DOCUMENT RESUME

ED 105 903 IR 001 946

AUTHOR	Spangenberg, Ronald W.
TITLE	Field Evaluation of a General Purpose Simulator.
PUB DATE	3 Apr 75
NOTE	21p.; Paper presented at the Annual Meeting of the American Educational Research Association (Washington, D.C., March 30 through April 3, 1975)
EDRS PRICE	MF-$0.76 HC-$1.58 PLUS POSTAGE
DESCRIPTORS	Aviation Mechanics; Electronic Equipment; Electronics; *Electronic Technicians; *Evaluation; Evaluation Criteria; Military Training; *Radar; Simulation; *Simulators; Subprofessionals; Technical Education; *Training; Training Techniques
IDENTIFIERS	General Purpose Simulator; Technicians; United States Air Force

ABSTRACT

The use of a general purpose simulator (GPS) to teach Air Force technicians diagnostic and repair procedures for specialized aircraft radar systems is described. An EC II simulator manufactured by Educational Computer Corporation was adapted to resemble the actual configuration technicians would encounter in the field. Data acquired in the evaluation included: (1) the experience level of the participating personnel, (2) learning patterns using the simulator, (3) evaluation of the training potential, and (4) attitudes and acceptance. All personnel exposed to the GPS stated that learning was easy, and tests given the technicians after their training sessions indicated a high level of achievement. The system was generally found to be acceptable to trainees, although some participants indicated a preference for more traditional teaching methods. The cost of using the GPS was found to be less than 10 percent of the costs of an actual equipment trainer. (DGC)

ED105903

FIELD EVALUATION OF A GENERAL PURPOSE SIMULATOR

A paper presented on April 3, 1975 to the

Annual meeting of the

American Educational Research Association

by

Dr. Ronald W. Spangenberg
Education and Training Research Specialist
Air Force Human Resources Laboratory
Technical Training Division
Lowry AFB Colorado 80230

FIELD EVALUATION OF A GENERAL PURPOSE SIMULATOR

INTRODUCTION

People learn by doing. Demonstrations can be useful in orienting a student to selected tasks. However, active practice of the task being learned must be provided systematically to the student in the design of instruction. Feedback to the learner also should be an integral part of this practice. One means of providing both practice and feedback opportunities in the learning process is simulation.

Simulation, as a method of instruction, is effective for teaching many tasks and skills in technical training. A wide variety of procedural sequences perceptual-motor skills, identifications, conceptual tasks, and team functions have been effectively learned through the use of simulation. The approach of systematically abstracting and partially duplicating tasks, activities, or operations provides transfer of training from a synthetic environment to a real environment. Simulation allows student involvement in learning, paced to the needs of each individual. Both practice opportunities and forms of feedback usually not available when using the actual equipment or when operating in the real world are also provided.

Simulators represent a real situation in which tasks are performed or operations are carried out. They omit, however, selected parts of the actual operation which are psychologically unimportant to the task or operation, parts which are dangerous, parts which are expensive, and hopefully they also omit some of the unpredictabilities of the real world. Simulators provide the learner with predetermined levels of control over the task or operation thus allowing controlled practice on representative or critical aspects of the selected tasks or operations.

For training effectiveness the simulator must provide psychological realism (see Miller, 1954). The student must receive information identical to job inputs or inputs identifiably representative of job information inputs must be provided. The meter reading, the trouble lights, the test results, and other information should be like the actual job task performance. The student must be able to exercise some level of control over the system, typically cued by the system inputs. The student should be able to correct a malfunction, for example. The consequences of the students interaction with the system must be represented. Baker and Warnick (1970) state that operational similarity and motivational similarity must be incorporated into the simulation.

Simulation has training advantages over real world operation. Baker and Warnick (1970) list six techniques to enhance transfer of training. Application of these techniques makes the training situation physically dissimilar to the actual situations. These six conditions are:

(1) Provide augemented feedback, i.e., extra knowledge of results during instruction.

(2) Increase the number and frequency of crises, conflicts, equipment breakdowns, and emergencies.

(3) Reduce the operational time for certain events, so as to increase the amount of practice on critical skills.

(4) In the total performance behavior, vary the part-task sequence,

because small amounts of practice on several similar tasks promote more learning than large blocks of practice on a single task.

(5) Provide guidance and stimulus support in the early or initial stages of learning.

(6) During training, vary the progression of difficulty levels; a progressively easy-to-difficult procedure facilitates transfer of training.

While actual equipment trainers or simulators are used for demonstrations, they are not widely available for student use in technical training for a variety of reasons. This results in a lack of hands-on practice or learner involvement for the students on job related skills. Unavailability of this training resource may result in lower level of training which uses more classroom instruction time. It may take more time to accomplish less. When not provided job related skill training in school, the technical training graduate requires more on-the-job training. This reduces the job time available to the field unit from both the student and the person training him. When available, actual equipment simulations typically are used as demonstration devices and procedures trainers. Job skills such as troubleshooting and maintenance often are not trained using this equipment due to (1) the difficulties in inserting malfunctions, and (2) the possibility of damage by inexperienced students.

One option for increasing hands-on training recently explored under Air Force contract by Applied Science Associates is the use of general purpose simulation. This type of simulation, intended to provide an economical approach to training, provides a standard frame with a control system to which modules are added to make specific pre-programmed simulations. Interchangeable faceplates associated with programmable electronic circuitry provide the required modular flexibility. Thus simple changes in the faceplate and programming of the electronics permit the general purpose simulator to provide a wide range of pre-planned simulations.

Currently in Meadville Pennsylvania, an experimental educational project in vocational guidance uses general purpose simulation to acquaint sixth to ninth grade students with skills and job tasks in the automotive, radio-TV, and major appliance repair areas. Programmed exploratory lessons are provided on audio tape which integrate hands-on training with the simulator. However, the most use of programmable simulators is in military training.

A general purpose simulator (GPS) marketed as the EC II was procured from the Educational Computer Corporation. Following special factory training and an analysis of the course learning requirements, a faceplate (simulation display panel) and a sequence of slides were designed so as to simulate the APQ 126 Radar System which is associated with the A7D Aircraft. The computer program implementing the faceplate and selected slides was developed by Educational Computer Corporation and procured from them. The finished product is pictured in Figure 1.

Insert Figure 1 about here

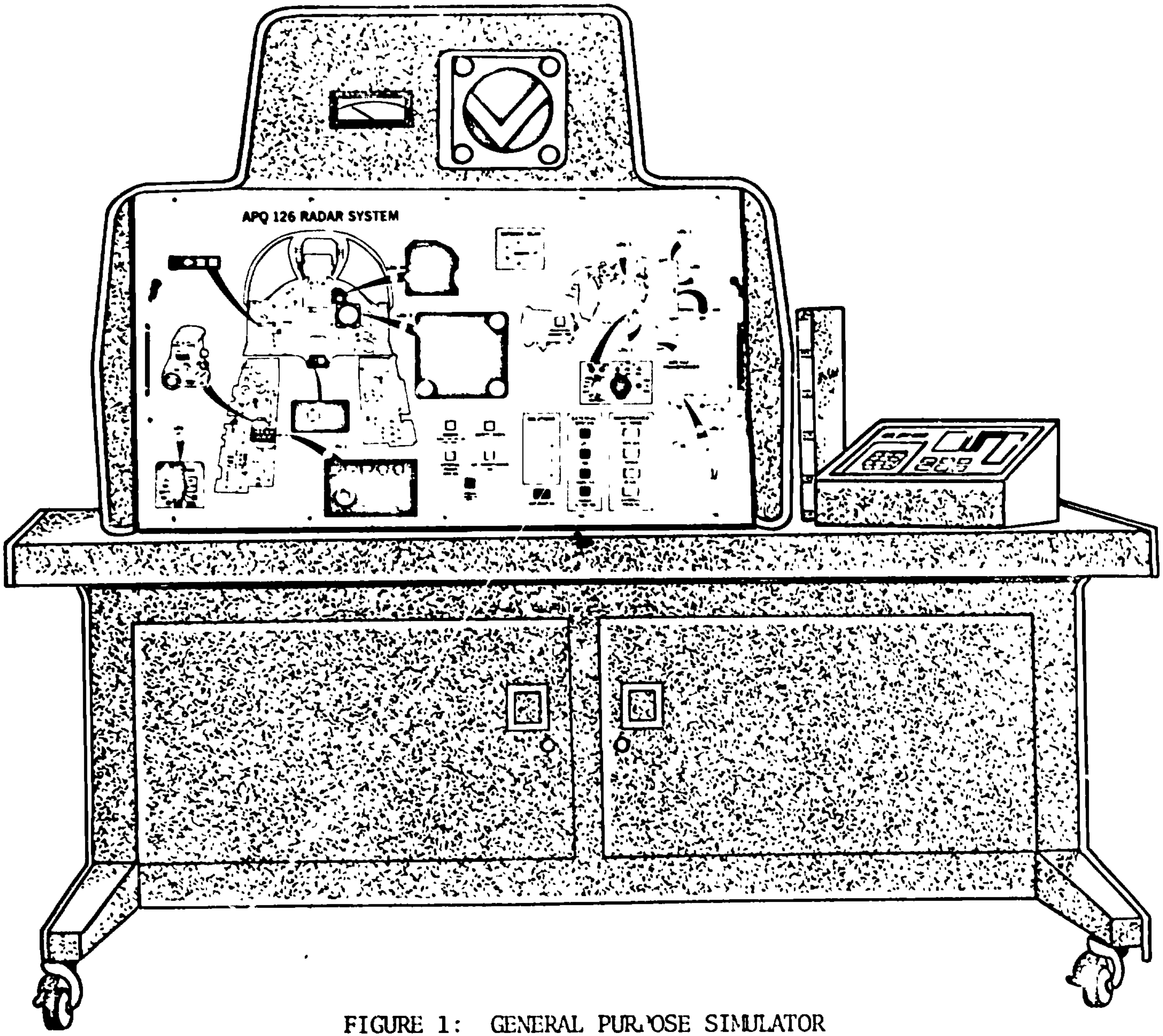

FIGURE 1: GENERAL PURPOSE SIMULATOR

Evaluation of the resulting simulator was performed in several ways. Cost comparisons, effectiveness in learning, learner attitudes, and an analysis of design difficulty were performed in a selected Avionics course and reported in McGuirk and Pieper (1974). Results showed that the initial cost for an operational GPS was less than ten percent that of the equivalent actual equipment trainer (AET). Moreover, training in techniques of malfunction isolation was not possible using the comparable AET. Training on both the GPS and the AET permitted student learning to the criterion performance level on normal operational procedures. No interference occurred when transferring either from the GPS to the AET or the AET to the GPS. Practice and feedback on the isolation of malfunctions was provided only on the GPS, a capability previously unavailable to the course of instruction. The GPS provided significant learning opportunities not previously available, nor readily feasible using other available modes.

A field evaluation using field personnel for instructors was requested by the Air National Guard Bureau to determine if general purpose simulation would assist in their on-the-job training program. While the GPS was shown cost-effective and feasible in a technical training resident school environment, its use in job training on the flight line had not been evaluated. The purpose of the present [redacted] study was to evaluate the usability, effectiveness, and acceptability (by instructors and students) of general purpose simulation. The simulation of the APQ 126 Radar System previously developed for use in an Avionics Course in a formal Technical Training School was used. This simulation, based on the school requirements, enabled training in normal operational procedures and malfunction isolation at the apprentice level on the APQ 126 Radar System.

METHOD

Training was conducted by National Guard personnel. An experienced journeyman level Weapons Systems Mechanic on the A7D aircraft was trained in the use of the APQ 126 simulation program on the GPS. Later an apprentice level mechanic with previous experience in teaching school was trained so as to perform as a instructor.

The journeyman level technician oriented all the Weapons Control Shop mechanics to the GPS at Buckley Field. Orientation consisted of showing the mechanics how to operate the simulator and providing practice on isolating some predetermined malfunctions. Then the mechanics were tested in malfunction isolation. A questionnaire (see Appendix A) was administered before and after working with the simulator. This questionnaire was used to determine previous experience, learning, a comparative evaluation of training potential, attitudes, and acceptance. The time and number of replacements for malfunction isolation also were recorded by each technician. Since all these technicians were skilled in troubleshooting this exercise provided an indicator of acceptability and perceived usefulness of the simulator. Also provided was an understanding of some of the capabilities of this approach to training.

On a different day, the three reserve Air National Guard personnel were trained by the apprentice level technician. For the first hour, all three were trained together in normal system operation. An additional hour and one half instruction was provided to each individually. Following training, each student was tested in malfunction isolation. Questionnaires were administered before and after training.

On the following day, three journeyman level technicians from the Avionics Aerospace Ground Equipment Repair Shop were cross-trained using the GPS. The apprentice level technician conducted the training in the same manner as previously described for the reserve personnel training. Data was thus acquired from eleven qualified (journeyman level Weapon's System Mechanics on the A7D Aircraft) personnel and six unqualified personnel. Participation was 100%.

RESULTS

Data acquired in the field evaluation included (1) the experience level of the participating personnel, (2) learning, (3) evaluation of training potential, and (4) attitudes and acceptance.

Experience. Nine of the eleven full time National Guard personnel in the Weapons Control Shop had between four [illegible] experience. Median level experience for the eleven qualified personnel was 4½ years. All were familiar with the AN/APQ 126 Radar System and reported themselves qualified to troubleshoot this system.

Distribution of skill level was as follows: Supervisory-level three men, journeyman-level seven men, apprentice-level one man. Six personnel had worked on other radar systems, while five had no experience on any other radar system. It was reported to the experimentor that other radar experience would provide only minimal transfer to the operation of this system. The primary mode of initial training received on the

APQ 126 Radar System by qualified personnel was reported as: Actual equipment trainer-6 persons, Equipment as installed on aircraft-4 persons, Lecture and technical order-1 person.

The three reserve personnel had between 2½ and 6½ years experience. One had worked on the A7D aircraft under supervision, and two had begun informal training on the APQ 126 Radar System. All had limited experience on another radar system. None was qualified to troubleshoot this radar system.

The three Avionics Aerospace Ground Equipment Repair Shop personnel each carried a journeyman level skill in their specialty and ranged from 3½ to 5 years experience. One reported some familiarity (and no training) with the APQ 126 Radar System and two had experience on other radar systems. None were qualified to troubleshoot the APQ 126 Radar System.

Learning. The apprentice level-training program, which the GPS implemented, was intended to teach:

(1) The purpose of the controls,

(2) The interpretation of normal versus malfunction operation,

(3) The performance of system self-checks, and

(4) The exercise of malfunction isolation.

Each person was asked to evaluate either if the GPS could effectively provide the desired instruction or if they were able to do what the program was intended to teach as a result of the instruction. Table 1 shows the results which include the performance test scores on malfunction isolation. To be noted is that the isolation of malfunctions is not possible without achieving the three enabling goals. Thus the scores which indicate a self report on learning are substantiated by the performance test. Two five-level personnel felt that appropriate system

----

Insert Table 1 about here

----

self checks were not adequately covered by the specific program evaluated and one felt that malfunction isolation was not adequate for field use in the three-level program.

Evaluation of Training Potential. Only the opinions of the qualified personnel are summarized since their duties could call for them to provide training. They also have enough job experience to realize which aspects of the job would require training. These experienced technicians felt that if they were a training person that the fastest primary mode of instruction would be:

General Purpose Simulator - 5 persons

Installed equipment - 4 persons

Actual equipment trainer - 2 persons

Experienced technicians felt that the most effective mode of learning would be:

Installed equipment - 8 persons

Actual equipment trainer - 3 persons

Mode of instruction making learning the easiest was felt by experienced technicians to be:

General Purpose Simulator - 6 persons

Installed equipment - 3 persons

Actual equipment trainer - 1 person

TABLE 1: LEARNING ON THE GPS

LEARNING INDICATOR	TYPE PERSONNEL		
	QUALIFIED	UNQUALIFIED	COMBINED (QUALIFIED & UNQUALIFIED)
Did you learn purpose of controls (Yes/Total)	11/11	6/6	17/17
Can you interprete normal/ malfunction operation (Yes/Total)	11/11	6/6	17/17
Can you perform system self checks (Yes/Total)	9/11	6/6	15/17
Can you isolate malfunctions (Yes/Total)	10/11	5/6	[illegible]/17
Mean number replacements (Units)	1.43	1.71	
Median of average malfunction isolation time (Minutes)	1.76	2.82	

Attitudes and acceptance. All personnel rated the learning on the GPS as easy, while fourteen of seventeen liked the GPS application to learning. All but one of the experienced technicians recommended the use of a simulator such as the GPS of the APQ 126 for use in training of the APQ 126 Radar System and other systems to be trained. Other specific recommendations concerning specific applications in Avionics systems training were made by various personnel.

DISCUSSION

The evaluation of the APQ 126 Radar System simulation on the GPS conducted at Buckley Field was designed to determine usability, effectiveness, and acceptance in a job environment.

All personnel exposed to the GPS stated that learning was easy. No difficulties were encountered in the use of the GPS. The training program on the APQ 126 was conducted by the least experienced of the Weapons Control Shop mechanics--an apprentice-level person. In only 2½ hours for each student, satisfactory training was completed in both normal and malfunction isolation mode for all students.

The goals which the simulator was designed to achieve were accomplished by all personnel. Not only were the students asked whether they had learned specific tasks or operations, a performance test also showed a high level of achievement using the GPS. Operational similarity was adequately achieved. Of particular note is the programmed capability provided by the simulator enabling training in the isolation of selected malfunctions. Experienced mechanics given the write-up (reported malfunction) averaged less than two minutes to correct each malfunction in the simulation. Average time on the flight line would average over an hour to correct each malfunction, and probably slightly longer when training is also being accomplished. This time compression enables more practice developing the concepts involved in the isolation of malfunctions. The big picture is made clearer.

Acceptance of the GPS provides an indication of motivational similarity--a similarity in feeling or attitude on the part of the student between the real equipment and the simulator. Experienced mechanics generally indicated that training could be performed faster and easier on the GPS. This would indicate acceptance. The GPS was recommended for training by most of the personnel. This also indicates acceptance. When directly queried most personnel liked using the APQ 126 Radar System simulation on the GPS. However, a preference for teaching the way in which you yourself have been taught is shown by the selection by several personnel of installed equipment as the most effective mode of learning.

Data collected from field use of a GPS indicated that psychological realism was economically captured in a simulation of the APQ 126 Radar System. Incorporated were satisfactory levels of operation similarity and motivational similarity to the real equipment. As previously stated, the simulation, specifically designed for training, provided many advantages not obtainable when using the real equipment, at far less cost than either the real equipment or an actual equipment trainer.

While simulation has been shown as an effective way of training for a wide variety of specific operations or tasks, the principles upon which the successes have been based are not clear. In fact, our knowledge of the psychological principle of the transfer of training is incomplete. No predictive body of knowledge is available which will ensure the adequate design of a simulator for effective training. The specific goals of the training program when used to direct the design of a simulator, generally result in a usable simulator, that is, a simulator which provides the required training. Factors which when manipulated, can reduce cost and increase effectiveness have not been identified prior to a simulation design. Thus, requirements for heuristic research as here presented continues.

One major difficulty, widely recognized by training technologists concerning simulation, is the issue of realism. Engineering fidelity and physical realism are not necessarily incorporated into a GPS. A fixed size face plate and a series of selected images and meter readings limit the possible visual inputs to the learner. However a visual representation can be provided which could not be perceived from any position on actual equipment. This enables the student to form a dynamic cognitive structuring of the overall situation; that is he can learn to put it all together. Typically other related units are not attached to the GPS, although it has been done when deemed necessary. Denenberg (1954) first showed that physical realism in a tank hull trainer may not be necessary in providing necessary and adequate transfer to the job. While no generalizable simulation studies have been reported, similar results to Denenberg's study have been reported for a wide variety of simulators. The visual materials used and selected for training must provide the necessary inputs to enable the cuing of appropriate task performances.

Physical realism provides no assurance that useful information will be seen, learned, or remembered. For example physical reality may be too complex for a beginning learner to make the appropriate discriminations, associations, and generalizations so as to meet the training requirements. Representations of reality frequently must be simplified and stylized when learning efficiency is desired. (see Travers and others 1964).

It has been customary in procuring new simulators to require engineering fidelity; that is, the simulator is required to function as nearly as possible in the way in which the real equipment functions. The false assumption is that better transfer can be directly associated to more realistic representations. Not only is this assumption expensive, it may also be detrimental to training. An operational item of equipment may not be designed for operating in ways which would provide the most effective training. For example, a landing gear hydraulic activator may be quite well designed for normal flight operations but might not hold up too well if operated 50 times an hour for 16 hours a day (if this were necessary in training).

The use of appropriate and well designed simulation is essential to cost-effective technical training. Design of the simulation, however, must be integrated with the design of the course and must implement the course goals. When selective practice of crucial job operations and appropriate feedback are required in training a simulator must be considered. Use of a GPS provides a reasonable economical simulation capability when a variety of simulations are required in a training program or when low student flow permits sharing of GPS capability among different programs.

REFERENCES

AFP 50-50 Handbook for Designers of Instructional Systems: Planning, Developing and Validating Instruction Vol IV Washington DC: Department of the Air Force, 15 July 1973.

Baker, Robert A. Jr., and Warnick, William L. The Improvement of Army Training Through Simulation, (Staff Paper) Fort Knox KY: Human Resources Research Organization, 1970.

Denenberg, Victor H. Training Effectiveness of a Tank Hull Trainer TR3, Alexandria, VA: Human Resources Research Office, George Washington University, 1954.

McGuirk, Frank D. and Pieper, William J. Evaluation of a General Purpose Simulator, Draft-TR, Lowry AFB CO: Technical Training Div., Air Force Human Resources Laboratory, 1974.

Miller, R. B. Psychological Considerations in the Design of Training Equipment WADC TR-54-563, Wright-Patterson AFB, OH: Wright Air Development Center, 1954.

Travers, R. M. W. (ed.) Research and Theory Related to Audiovisual Information Transmission. Salt Lake City, Utah: Bureau of Educational Research, University of Utah, 1964.

PLEASE ANSWER THESE QUESTIONS BEFORE TRAINING

SSN____________________ RANK/GRADE__________ YEARS OF SERVICE__________

Primary AFSC

Secondary AFSC

Have you had any experience with the A-7 aircraft? Yes No

I have experience working on equipment on the following aircraft

series: ____

____

Are you familiar with the APQ 126 Radar System? Yes No

Have you received training on the APQ 126 Radar System? Yes No

If yes, did you learn from:

(a)	Actual equipment trainer	Yes	No	P
(b)	Equipment as installed on the A-7 aircraft	Yes	No	P
(c)	TO and lecture	Yes	No	P
(d)	EC II Simulator	Yes	No	P

(Please circle P for primary mode of training)

Have you worked on the APQ 126 Radar System? Yes No

Are you qualified to troubleshoot the APQ 126 Radar System? Yes No

Have you worked on other radar systems? Yes No

If yes, which____

PLEASE ANSWER THESE QUESTIONS FOLLOWING TRAINING

SSN ____________________

1. Did you like using this approach to learning? Yes No

2. Was the learning (a) easy or (b) difficult when using the ECII Simulator?

   (circle one) (a) (b)

3. Did you learn the purpose of the controls? Yes No

4. Can you interpret normal versus abnormal (malfunction) operation? Yes No

5. Can you perform the appropriate system self checks? Yes No

6. Can you isolate malfunctions? Yes No

7. Will this training enable you to work more effectively on the actual equipment? Yes No

8. As a training person using as a primary mode of instruction each of the following modes

   (a) Actual equipment trainer
   (b) Equipment as installed on A/C
   (c) TO and lecture
   (d) EC II Simulation

   Which mode would be the fastest? (a) (b) (c) (d) (Rank order with top choice #1)

   Which mode would provide most effective learning? (a) (b) (c) (d) (Rank order with top choice #1)

   Which mode would make learning the easiest? (a) (b) (c) (d) (Rank order with top choice #1)

9. Would you recommend the use of a simulator such as the EC II simulation of the APQ 126 for your training program?

   (a) For the APQ 126 Yes No
   (b) For other systems to be trained Yes No

BEST COPY AVAILABLE

MALFUNCTION MODES

MALF #	NUMBER OF REPLACEMENTS	TOTAL TIME
02		
06		
07		
08		
10		
11		
12		