the student CRT to find the correct symptom and perform the correct troubleshooting tests. Other segments that interviewees noted as effective include Segment 5 (troubleshooting last good/first bad), Segment 6 (high voltage power supply test set), Segment 8 (troubleshooting the PA high voltage PS A2), and Segment 13 (weekly check procedures).

Ratings made by the interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	3	6	1
Rate the potential training value of these features as a whole.	3	6.67	.58

QUESTION 5: Of the lessons taught by the simulator, which ones did you feel were ineffective?

Two interviewees indicated that Segment 4 (indicator relationships) was ineffective. In this segment, students are shown the symptoms of a variety of malfunctions, but are not required to correct the malfunctions. The interviewees felt that this segment was ineffective because students were presented with a great deal of information that would be quickly forgotten. Students progressed through the segment very quickly because they did not want to devote a great deal of time to a lesson that was of little value.

A training specialist felt that Segment 2 (high voltage circuits - games) was ineffective because that segment took too much time to complete and because the block diagram shown on the student CRT in this segment was different from the block diagram provided as a student handout. The interviewee felt that the different diagrams confused students. Other segments that interviewees found to be ineffective include Segment 3 (weekly high voltage checks), Segment 10 (introduction to troubleshooting), and Segment 6 (high voltage power supply test set).

QUESTION 6: Were there any occasions when you felt the difficulty level of the material presented by the simulator was above the students?

None of the interviewees felt that the material presented by the simulator was too difficult for students to understand.

QUESTION 7: Were there any occasions when you felt the difficulty level of the material being presented by the simulator should be increased?

Two interviewees felt that the difficulty level of material presented by the simulator did not need to be increased. One of these interviewees stated that if necessary, however, the difficulty level of lessons could be increased by removing repetitive information from the lessons.

One interviewee stated that the difficulty level for troubleshooting high voltage problems needed to be increased. These lessons could mislead students into believing that each high voltage problem is always caused by a single failed component where in reality these problems may be caused by one of several faulty components or by multiple faulty components. The interviewee also disliked these lessons because certain components (high voltage cables, wiring) were always assumed to function correctly when in reality these components could malfunction.

QUESTION 8: What hardware features of the simulator made it more effective than conventional training?

The interviewees described a variety of features that made the simulator more effective than conventional training. These features include: 1) rapid insertion and removal of malfunctions, 2) durability of simulator components, 3) standardized symptoms of faulty components (symptoms of faulty components may vary on operational equipment), 4) reliability of symptoms (symptoms may disappear on operational equipment before the faulty component is located), 5) safety of the 3-D module (high voltages are not present), 6) accessibility of components of the 3-D module (students are able to stand when working on the 3-D module while they must assume an awkward position when working on operational equipment), 7) the hardcopy printout of student performance, 8) the touch panel, and 9) the video disc system.

Ratings made by the interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	4	5.5	.58
Rate the potential training value of these features as a whole.	4	7	0

QUESTION 9: What were the features that made this simulator easy for the instructors to operate?

Four interviewees felt that the simulator was easy to start. Students could begin using the device after the operator activated a few switches and buttons. Three interviewees felt that the device was easy to operate because it kept track of the lessons that students completed. These interviewees noted that the device automatically presented the student with the appropriate lesson.

Other features mentioned by interviewees include the instructor station, the lesson summary that appeared at the beginning of each lesson, the reliability of the system, the universal instructor, and the automated pre-lesson check.

Ratings made by the interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	5	5.8	.84
Rate the potential training value of these features as a whole	5	6.4	.89

QUESTION 10: What were the features that made this simulator easy for students to operate?

All of the interviewees stated that the touch panel made the simulator easy for students to operate. Two interviewees felt that entering responses on the touch panel was less threatening to students than entering responses on a keyboard. Four interviewees stated that the audio track of the video disc system simplified the task of operating the simulator. This feature reduced the requirement to read text that appeared on the CRT. Interviewees also felt that the audio "chirp" feature, the request help feature, and the 3-D module made the device easy for students to operate.

Ratings made by the interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	5	4.6	.89
Rate the potential training value of these features as a whole.	5	5.8	.84

QUESTION 11: What aspects of the device would be appropriate for substituting for actual equipment?

All of the interviewees who responded to the question concluded that the 3-D module can be substituted for actual equipment. Two interviewees felt that the safety features of the 3-D module (low voltage and minimal generation of heat) make it ideal for substitution for actual equipment. The on-site data collector, however, stated that the simulator could not completely replace actual equipment. She felt that students need to have some training experience on actual equipment.

Other features mentioned by interviewees included the ease of inserting malfunctions into the device and the lessons presented by the device.

Ratings made by the interviewees are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of these features as a whole.	4	5.25	.96
Rate the potential training value of these features as a whole.	4	6.5	.58

QUESTION 12: What types of problems did the students have?

All the interviewees agreed that the reliability of the device created serious problems for students. The device would frequently "lock up" (i.e., would not accept any student input) which required students to repeat the lesson in which they were participating when the lock up occurred. Four interviewees indicated that students experienced problems with the touch panel. Students received error messages even though they touched the panel at the appropriate location. This same problem occurred with the 3-D module. Students received error messages on the CRT when they performed correct procedures on the 3-D module.

A training specialist felt that students were required to spend excessive amounts of time adjusting controls on the 3-D module because the device was overly sensitive. Although displays on the 3-D module indicated that a control had been adjusted correctly, messages on the student CRT indicated that further adjustment was necessary.

Students experienced problems because the call instructor feature could not be disabled. The course developer stated that this feature created problems because it could halt student progress even though very minor errors were committed by the student.

Other problems cited by interviewees include: 1) the poor quality of photographs in Segment 1; 2) the request help feature did not always provide useful information; 3) the lessons presented on the simulator involved the use of an outdated TM (weekly check procedure); and 4) the system frequently required an inordinate amount of time to respond to student input.

QUESTION 13: How would you employ the simulator in order to gain maximum benefit from it?

All of the interviewees agreed that the simulator should be used in a classroom setting. The course developer stated that the simulator should be used in conjunction with actual equipment. Three interviewees stated that under ideal conditions, only one student at a time would work on the device, although the device would still be effective if two students used it at the same time.

Ratings made by the interviewees for the simulator as a whole are presented below:

RATINGS (1 = None, 7 = Greatest)	N	MEAN RATING	STANDARD DEVIATION
Rate the training value of the simulator as a whole.	3	4.3	1.53
Rate the potential training value of the simulator as a whole.	3	6.67	.58

Data Collector Observations. The observations made by the on-site data collector during the evaluation of the Grumman device are summarized below.

- o The training device frequently refused to accept input from the 3-D module, the student touch panel, or the instructor keyboard. When such a "lock up" occurred, the instructor was forced to turn the entire system off and then turn the system on again (i.e., reboot the system) in order to alleviate the "lock up."

- o When an error message appeared on the student CRT, students were required to follow directions in the message (for example, the PA circuit breaker is off, turn it on) before they could continue with a lesson. However, instructors (and students) were not always able to clear such error messages from the CRT in order to continue a lesson. On some occasions, instructors responded to the error message appropriately, but the device did not recognize these corrective actions. On other occasions, additional inappropriate error messages appeared on the student CRT after an initial error message had been cleared. On still other occasions, actions undertaken by an instructor in order to clear an initial error message resulted in a subsequent error message that indicated that the actions undertaken by the instructor were incorrect. (For example, an error message would indicate that switch A should be turned off. When the switch was turned off, an error message would appear indicating that switch A should be turned on.) Problems such as those described above could only be alleviated by rebooting the system.

o The system failed to present an entire lesson to certain students, that is, portions of segments were skipped. Since the device was not designed to allow instructors to repeat portions of segments, the system was rebooted when this error occurred.

o When the system was rebooted before a segment was completed, all information concerning student performance in the current segment was lost. Further, after the system was rebooted, students were required to repeat the entire segment since there was no mechanism to automatically advance to the point where the malfunction occurred. The system was rebooted for nine of the 10 students involved in the evaluation. The mean number of reboots per student was 4.1, resulting in a mean of over two hours of lost training time per student.

o The printout of student performance indicated total elapsed time per segment, number of errors committted per segment, and a performance index related to elapsed time per segment. These measures of performance were frequently incorrect or misleading. The time measure was misleading because it did not account for system reboots. That is, no record was available for the amount of time spent in segments that were rebooted. Further, this measure was frequently inflated. For some segments, students were unaware that they were required to perform an action (press "next" on the touch screen) in order to end a segment and thereby terminate timing.

The number of student errors recorded by the training device differed substantially from the number of errors recorded by the on-site data collector. The device displayed error messages when no error was comittted and it failed to display error messages when errors were committed. Further, many error messages appeared when instructors attempted to rectify legitimate student errors or device malfunctions. These errors, committed by instructors, were included as part of the student performance record. The device also failed to account for errors committed during the first time through segments that were repeated because system reboots were required.

o Students experienced a variety of problems operating controls on the 3-D module. The standby, radiate, and off pushbuttons had to be pressed for an extended period of time before the device recognized that these buttons had been activated. Similarly, the device did not recognize student adjustment of the PA beam control, MO beam control, PA filament control, or the MO filament control unless students made rapid, gross adjustments.

o The touch panel was unreliable. In some segments students were required to touch certain locations on the CRT in order to progress through a lesson. In some instances, students appeared to press the correct location on the CRT, but were provided feedback indicating that their response was incorrect. This type of error occurred most frequently when the angle between the student's finger and the touch panel was significantly greater or less than 90 degrees.

o In some instances, material presented to students on the CRT was degraded or incorrect. Degraded displays included poor quality video frames, and computer-generated text that appeared near the edges of the CRT (the bevel surrounding the CRT obstructed text that appeared near the edges of the CRT). Students were presented with inaccurate diagrams and text on the CRT.

Discussion

Opinions concerning the Grumman device at Fort Bliss are summarized in a series of positive and negative statements that appear below.

Positive Statements. Instructors, course developers, and trainees hold favorable opinions of the Grumman simulator. Instructors indicated that they had little difficulty learning to operate the simulator. The course developer indicated that the simulator curriculum addressed critical tasks and that students trained with the simulator would perform well on operational equipment. Trainees indicated that they enjoyed working with the simulator and felt that they were well-prepared to work on operational equipment. All three of these groups of respondents, however, felt that the utility of the device was limited by its low reliability.

The simulator is safer than operational equipment. Several interviewees and the course developer indicated the students were less likely to injure themselves on the simulator than on operational equipment because low voltages are present in the simulator. Students felt that the simulator was less threatening than operational equipment because lethal voltages are not present.

Certain automated features are valuable. Responses to several different questions indicated that various automated device features were regarded as valuable. These features include the automated pre-lesson check, request help, feedback, and automatic malfunction insertion.

The simulator allows students to practice tasks that cannot be practiced on operational equipment. Students, instructors, and course developers praised the device for its capability to train students to troubleshoot high voltage components of the transmitter. They indicated that conventionally trained students are not taught this important skill because insertion of malfunctions into operational equipment is time consuming, presents a safety hazard, and damages equipment.

Negative Statements. The device frequently malfunctioned. The predominant criticism of the device was its low reliability. Various kinds of hardware and software failures were identified by trainees, the course developer, and instructors. These failures caused numerous delays in training sessions.

Rebooting is a poor method for restarting a lesson. In many cases, rebooting was the only method available to correct a system malfunction. When the system is rebooted, all information pertaining to the current lesson segment is lost. Students were frustrated because frequent rebooting required them to repeat lesson segments.

The instructor CRT provided little valuable information. Instructors had little use for the information presented on the instructor CRT. They did not understand the information that was presented on the CRT and the information they desired (student performance) was not presented on this CRT.

Lessons are inflexible. Instructors were unable to change the sequence in which lessons appeared. Students did not like the fact that they could not repeat segments (or parts of segments) or omit segments (or parts of segments) on request.

DISCUSSION AND CONCLUSIONS

One of the objectives of the AMTESS program is to develop a family of training devices that is applicable to a range of training applications. For example, AMTESS devices should be capable of training both mechanical and electronic maintenance tasks. By comparing the comments of respondents across experiments for each device, we can determine if the perceived effectiveness of the device (and specific device features) varied according to training application (automotive or radar).

The objective of the following discussion is to determine (for each device) the extent to which the opinions of students, instructors, and course developers varied across the radar and automotive applications.

Table 9 displays the positive and negative statements that were presented at the end of each of the six experiments. A comparison of the statements made at the end of Experiments 1 and 2 (the automotive MOSs) reveals many similarities. In both cases, the simulator was generally well-received by students, instructors, and course developers. Further, several of the features that were rated highly in the 63B30 context (malfunction insertion, performance monitoring) were also rated highly in the 63W10 context.

The 63B30 respondents seemed to emphasize the safety value of the device more than the 63W10 respondents. This may be a function of the fact that tasks performed by 63B30 students during the device evaluation (adjust alternator belt, remove/replace starter motor, troubleshoot an oil pump failure, and inspect the electrical system) were more difficult and dangerous than those performed by 63W10 students during the device evaluation (troubleshoot, remove and replace an oil pump).

The 63B30 and 63W10 respondents also made similar negative comments about the Seville/Burtek device. In both cases, respondents disliked the fact that set up and check out of the STE/ICE equipment was not included in the simulator curriculum. The reliability of the device was criticized in both cases, as was the sensitivity of the 3-D module.

The 63B30 respondents criticized the device as being difficult for students to operate because there were many stimuli demanding attention. Although the 63W10 instructor stated that some students experienced difficulty operating the device, he attributed this difficulty to the abbreviated introduction to the device that was provided to students. In general, the 63W10 students may have experienced fewer problems operating the device than the 63B30 students because they performed one relatively simple task while 63B30 students performed several complicated tasks.

More negative comments about the low physical fidelity of the 3-D module were elicited from the 63B30 respondents than from the 63W10 respondents. The negative comment from 63B30 respondents is a function of the low physical fidelity of components associated with the starter motor remove/replace task. Since 63W10 respondents did not perform this task, they did not make similar comments.

The positive comments about the Seville/Burtek device that were made in the context of the 63W10 and 63B30 MOSs (the automotive MOSs) were similar to each other, but somewhat different from the statements presented at the end of Experiment 5, which involves electronic troubleshooting. The outstanding aspect of the Seville/Burtek device noted during Experiment 5 was its ability to provide "hands-on" training for high voltage problems which cannot be taught using operational equipment. Students and instructors repeatedly indicated that this capability was quite valuable. Since students know that they will be required to troubleshoot high voltage components of the Hawk radar in the field (a very dangerous task), they appreciate the opportunity to practice this task in a non-threatening environment. Although

Table 9

Summary of Positive and Negative Statements about the AMTESS Devices

	--- Seville/Burtek Device Experiment 1 (MOS 63B30) ---
Positive:	Respondents hold favorable opinions of the simulator.
	Ease of inserting malfunctions is valuable.
	Performance monitoring is valuable.
	The simulator is safer than operational equipment.
Negative:	Students were confused by the materials to which they must attend.
	Physical fidelity of the 3-D module is too low for certain remove/replace tasks.
	The reliability and durability of the device should be increased.
	Lessons did not include STE/ICE set-up and check-out.
	The 3-D module is too sensitive.
	--- Seville/Burtek Device Experiment 2 (MOS 63W10) ---
Positive:	Respondents hold favorable opinions of the simulator.
	Respondents liked features including feedback, proceduralized instructions, slide projector unit, malfunction insertion.
Negative:	Lessons did not include STE/ICE set-up and check-out.
	The 3-D module is too sensitive.
	The durability of the device is low.
	--- Seville/Burtek Device Experiment 5 (MOS 24C10) ---
Positive:	Respondents hold favorable opinions of the device.
	"Hands-on" troubleshooting is a highly valued device feature.
Negative:	Low fidelity components of the 3-D module reduced device effectiveness.
	--- Grumman Device Experiment 3 (MOS 63H30) ---
Positive:	The ability to perform troubleshooting tasks on the 3-D module is a valuable feature.
	The video disc system is an effective motivating feature.
Negative:	The device frequently malfunctions.
	Lessons are inflexible.
	Some lessons are too simple or inappropriate.
	The student performance record is of little value.
	System response time is too slow.
	--- Grumman Device Experiment 4 (MOS 63D30) ---
Positive:	Students liked features including the 3-D module, the request help feature, the video disc system, proceduralized lessons, and lessons addressing STE/ICE.
Negative:	The device frequently malfunctioned and operated too slowly.
	--- Grumman Device Experiment 6 (MOSs 24E, G, R) ---
Positive:	Respondents hold favorable opinions of the device.
	The device is safer than operational equipment.
	Automated features (request help, pre-lesson check, feedback, malfunction insertion) are valuable.
	The device allows students to practice tasks that cannot be practiced on operational equipment.
Negative:	The device frequently malfunctioned.
	Rebooting is a poor method for restarting a lesson.
	The instructor CRT provides little valuable information.
	Lessons are inflexible.

the Seville/Burtek device also allows 63W10 and 63B30 students an opportunity to practice tasks that are not included in conventional training (due to potential equipment damage), this feature of the device is less important for these automotive MOSs because the tasks are not dangerous to the student and the tasks comprise a small part of the automotive curriculum whereas the high voltage tasks comprise a substantial aspect of the radar curriculum.

The negative comments for the 63W10 and the 63B30 respondents are also similar to each other and disparate from the negative comment from the 24C10 respondents. Respondents from both automotive MOSs commented negatively on the lack of STE/ICE lessons, the high sensitivity of the 3-D module to remove/replace activities and the low reliability of the device. The first two comments do not apply to the Seville/Burtek device at Fort Bliss since it does not involve STE/ICE or remove/replace activities. Although the slide projector unit failed at Fort Bliss, these failures were apparently less severe than those at APG. Further, the low reliability of the device at APG also addresses failure of components (bolts, coils) involved in remove/replace activities. These failures did not occur at Fort Bliss since remove/replace tasks were not performed.

The 63B30 respondents at APG and the respondents at Fort Bliss agreed that the low physical fidelity of certain components of the 3-D modules detracted from the effectiveness of the device. This comment applies to quite different tasks at the two locations. At APG, the lack of a propeller shaft and frame on the 3-D module made the starter motor remove/replace task simple to perform on the simulator. Students were not well-prepared to perform this task on operational equipment, however, when they were required to maneuver around obstacles (propeller shaft and frame) not represented on the simulator. At Fort Bliss, students indicated that they experienced difficulty troubleshooting the local oscillator tuning motor, cavity tuning motor, and arc detector crystals because these components were represented on the simulator with low physical and functional fidelity.

The similarities and differences between the comments made by respondents at APG and Fort Bliss for the Grumman device parallel those for the Seville/Burtek device in that comments about the automotive MOSs are somewhat similar to each other and different from comments about the missile MOSs.

Positive comments about the Grumman device in Experiment 3 centered around two valuable device features: troubleshooting on the 3-D module, and the video disc system. Comments derived from Experiment 4 are limited, but they also address device features including the 3-D module and the video disc system.

The overriding negative comment for both Experiment 3 and Experiment 4 concerns the reliability of the device. In both experiments, students and instructors stated that device malfunctions resulted in numerous delays. Other negative comments reported in Experiment 3 (inflexible lessons, simple/inappropriate lessons, insufficiently detailed student performance record) were not reported in Experiment 4. This difference is artifactual since much more data was reported in the former experiment than in the latter.

As was the case with the Seville/Burtek device at Fort Bliss, the most important feature of the Grumman device at Fort Bliss is its ability to provide safe, hands-on troubleshooting practice for high voltage problems. These problems cannot normally be taught with operational equipment.

The list of automated features that were rated highly by the respondent at Fort Bliss overlaps considerably with the features that were rated highly in the automotive MOSs. However, the video disc system, a major component of the Grumman device, was rated more highly by respondents in Experiments 3 and 4 than by respondents in Experiment 6. Respondents in Experiments 3 and 4 felt that the high resolution graphics and audio track of the video disc system were helpful to soldiers because they possessed minimal reading skills. The video disc system may not have been valued as highly at Fort Bliss because the soldiers participating in the study possessed considerable skill in reading and interpreting schematics, flow charts, etc. Thus, the video disc system may have been "overkill" at Fort Bliss.

The negative comments about the Grumman device at Fort Bliss are similar to the negative comments about the device at APG. Frequent device malfunctions and the subsequent requirement to reboot the system are the predominant negative comments. Respondents at Fort Bliss and at APG both noted the inflexible nature of lesson segments. Additionally, respondents at Fort Bliss noted the limited value of the instructor CRT. This weakness may have been noticed to a greater degree at Fort Bliss than at APG because there was great interest in modifying the lesson arrangement at Fort Bliss, but not at APG.

In summary, respondents in the radar and automotive MOSs generally made the same type of comments about the devices. There are, however, several notable exceptions:

1. For both devices, respondents at Fort Bliss emphasized the simulators' capability to provide hands-on practice to a greater extent than did respondents at APG.

2. For the Grumman device, respondents at APG commented on the value of the video disc system to a greater extent than di ' respondents at APG.

3. The 63B30 students at APG (Seville/Burtek device) reported confusion with respect to the number of stimuli to which they were required to attend. This negative comment was not made by 63W10 students or by students at Fort Bliss.

The preceding discussion compared comments made by respondents in different MOSs. While this information is valuable, it does not provide an assessment of the conceptual approaches undertaken by the two device manufacturers. The purpose of this section of the report is to integrate the results of all six experiments in order to determine the benefits and liabilities of the conceptual approach utilized by Grumman and Seville/Burtek.

Benefits of the Grumman Approach

The Grumman approach can be characterized as one that incorporates recent advances in microelectronics and video storage. Respondents at APG indicated that they were favorably impressed by the video disc approach used in the Grumman device. The still and motion video frames presented on the student CRT were useful at both locations. The sound track of the video disc system was especially useful at APG since the soldiers who used the device at APG possessed poor reading skills. The touch panel simplified the students' tasks and added to their enthusiasm for using the training device. The component location "games" included as part of the curriculum at Fort Bliss also seemed to heighten student interest in the simulator.

A second, and perhaps more important, benefit of the Grumman approach, is the ability of the device to train students to perform tasks that cannot be practiced on operational equipment. This benefit was especially important at Fort Bliss since it is highly useful for radar mechanics to practice troubleshooting high voltage problems.

Liabilities of the Grumman Approach

The predominant liability of the Grumman approach is the very low reliability of the training device. This low reliability prevented instructors from understanding how to operate the device (the effectiveness of operator training sessions was seriously limited by device malfunctions), caused numerous delays in training sessions, and adversely affected student and instructor attitude towards working with the device. Although it is acknowledged that the reliability of a breadboard device cannot be expected to be as great as the reliability of a production model, the device must function well enough to demonstrate its capabilities. If the reliability of the device cannot be improved significantly without substantial effort, then the utility of the device is questionable.

Opinions solicited from individuals at both locations indicate that the device is inflexible. This inflexibility is manifested in several ways: 1) it would be costly and time consuming to change the material that is presented by the video disc system, 2) student progress through each segment more closely resembles lockstep training than it does self-paced training, 3) the order in which students participate in training segments cannot be readily changed, and 4) the call instructor feature cannot be disabled by an instructor while a segment is in progress.

The manner in which malfunctions are inserted and removed from the device is awkward and time consuming. For example, at the start of the weekly check procedures, an instructor is required to spend a considerable amount of time ensuring that controls on the 3-D module are set to correct positions. As a student progresses through a lesson, these controls are set to a variety of new positions requiring the instructor to correctly reset the controls again after the lesson has been completed. This procedure of setting and resetting controls wastes a great deal of instructors' time.

Benefits of the Seville/Burtek Approach

As was the case with the Grumman device, the Seville/Burtek device allows students to practice tasks that they could not practice on operational equipment. Although this feature is especially important for training students to perform high voltage tasks on the radar transmitter at Fort Bliss, it was also found to be appropriate at APG.

Data gathered from both locations on both devices indicated that the device was quite flexible. Instructional materials presented to students by the slide projector or the student CRT can be updated easily. Students may skip steps in a lesson (if the instructor chooses) and may complete lessons in any sequence desired by the instructor. Further, the halt on student error feature can be disabled by an instructor during the course of a lesson.

The Seville/Burtek device was found to be fairly reliable. Although difficulties with the slide projector unit were experienced, these difficulties did not seriously delay training sessions.

Insertion of malfunctions is simple and efficient. At the beginning of the weekly check procedure, for example, instructors spend a minimal amount of time setting controls on the 3-D module out of tolerance. As students progress through a lesson, they must set these controls back to specific correct settings. Thus, it is the student rather than the instructor who must expend effort setting controls to their correct positions.

Liabilities of the Seville/Burtek Approach

At APG (especially the 63B30 MOS), it seemed that there were too many stimuli that required student attention. Further, procedures for entering decisions on the student station were somewhat complicated. A different approach for presenting information to students and accepting information from students appears warranted. That is, the number of stimuli to which students must attend should be decreased.

The durability of the Seville/Burtek device should be increased. If the device is to incorporate an effective remove/replace capability, the helical coils, bolts, etc. must be "hardened" to withstand the rigors of normal use.

Conclusions

The data reported in this volume of the report are diverse and substantial. Individuals with very different backgrounds and attitudes towards training devices provided information about the AMTESS devices. Two conclusions can be drawn from these diverse data:

- The conceptual approaches to generic, modular maintenance training devices developed by Grumman and Seville/Burtek are viable. Although deficiencies in both devices were noted, data presented in this report indicate enthusiasm for this type of training device.

- The utility of the devices (and specific device features) varies according to training application. Additional research is required to identify the conditions under which the training effectiveness of the devices (and device features) are optimized.

REFERENCES

Criswell, E. L., Unger, K. W., Swezey, R. W., & Hays, R. T. (1983). Army maintenance training and evaluation simulation system (AMTESS) development and device features (ARI Technical Report 589). Alexandria, VA: U.S. Army Research Institute. (AD A146 237)

Dybas, R. T. (1981). Army maintenance training and evaluation simulation system (AMTESS). In I/ITEC Proceedings. Orlando, FL: PMTRADE.

Dybas, R. T. (1983). Army maintenance training and evaluation simulation system (AMTESS). Paper presented at Interanational Conference on Simulators. London, England: Institute of Electrical Engineers.

Woelfel, J. C., Duffy, P. J., Unger, K. W., Swezey, R. W., Hays, R. T., & Mirabella, A. (1984). A critical review of front-end analysis procedures employed in the Army maintenance training and evaluation system (AMTESS) (SAI Report No.: SAI-84-01-178). McLean, VA: Science Applications, Inc.

APPENDIX A

QUESTIONNAIRES AND STRUCTURED INTERVIEW PROTOCOL USED DURING THE EVALUATION OF THE AMTESS DEVICES

TRAINEE QUESTIONNAIRE

Please answer the following questions about the simulator:

1. How do you feel about the simulator? (Circle one.)

LIKE IT VERY MUCH	LIKE IT SOMEWHAT	NO STRONG FEELINGS ABOUT IT	DISLIKE IT SOMEWHAT	DISLIKE IT VERY MUCH

2. Why did you answer question #1 as you did?

3. What specific features of the simulator do you like or dislike?

4. Why do you like or dislike these features?

5. Please make any additional comments you feel are appropriate.

INITIAL INSTRUCTOR QUESTIONNAIRE

Please answer the following questions about the simulator:

1. How easy or hard is it to learn to use the simulator? (Circle one.)

VERY EASY	FAIRLY EASY	AVERAGE	FAIRLY HARD	VERY HARD

2. Why did you answer question #1 as you did?

3. How do you feel about the simulator? (Circle one.)

LIKE IT VERY MUCH	LIKE IT SOMEWHAT	NO STRONG FEELINGS ABOUT IT	DISLIKE IT SOMEWHAT	DISLIKE IT VERY MUCH

4. Why did you answer question #3 as you did?

5. Please make any additional comments you feel are appropriate.

INSTRUCTOR QUESTIONNAIRE

TASK TO BE TRAINED: ______________________________

Please answer the following questions about the simulator:

1. How well does the simulator train this task? (Circle one.)

VERY WELL	MODERATELY WELL	FAIR	POORLY	VERY POORLY

2. Why did you answer question #1 as you did?

3. What specific features of the simulator (involved in this task) do you like or dislike?

4. Why do you like or dislike these features?

5. Please make any additional comments you feel are appropriate.

COURSE DEVELOPER QUESTIONNAIRE

TASK TO BE TRAINED:____

Please answer the following questions about the simulator:

1. Is this a critical task which needs to be trained? (Circle one.)

YES NO

2. Is this task currently trained on operational equipment?

YES NO

If no, why not?

3. How difficult is it to perform this task?

VERY DIFFICULT	SOMEWHAT DIFFICULT	ABOUT AVERAGE IN DIFFICULTY	SOMEWHAT EASY	VERY EASY

4. At what skill level should a trainee perform this task at the end of training?

NOVICE	BETTER THAN NOVICE	APPRENTICE	LESS THAN EXPERT	EXPERT

5. Please make any additional comments you feel are appropriate.

STRUCTURED INTERVIEW FOR AMTESS SIMULATORS

NAME: ______________________ GRADE: ______________________

TITLE: ______________________ DATE: ______________________

FORT BLISS: ____________ ABERDEEN PROVING GROUND: ____________

MANUFACTURER: GRUMMAN ____ SEVILLE/BURTEK ______

SIMULATOR CONFIGURATION:

____ HAWK MISSILE TRANSMITTER

____ NHC-250 DIESEL ENGINE

____ M-110A2 STARTING/CHARGING SYSTEM

MOS OF STUDENTS TAUGHT ON SIMULATOR:

24C10 ____ 63W10 ____ 63B30 ____ 63D30 ____ 63H30 ____

CONDUCTED BY: ______________________

PURPOSE:

This interview is being conducted as part of the evaluation of the Army Maintenance Training and Evaluation Simulation System (AMTESS) breadboard simulators. The purpose of the AMTESS study is to appraise different configurations and features of generic training devices addressing various maintenance tasks.

OBJECTIVE:

The objective of this effort is to collect qualitative data from those who have expert knowledge of these devices or have taught experiment students with the simulators. The results of this material will then be reported in conjunction with other quantitative information.

METHOD:

The interview will be conducted on an individual basis and will require from one and one-half to two hours to complete. It consists of 13 questions. The arrangement of the questionnaire is as follows: 1 through 7 address instructional subjects, 8 through 11 refer to hardware features and the remaining two questions are general in nature. Finally, at the end of each question, the subject matter expert/instructor will be asked to rate the simulator features for their training value in the present setting and their potential training value.

VALUE:

The data collected from these interviews will be a portion of the qualitative material gathered for this study. The information learned from subject matter experts/instructors will be valuable in the evaluation of the AMTESS concept of generic maintenance trainers.

INSTRUCTIONAL

1. What were the instructional features of the simulator that were applicable to the school's training course?

- o Automated performance feedback
- o Automated malfunction insertion
- o Hardcopy
- o Programmed task scenarios/ lessons
- o Editing capabilities
- o 3-Dimensional module

Grumman

- o 3-D module
- o CRT feedback
- o Audio feedback
- o Sound affects
- o Printer
- o Hardcopy
- o Arrangement of lessons on program
- o Editing capability
- o Universal instructor
- o Student file
- o Student CRT
- o Instructor CRT
- o Automated pre-lesson check
- o Video disc and player
- o Floppy disc and drive
- o Call instructor after 2 errors
- o Request repeat of lesson on CRT
- o Self-paced

Seville/Burtek

- o 3-D module
- o Student CRT feedback
- o Instructor CRT feedback
- o Hardcopy
- o Student file
- o Program arrangement
- o Malfunction insertion
- o Troubleshoot only
- o Remove/replace capability
- o Editing system
- o Random malfunction selection
- o Visual projection unit
- o Floppy disc and drive
- o Self-paced

RESPONSE:

A. Rate the training value of these features as a whole.

NEVER USED OR UNAVAILABLE	NONE	MINIMAL	SOME	MODERATE	CONSIDERABLE	GREAT	GREATEST
0	1	2	3	4	5	6	7

B. Rate the potential training value of these features as a whole.

NONE	MINIMAL	SOME	MODERATE	CONSIDERABLE	GREAT	GREATEST
1	2	3	4	5	6	7

INSTRUCTIONAL

2. What were the instructional features of the simulator that were not applicable to the school's training course?

	Grumman	Seville/Burtek
o Automated performance feedback	o 3-D module	o 3-D module
o Automated malfunction insertion	o CRT feedback	o Student CRT feedback
o Hardcopy	o Audio feedback	o Instructor CRT feedback
o Programmed task scenarios/ lessons	o Sound affects	o Hardcopy
o Editing capabilities	o Printer	o Student file
o 3-Dimensional module	o Hardcopy	o Program arrangement
	o Arrangement of lessons on program	o Malfunction insertion
	o Editing capability	o Troubleshoot only
	o Universal instructor	o Remove/replace capability
	o Student file	o Editing system
	o Student CRT	o Random malfunction selection
	o Instructor CRT	o Visual projection unit
	o Automated pre-lesson check	o Floppy disc and drive
	o Video disc and player	o Self-paced
	o Floppy disc and drive	
	o Call instructor after 2 errors	
	o Request repeat of lesson on CRT	
	o Self-paced	

RESPONSE:

3. In your opinion, which features of the lesson presentation helped make the simulator lessons interesting to the students?

****

	Grumman	Seville/Burtek
o Automated performance feedback/hardcopy	o Self-paced	o Student CRT material
o Method of lesson presentation	o Request help on CRT	o List of responder numbers
o Pre-programmed malfunctions	o Photos	o Student responder unit
o Self-paced/pacing of lesson	o Graphics	o Self-paced
o Audio/visuals	o Audio	o Visual projection unit
	o Printed material	o Slides
	o Sound effects	o Technical manuals
	o Hardcopy	o 3-D module
	o 3-D module	o Sound effects
	o Technical manuals	o Audio signals
	o Speed of presentation	o CRT feedback
	o Speed of computer	
	o CRT feedback	

****

RESPONSE:

****

A. Rate the training value of these features as a whole.

NEVER USED OR UNAVAILABLE	NONE	MINIMAL	SOME	MODERATE	CONSIDERABLE	GREAT	GREATEST
0	1	2	3	4	5	6	7

B. Rate the potential training value of these features as a whole.

NONE	MINIMAL	SOME	MODERATE	CONSIDERABLE	GREAT	GREATEST
1	2	3	4	5	6	7

****

INSTRUCTIONAL

4. Of the lessons taught by the simulator, which ones did you feel were particularly effective?

	Grumman	Seville/Burtek
o Identify the lesson o Why?	o See Instructor Guides for listings	o See Instructor Guides for listings

RESPONSE:

A. Rate the training value of these lessons as a whole.

NEVER USED OR UNAVAILABLE	NONE	MINIMAL	SOME	MODERATE	CONSIDERABLE	GREAT	GREATEST
0	1	2	3	4	5	6	7

B. Rate the potential training value of these lessons as a whole.

NONE	MINIMAL	SOME	MODERATE	CONSIDERABLE	GREAT	GREATEST
1	2	3	4	5	6	7

INSTRUCTIONAL

5. Of the lessons taught by the simulator, which ones did you feel were ineffective?

	Grumman	Seville/Burtek
o Identify the lesson o Why?	o See Instructor Guides for listings	o See Instructor Guides for listings

RESPONSE:

INSTRUCTIONAL

6. Were there any occassions when you felt that the difficulty level of the material being presented by the simulator was above the students?

	Grumman	Seville/Burtek
o Which occasions and why?	o Troubleshooting	o Troubleshooting
o What level of student more appropriate?	o Using test equipment	o Remove/replace
o How would you make it more compatible?	o Lesson number	o Task guide number
o Pacing	o Segment number	o Lesson number
	o Use of manuals	o Use of manuals
	o Operation of device	o Operation of device

RESPONSE:

INSTRUCTIONAL

7. Were there any occassions when you felt that the difficulty level of the material being presented by the simulator should be increased?

	Grumman	Seville/Burtek
o Which occasions and why?	o Troubleshooting	o Troubleshooting
o What level of student more appropriate?	o Using test equipment	o Remove/replace
o How would you make it more compatible?	o Lesson number	o Task guide number
o Pacing	o Segment number	o Lesson number
	o Use of manuals	o Use of manuals
	o Operation of device	o Operation of device

RESPONSE:

HARDWARE

8. What hardware features of the simulator made it more effective than conventional training?

- o Accessibility of components
- o Safety
- o Time/cost effectiveness

Grumman

- o Low voltage on 3-D
- o 3-D module
- o Printer
- o Hardcopy
- o Student CRT
- o Instructor CRT
- o Video disc and player
- o Floppy disk and drive
- o Touch panel
- o Keyboard
- o Computer

Seville/Burtek

- o Low voltage on 3-D
- o 3-D module
- o Student CRT
- o Response panel
- o List of responder numbers
- o Visual projection unit
- o Instructor CRT
- o Instructor keyboard
- o Instructor panel
- o Printer
- o Hardcopy
- o Floppy disk and drive
- o Computer

RESPONSE:

A. Rate the training value of these features as a whole.

NEVER USED OR UNAVAILABLE	NONE	MINIMAL	SOME	MODERATE	CONSIDERABLE	GREAT	GREATEST
0	1	2	3	4	5	6	7

B. Rate the potential training value of these features as a whole.

NONE	MINIMAL	SOME	MODERATE	CONSIDERABLE	GREAT	GREATEST
1	2	3	4	5	6	7

HARDWARE

.9. What were the features that made this simulator easy for the instructors to operate?

	Grumman	Seville/Burtek
o Instructor station	o Video disc and player	o Instructor CRT
o Instructor guidebook	o Floppy disk and drive	o Instructor panel
o Editing capability	o CRT	o Panel
o Reliability	o Keyboard	o Printer
	o Guidebook	o Disk drive
	o Printer	o Programmed lessons
	o Printout for each lesson	o 3-D module
	o Student CRT	o Editing system
	o Touch panel	o Malfunction list
	o 3-D module	o Variable endings on tasks
	o Self-check at start of task	o Task/activity guides
	o Programmed lessons	o Troubleshooting exercises
	o Universal instructor	o Flexible program
	o Editing system	o Remove/replace
		o Visual projection unit
		o Student CRT
		o Student responder

RESPONSE:

A. Rate the training value of these features as a whole.

NEVER USED OR UNAVAILABLE	NONE	MINIMAL	SOME	MODERATE	CONSIDERABLE	GREAT	GREATEST
0	1	2	3	4	5	6	7

B. Rate the potential training value of these features as a whole.

NONE	MINIMAL	SOME	MODERATE	CONSIDERABLE	GREAT	GREATEST
1	2	3	4	5	6	7

HARDWARE

10. What were the features that made this simulator easy for the students to operate?

- Student module
- Components of the 3-D module
- Student Guidebook

Grumman

- Touch panel
- Audio
- 3-D module
- Guidebook

Seville/Burtek

- Student responder system
- 3-D module
- Guidebook

RESPONSE:

A. Rate the training value of these features as a whole.

NEVER USED OR UNAVAILABLE	NONE	MINIMAL	SOME	MODERATE	CONSIDERABLE	GREAT	GREATEST
0	1	2	3	4	5	6	7

B. Rate the potential training value of these features as a whole.

NONE	MINIMAL	SOME	MODERATE	CONSIDERABLE	GREAT	GREATEST
1	2	3	4	5	6	7

HARDWARE

11. What aspects of the device would be appropriate for substituting for actual equipment?

- Ease of inserting malfunctions
- Hardcopy of student performance
- Safety
- Avoidance of routine tasks (removing access panels)

Grumman

- 3-D module
- Hardcopy
- Student record
- Programmed lessons
- Student CRT

Seville/Burtek

- 3-D module
- Hardcopy
- Student record
- Programmed lessons
- Malfunction insertion
- Flexible program
- Student CRT
- Visual display unit
- Graphics

RESPONSE:

A. Rate the training value of these features as a whole.

NEVER USED OR UNAVAILABLE	NONE	MINIMAL	SOME	MODERATE	CONSIDERABLE	GREAT	GREATEST
0	1	2	3	4	5	6	7

B. Rate the potential training value of these features as a whole.

NONE	MINIMAL	SOME	MODERATE	CONSIDERABLE	GREAT	GREATEST
1	2	3	4	5	6	7

GENERAL

12. What types of problems did the students have?

	Grumman	Seville/Burtek
o Difficulty following lesson o Lack of feedback o Difficulty operating device o Malfunctions	o Lock ups o 3-D module breaks o Touch panel o CRT indicating errors not made o Using manuals	o Too little feedback during remove/replace o 3-D module breaks o Student responder panel o List of responder numbers o Using manuals

RESPONSE:

GENERAL

13. How would you employ the simulator in order to gain maximum benefit from it?

	Grumman	Seville/Burtek
o Classroom/field units-deployment	o 63D10 AIT	o 63W10
o Simulator:Student ratio	o Battalion level field units	o 63B30
o In conjunction with actual equipment or by itself	o D.S. vs. Organizational	o D.S. vs. Organizational
	o OJT	o OJT

RESPONSE:

A. Rate the training value of this simulator as a whole.

NEVER USED OR UNAVAILABLE	NONE	MINIMAL	SOME	MODERATE	CONSIDERABLE	GREAT	GREATEST
0	1	2	3	4	5	6	7

B. Rate the potential training value of this simulator as a whole.

NONE	MINIMAL	SOME	MODERATE	CONSIDERABLE	GREAT	GREATEST
1	2	3	4	5	6	7

APPENDIX B

RAW DATA FROM QUESTIONNAIRES ADMINISTERED DURING EXPERIMENT 1

Table B-1

Responses to the Instructor Questionnaire
Administered during Experiment 1

QUESTION: How well does the simulator train this task?
RATINGS: 1 = very poorly
2 = poorly
3 = fair
4 = moderately well
5 = very well

Task Number	Description	Rating
4	Remove and replace oil pump	5
5	Perform an oil pressure test using STE/ICE	5
6	Remove and replace thermostat	5
7	Remove and replace water pump	5
8	Remove and replace alternator	5
9	Perform a DC voltage test using STE/ICE	5
10	Remove and replace starter motor	5
11	Perform a DC current test using STE/ICE	3
12	Remove and replace fuel pump	4
13	Perform a resistance test using STE/ICE	4
17	Troubleshoot and repair engine (oil pump failure-low pressure)	5
18	Troubleshoot and repair the cooling system (thermostat failure-low temperature)	4
19	Troubleshoot and repair the cooling system (water pump failure-high temperature)	4
20	Troubleshoot and repair fuel system (fuel pump failure-engine stalls)	4
21	Troubleshoot and repair electrical system (starter motor failure-slow start)	3
22	Troubleshoot and repair electrical system (alternator failure-high charge)	4
23	Troubleshoot and repair electrical system (loose alternator belt-low charge)	4
24	Troubleshoot and repair electrical system (alternator failure-BG point low)	4
25	Troubleshoot and repair electrical system (fuel pump failure-hard start)	4
26	Troubleshoot and repair electrical system (battery switch failure)	5
27	Troubleshoot and repair electrical system (front harness failure)	4
28	Troubleshoot and repair NHC-250 Diesel (protective control box failure)	4

Table B-2

Responses to Question 1 of the Course Developer Questionnaire Administered during Experiment 1

QUESTION: Is this a critical task which needs to be trained?
RESPONSE: Yes, No

Task Number	Description	Responses Developer 1	Responses Developer 2
4	Remove and replace oil pump	Y	N
5	Perform an oil pressure test using STE/ICE	Y	N
6	Remove and replace thermostat	Y	N
7	Remove and replace water pump	Y	N
8	Remove and replace alternator	Y	Y
9	Perform a DC voltage test using STE/ICE	Y	Y
10	Remove ane replace starter motor	Y	Y
11	Perform a DC current test using STE/ICE	Y	Y
12	Remove and replace fuel pump	Y	Y
13	Perform a resistance test using STE/ICE	Y	N
17	Troubleshoot and repair engine (oil pump failure-low pressure)	Y	Y
18	Troubleshoot and repair the cooling system (thermostat failure-low temperature)	Y	N
19	Troubleshoot and repair the cooling system (water pump failure-high temperature)	Y	N
20	Troubleshoot and repair electrical system (fuel pump failure-engine stalls)	Y	Y
21	Troubleshoot and repair electrical system (starter motor failure-slow start)	Y	Y
22	Troubleshoot and repair electrical system (alternator failure-high charge)	Y	Y
23	Troubleshoot and repair electrical system (loose alternator belt-low charge)	Y	N
24	Troubleshoot and repair electrical system (alternator failure-BG point low)	Y	N
25	Troubleshoot and repair electrical system (fuel pump failure-hard start)	Y	Y
26	Troubleshoot and repair electrical system (battery switch failure)	Y	Y
27	Troubleshoot and repair electrical system (front harness failure)	Y	Y
28	Troubleshoot and repair NHC-250 Diesel (protective control box failure)	-	-

Table B-3

Responses to Question 2 of the Course Developer Questionnaire Administered during Experiment 1

QUESTION: Is this task currently trained on operational equipment?
RESPONSE: Yes, No

Task Number	Description	Responses Developer 1	Responses Developer 2
4	Remove and replace oil pump	Y	Y[a]
5	Perform an oil pressure test using STE/ICE	N	Y
6	Remove and replace thermostat	Y	Y
7	Remove and replace water pump	Y	Y
8	Remove and replace alternator	Y	Y
9	Perform a DC voltage test using STE/ICE	Y	Y
10	Remove ane replace starter motor	Y	Y
11	Perform a DC current test using STE/ICE	Y	Y
12	Remove and replace fuel pump	Y	Y
13	Perform a resistance test using STE/ICE	Y	N[b]
17	Troubleshoot and repair engine (oil pump failure-low pressure)	Y	Y
18	Troubleshoot and repair the cooling system (thermostat failure-low temperature)	Y	Y
19	Troubleshoot and repair the cooling system (water pump failure-high temperature)	Y	Y
20	Troubleshoot and repair electrical system (fuel pump failure-engine stalls)	Y	Y
21	Troubleshoot and repair electrical system (starter motor failure-slow start)	Y	Y
22	Troubleshoot and repair electrical system (alternator failure-high charge)	Y	Y
23	Troubleshoot and repair electrical system (loose alternator belt-low charge)	Y	Y
24	Troubleshoot and repair electrical system (alternator failure-BG point low)	Y	Y
25	Troubleshoot and repair electrical system (fuel pump failure-hard start'	Y	Y
26	Troubleshoot and repair electrical system (battery switch failure)	Y	Y
27	Troubleshoot and repair electrical system (front harness failure)	Y	Y
28	Troubleshoot and repair NHC-250 Diesel (protective control box failure)	-	-

[a]Course developer indicated that this task is taught on operational equipment only to support the AMTESS evaluation.

[b]Course developer indicated that this task is taught on an engine other than the Cummins NHC-250.

Table B-4

Responses to Question 3 of the Course Developer Questionnaire Administered during Experiment 1

QUESTION: How difficult is it to perform this task?
RATINGS: 1 = very easy
2 = somewhat easy
3 = about average in difficulty
4 = somewhat difficult
5 = very difficult

Task Number	Description	Responses Developer 1	Responses Developer 2
4	Remove and replace oil pump	3	3
5	Perform an oil pressure test using STE/ICE	3	3
6	Remove and replace thermostat	2	2
7	Remove and replace water pump	4	3
8	Remove and replace alternator	2	3
9	Perform a DC voltage test using STE/ICE	3	4
10	Remove ane replace starter motor	3	4
11	Perform a DC current test using STE/ICE	4	4
12	Remove and replace fuel pump	3	4
13	Perform a resistance test using STE/ICE	4	2
17	Troubleshoot and repair engine (oil pump failure-low pressure)	4	2
18	Troubleshoot and repair the cooling system (thermostat failure-low temperature)	4	2
19	Troubleshoot and repair the cooling system (water pump failure-high temperature)	4	2
20	Troubleshoot and repair electrical system (fuel pump failure-engine stalls)	4	4
21	Troubleshoot and repair electrical system (starter motor failure-slow start)	4	4
22	Troubleshoot and repair electrical system (alternator failure-high charge)	4	4
23	Troubleshoot and repair electrical system (loose alternator belt-low charge)	4	2
24	Troubleshoot and repair electrical system (alternator failure-BG point low)	4	4
25	Troubleshoot and repair electrical system (fuel pump failure-hard start)	4	4
26	Troubleshoot and repair electrical system (battery switch failure)	4	4
27	Troubleshoot and repair electrical system (front harness failure)	4	4
28	Troubleshoot and repair NHC-250 Diesel (protective control box failure)	-	-

Table B-5

Responses to Question 4 of the Course Developer Questionnaire Administered during Experiment 1

QUESTION: At what skill level should a trainee perform this task at the end of training?

RATINGS: 1 = novice
2 = better than novice
3 = apprentice
4 = less than expert
5 = expert

Task Number	Description	Responses Developer 1	Responses Developer 2
4	Remove and replace oil pump	3	3
5	Perform an oil pressure test using STE/ICE	3	3
6	Remove and replace thermostat	4	3
7	Remove and replace water pump	3	3
8	Remove and replace alternator	4	4
9	Perform a DC voltage test using STE/ICE	3	3
10	Remove ane replace starter motor	4	3
11	Perform a DC current test using STE/ICE	3	3
12	Remove and replace fuel pump	3	3
13	Perform a resistance test using STE/ICE	3	3
17	Troubleshoot and repair engine (oil pump failure-low pressure)	3	4
18	Troubleshoot and repair the cooling system (thermostat failure-low temperature)	4	4
19	Troubleshoot and repair the cooling system (water pump failure-high temperature)	4	4
20	Troubleshoot and repair electrical system (fuel pump failure-engine stalls)	4	3
21	Troubleshoot and repair electrical system (starter motor failure-slow start)	4	3
22	Troubleshoot and repair electrical system (alternator failure-high charge)	4	3
23	Troubleshoot and repair electrical system (loose alternator belt-low charge)	4	4
24	Troubleshoot and repair electrical system (alternator failure-BG point low)	4	3
25	Troubleshoot and repair electrical system (fuel pump failure-hard start)	4	3
26	Troubleshoot and repair electrical system (battery switch failure)	4	3
27	Troubleshoot and repair electrical system (front harness failure)	4	3
28	Troubleshoot and repair NHC-250 Diesel (protective control box failure)	-	-

APPENDIX C

RAW DATA FROM QUESTIONNAIRES ADMINISTERED DURING EXPERIMENT 2

Table C-1

Responses to the Instructor Questionnaire
Administered during Experiment 2

QUESTION: How well does the simulator train this task?
RATINGS: 1 = very poorly
2 = poorly
3 = fair
4 = moderately well
5 = very well

Task Number	Description	Rating
4	Remove and replace oil pump	5
5	Perform an oil pressure test using STE/ICE	5
6	Remove and replace thermostat	3
7	Remove and replace water pump	5
8	Remove and replace alternator	3
9	Perform a DC voltage test using STE/ICE	5
10	Remove and replace starter motor	4
11	Perform a DC current test using STE/ICE	5
12	Remove and replace fuel pump	5
13	Perform a resistance test using STE/ICE	5
17	Troubleshoot and repair engine (oil pump failure-low pressure)	5
18	Troubleshoot and repair the cooling system (thermostat failure-low temperature)	5
19	Troubleshoot and repair the cooling system (water pump failure-high temperature)	5
20	Troubleshoot and repair fuel system (fuel pump failure-engine stalls)	5
21	Troubleshoot and repair electrical system (starter motor failure-slow start)	5
22	Troubleshoot and repair electrical system (alternator failure-high charge)	5
23	Troubleshoot and repair electrical system (loose alternator belt-low charge)	5
24	Troubleshoot and repair electrical system (alternator failure-BG point low)	5
25	Troubleshoot and repair electrical system (fuel pump failure-hard start)	5
26	Troubleshoot and repair electrical system (battery switch failure)	5
27	Troubleshoot and repair electrical system (front harness failure)	5
28	Troubleshoot and repair NHC-250 Diesel (protective control box failure)	5

APPENDIX D
RAW DATA FROM QUESTIONNAIRES ADMINISTERED DURING EXPERIMENT 3

Table D-1

Responses to the Instructor Questionnaire Administered during Experiment 3

QUESTION: How well does the simulator train this task?
RATINGS: 1 = very poorly
2 = poorly
3 = fair
4 = moderately well
5 = very well

Lesson	Segments	Ratings Instructor No. 1	2	3	4	5	6
Introduction	0: Introduction, Part 1	4	5	5	3	2	3
	1: Introduction, Part 2	3	4	3	2	1	3
1	2: VTM Set-up and Check-Out Tutorial	5	-	3	-	2	2
	3: VTM Set-up and Check-out Exercise	5	5	4	-	2	2
2	4: Introduction to the Starting System	4	-	4	-	2	2
	5: Starting System Problem, Part 1 (VTM Set-up and Check-out)	5	5	4	2	2	2
	6: Starting System Problem, Part 2 (Troubleshooting Defective Transmission Neutral Position Switch)	4	-	2	1	1	-
3	7: Charging System Problem 1 (Defective Lead 1)	4	4	3	-	1	-
	8: Charging System Problem 2 (Defective Voltage Regulator)	3	3	2	-	-	-
	9: Charging System Problem 3 (Defective Generator)	4	4	4	-	-	-

Table D-2

Responses to Question 1 of the Course Developer Questionnaire Administered during Experiment 3

QUESTION : Is this a critical task which needs to be trained?
RESPONSES: Yes, No

Lesson	Segments	Responses Course Developer 1	2	3
Introduction	0: Introduction, Part 1	-	N	N
	1: Introduction, Part 2	-	Y	Y
1	2: VTM Set-up and Check-out Tutorial	-	Y	Y
	3: VTM Set-up and Check-out Exercise	-	Y	-
2	4: Introduction to the Starting System	-	Y	Y
	5: Starting System Problem, Part 1 (VTM Set-up and Check-out)	Y	Y	-
	6: Starting System Problem, Part 2 (Troubleshooting Defective Transmission Neutral Position Switch)	-	N	N
3	7: Charging System Problem 1 (Defective Lead 1)	Y	Y	-
	8: Charging System Problem 2 (Defective Voltage Regulator)	-	Y	Y
	9: Charging System Problem 3 (Defective Generator)	-	Y	Y

Table D-3

Responses to Question 2 of the Course Developer Questionnaire
Administered during Experiment 3

QUESTION: Is this task currently trained on operational equipment?
RESPONSES: Yes, No

Lesson		Segments	Responses Course Developer 1	2	3
Introduction	0:	Introduction, Part 1	-	N	N
	1:	Introduction, Part 2	-	Y	Y
1	2:	VTM Set-up and Check-out Tutorial	-	Y	Y
	3:	VTM Set-up and Check-out Exercise	-	Y	-
2	4:	Introduction to the Starting System	-	Y	Y
	5:	Starting System Problem, Part 1 (VTM Set-up and Check-out)	Y	Y	-
	6:	Starting System Problem, Part 2 (Troubleshooting Defective Transmission Neutral Position Switch)	-	N	Y
3	7:	Charging System Problem 1 (Defective Lead 1)	Y	N	-
	8:	Charging System Problem 2 (Defective Voltage Regulator)	-	Y	Y
	9:	Charging System Problem 3 (Defective Generator)	-	N	N

Table D-4

Responses to Question 3 of the Course Developer Questionnaire Administered during Experiment 3

QUESTION: How difficult is it to perform this task?
RATINGS: 1 = very easy
2 = somewhat easy
3 = about average in difficulty
4 = somewhat difficult
5 = very difficult

Lesson	Segments	Responses Course Developer 1	2	3
Introduction	0: Introduction, Part 1	1	-	-
	1: Introduction, Part 2	3	1	3
1	2: VTM Set-up and Check-out Tutorial	-	2	3
	3: VTM Set-up and Check-out Exercise	-	1	-
2	4: Introduction to the Starting System	-	1	2
	5: Starting System Problem, Part 1 (VTM Set-up and Check-out)	3	1	-
	6: Starting System Problem, Part 2 (Troubleshooting Defective Transmission Neutral Position Switch)	-	2	2
3	7: Charging System Problem 1 (Defective Lead 1)	3	2	-
	8: Charging System Problem 2 (Defective Voltage Regulator)	-	4	4
	9: Charging System Problem 3 (Defective Generator)	-	2	3

Table D-5

Responses to Question 4 of the Course Developer Questionnaire Administered during Experiment 3

QUESTION: At what skill level should a trainee perform this task at the end of training?

RATINGS:
1 = novice
2 = better than novice
3 = apprentice
4 = less than expert
5 = expert

Lesson	Segments	Responses Course Developer 1	2	3
Introduction	0: Introduction, Part 1	4	-	-
	1: Introduction, Part 2	3	5	2
1	2: VTM Set-up and Check-out Tutorial	-	5	2
	3: VTM Set-up and Check-out Exercise	-	5	-
2	4: Introduction to the Starting System	-	5	2
	5: Starting System Problem, Part 1 (VTM Set-up and Check-out)	3	5	-
	6: Starting System Problem, Part 2 (Troubleshooting Defective Transmission Neutral Position Switch)	-	5	1
3	7: Charging System Problem 1 (Defective Lead 1)	3	5	-
	8: Charging System Problem 2 (Defective Voltage Regulator)	-	4	4
	9: Charging System Problem 3 (Defective Generator)	-	3	4

APPENDIX E
RAW DATA FROM QUESTIONNAIRES ADMINISTERED DURING EXPERIMENT 5

Table E-1

Responses to the Instructor Questionnaire
Administered during Experiment 5

QUESTION: How well does the simulator train this task?
RATINGS: 1 = very poorly
2 = poorly
3 = fair
4 = moderately well
5 = very well

Content Area	Rating
Introduction to the transmitter	4
Master oscillator and power amplifier high voltage circuits	5
Modulator bias and arc detection circuits	5
Noise degeneration circuits	2
Radio frequency generation circuits	5
Modulation circuits	4