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The following corrections apply to Technical Report No. AMRL-TR-67-208, Learner-Centered Instruction (LCI): Volume I - A Systems Approach to Electronics Maintenance Training.

Page 52

Figure 21: Delete and substitute the attached figure 21.

Page 54

Figure 22: Delete and substitute the attached figure 22.

AEROSPACE MEDICAL RESEARCH LABORATORIES
AEROSPACE MEDICAL DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

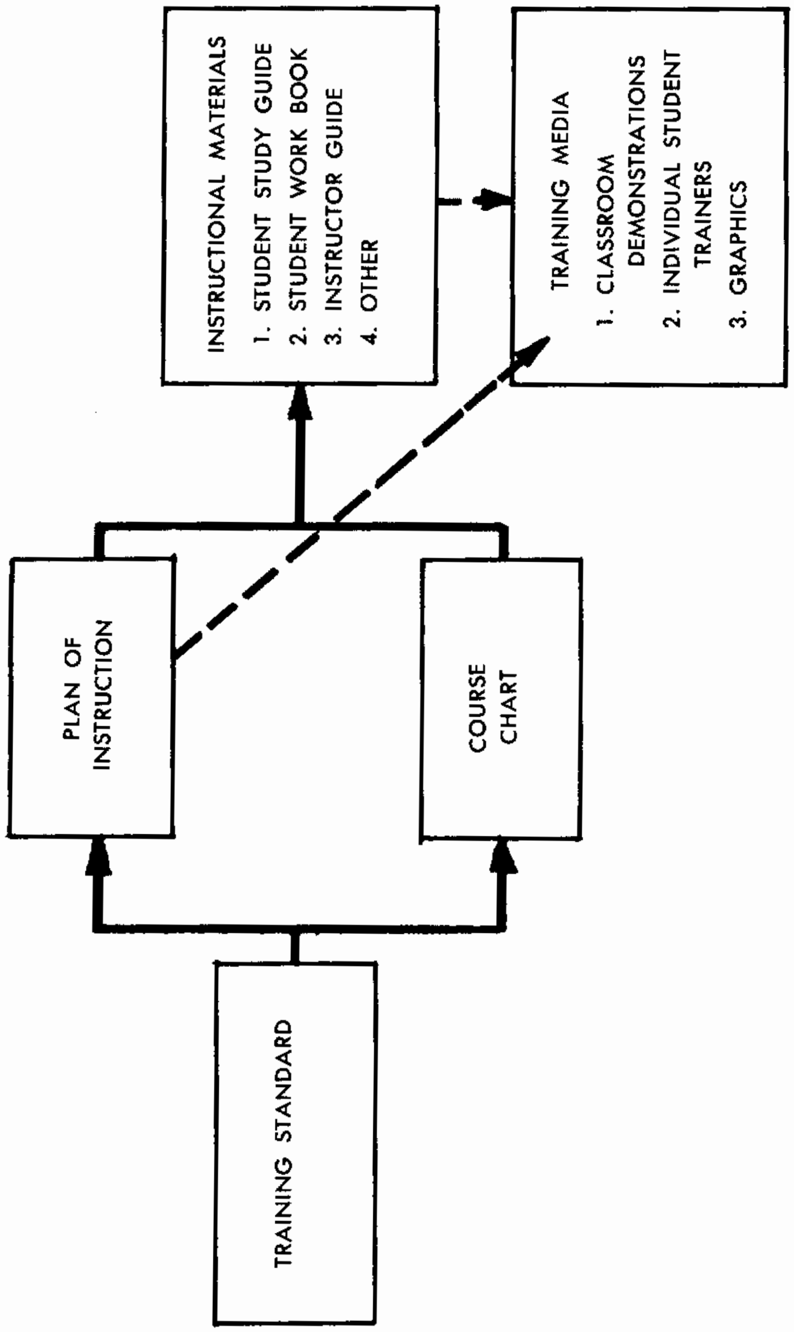

Figure 21. General Procedure for Course Development

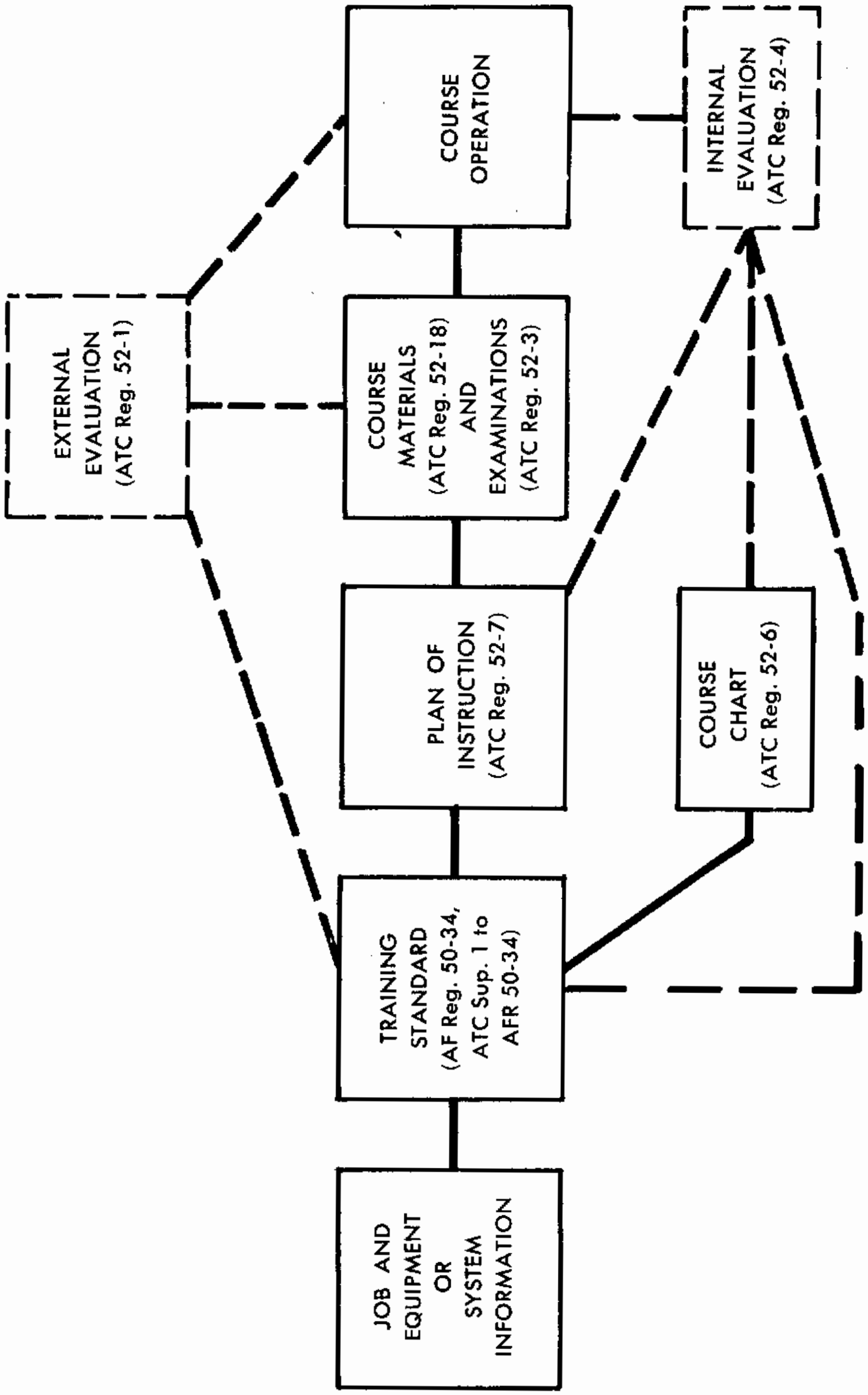

Figure 22. Course Development, Preparation, and Evaluation Sequence of Air Force Technical Training Courses

AMRL-TR-67-208

LEARNER-CENTERED INSTRUCTION (LCI):

VOLUME I — A SYSTEMS APPROACH TO ELECTRONICS MAINTENANCE TRAINING

HORACE H. VALVERDE

Foreword

This report represents a portion of the advanced development program of the Technical Training Branch, Training Research Division, Behavioral Sciences Laboratory of the Aerospace Medical Research Laboratories. Dr. Gordon A. Eckstrand, Chief of the Training Research Division, was the Project Scientist and Dr. Ross L. Morgan, Chief of the Technical Training Branch, was the Task Scientist.

The author appreciates the assistance received from Colonel C. W. Porter, Lieutenant Colonel M. Karp, Major V. L. Elslager, Captain D. A. Krichbaum, Mr. C. L. Bueker, Mr. S. F. Rullo, and Mr. J. O. Mings of Headquarters, Air Training Command, Randolph Air Force Base, Texas; Lieutenant Colonel J. Robinson, Major H. Barnhart, Captain D. L. McEwen, SMSgt J. Malavepena, and Mr. J. McManus of Headquarters, Tactical Air Command, Langley Air Force Base, Virginia; Colonel J. F. Reed, Colonel C. L. Boyd, Colonel E. M. Miller, SMSgt D. L. Lovelace, MSgt P. M. May, TSgt J. Banks, and Mr. A. Hanson of Lowry Air Force Base, Colorado; Mr. Andy Jeffers, F-111A Systems Program Office, Wright-Patterson Air Force Base, Ohio.

The author also expresses appreciation to Dr. J. P. Foley, Jr., Aerospace Medical Research Laboratories, for his advice and assistance in the preparation of Section II and Section VII of this report, and to Dr. J. D. Folley, Jr. and Mr. W. A. Pieper of Applied Sciences Associates, Inc., for their technical advice.

This report has been reviewed and is approved.

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Abstract

This report describes the proposed development and evaluation of a Learner-Centered (LCI) systems approach to electronics maintenance training. An electronics course, appropriate for airmen of various aptitudes, will be prepared to develop proficiency in the specific duties required of the Weapon Control Systems Mechanic/Technician (AFSC 322XIR) in the F-111A weapon system. The course will be developed within the environment of the weapon system development cycle, using data available during the time period and meeting the demanding time schedules. The course will be highly job-relevant and will include multimedia, self-instructional, apprentice-like experiences. Personnel of various levels of aptitude in electronics, including levels lower than those currently used, will take the course. Their on-the-job performance will be carefully and systematically evaluated and compared with the performance of personnel from the parallel course. The total program will focus and demonstrate the technology for developing job specific, apprentice-like technical courses as an integral part of the weapon system development cycle. Also, the weapon control system equipment and Air Force training and course development procedures are described.

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Section I.

INTRODUCTION

THE TRAINING PROBLEM

Modern technological advancements have greatly increased weapon systems complexity. Although greater equipment reliability, maintainability, and built-in test capabilities have been achieved, there is still a continuing need to train personnel to perform duties in an expanding number of weapon systems support job activities. The high cost of training and low reenlistment rates have served as a stimulus, especially in the electronics area, for exploring new training methods in the Armed Forces. Research efforts by the Air Force, Army, and Navy have shown the potential benefits of electronics resident training under job-like conditions. Some of these studies are described in Section II of this report.

The Air Training Command (ATC) conducts one of the world's largest training programs. During the fiscal year 1967, ATC trained approximately 760,000 students in 3,500 technical courses which required 13,000 instructors and 4,000 classrooms. The total cost of training is millions of dollars. This cost does not include the many training programs conducted by the other major air commands. Therefore, since only a small percentage of first-term airmen reenlist, the result is a very high ratio of training cost to effective work time in the operational situation. One of the most direct means of reducing the ratio is to reduce the cost of training. (See ref. 26.)

The current reenlistment rate for all enlisted Air Force personnel is 16%, and the rate is about 12% for electronics technicians. When it is considered that the effective utilization of the electronics technician averages about 2 to 2½ years on his first enlistment, it seems desirable to train such personnel in the shortest time practicable. Rigney and Fromer (ref. 90) expressed this view when considering the Navy's reenlistment rate of approximately 15% and the electronics technicians' useful career of no more than one or two years. Specifically, the authors indicated that the research problem is to find means of relieving the electronics technician of some of the theoretical or verbal aspects of his job.

Because of the low reenlistment rate and short effective utilization span of first-term airmen, it would seem to be both economical and practical to train them in the shortest possible time to perform efficiently on the job. Comprehensive theory instruction may then be offered to airmen selected for reenlistment.

In the future, computers, greater systems reliability and maintainability, the use of procedural and troubleshooting aids, and the implementation of infrared diagnostic techniques will probably decrease the need for the maintenance technician to utilize theory on the job. Already these technological advancements are in exploratory stages of development. One such development (ref. 106), the Presentation of Information for Maintenance and Operation (PIMO), Figure 1, will be tested at Dover Air Force Base, Delaware and Charleston Air Force Base, South Carolina for possible use as a convenient retrieval system for cognitive maintenance and operation information. The principal goals of the PIMO program are:

1. Precise definition of the maintenance and operational data requirements of future systems at each level of maintenance and mode of operation.

2. Identify and define the optimum media for storage, retrieval transmission and presentation, and updating of these data.

3. Evaluate the capabilities of present mechanized systems to meet stated requirements.

4. Formulate design criteria for future systems to assure built-in compatibility of the information system requirements with the operational and maintenance and hardware requirements.

To achieve the expected degree of efficient operation, the information system must encompass the following features:

1. Provide accurate and current operational, maintenance, and emergency technical informamation rapidly at point of use.
2. Provide rapid fault isolation capabilities.
3. Simplify instructions.
4. Provide rapid access to all technical information.
5. Expedite distribution of data.
6. Facilitate control and rapid distribution of change information.
7. Provide for rapid verification of data.
8. Must be able to predict a cost savings through increased effectiveness.

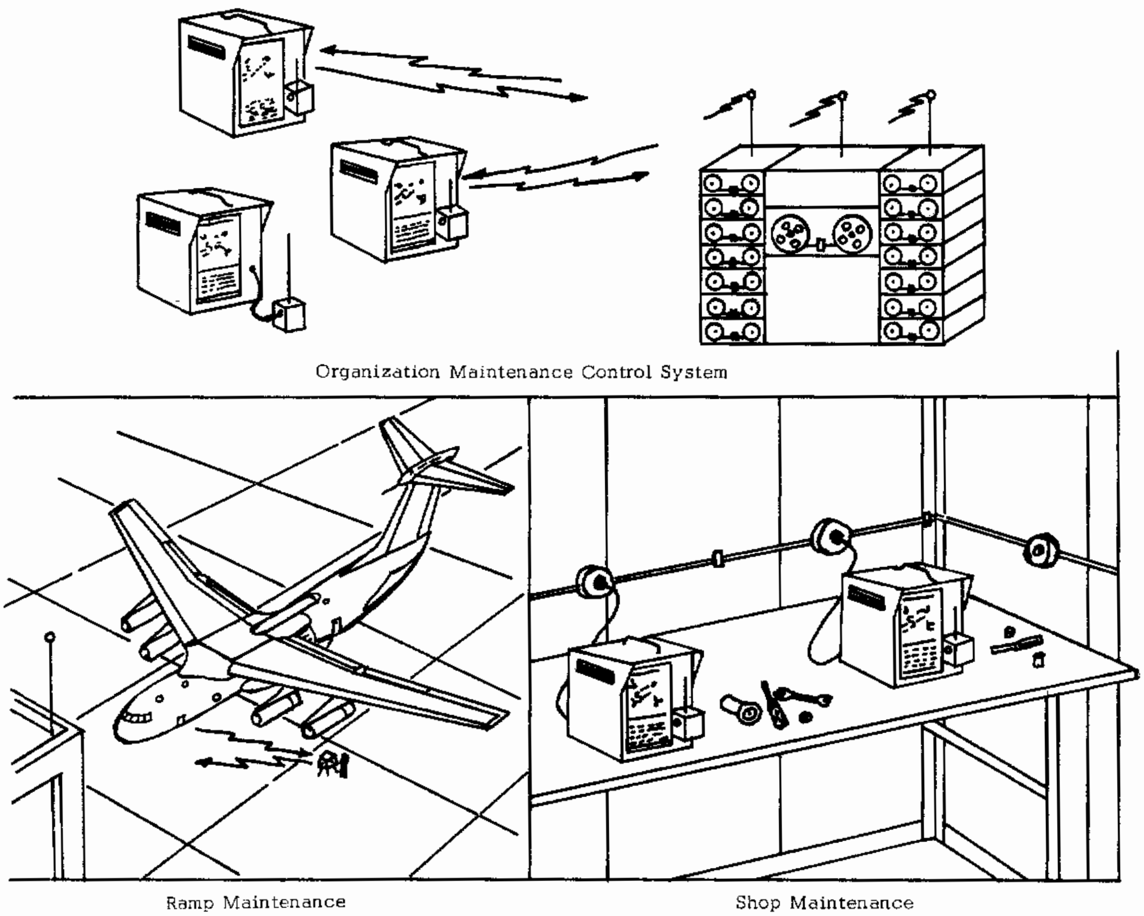


Figure 1. Application Drawings of Proposed System for PIMO II

Studies reported by Harris (refs. 53, 54) found that microelectronic configurations of electronic systems reduced significantly the maintenance burden and thus reduced certain maintenance personnel and training requirements. The microelectronic configurations also suggested new techniques of organizing maintenance activities to further reduce training and personnel requirements.

Thus, for first-term airmen, it seems justifiable to consider an advanced development program designed to demonstrate the feasibility of training airmen to become proficient in the use of pertient information retrieval systems, tools and test equipment, and troubleshooting techniques. In view of the technological advancements in modern weapon systems and maintenance concepts, it appears unrealistic to extensively educate the trainee in front-end principles with the expectation that he will apply the information later in the operational setting.

PURPOSE AND GOALS

This report is the first of a series which will describe the progress in the development of the Air Force Learner-Centered Instruction (LCI) Electronics Maintenance Course for the F-111A Fire Power Control System.* The F-111A aircraft is shown in Figure 2. The development of the systems-oriented course will be a contractual effort by Applied Science Associates, Valencia, Pennsylvania, and the course training will be conducted by Air Force instructors at the Air Force

Figure 2. The F-111A

Training Command, Lowry Technical Training Center, Lowry Air Force Base, Colorado. Ensuing reports will present the developmental results of the proposed activities contained in Sections III, IV, and V of this report.

*For the purpose of this advanced development program, LCI refers to a systems approach to training.

The purpose of the Lowry LCI Project is to demonstrate and evaluate the technology for developing job-specific electronics maintenance courses that: (1) are systems oriented and compatible with time schedules and data provisions associated with the development of both the aircraft and the fire power control subsystem, (2) increase the efficiency of training through the use of multimedia including automated instruction, and (3) allow effective use of first-term airmen of lower aptitudes than those currently entered in electronic maintenance training by providing for individual differences. The effort will also aid in determining savings and performance increments.

A course appropriate for personnel with various aptitude percentiles (60 through 95) will be prepared to develop proficiency in the specific duties required of the Air Force Specialty (AFS) Weapon Control Systems Mechanic, Air Force Specialty Code (AFSC) 32231R for the F-111A fire power control system. (See Figure 3 and Figure 4.) The Quantitative and Qualitative Personnel Requirements Information (QQPRI) position description for AFSC 322X1R is given in Appendix I. The "X" in AFSC 322X1R indicates that all skill levels (1, 3, 5, 7, and 9) of the career field are included. The LCI program will be designed to train airmen at the "3" (apprentice) skill level and prepare them to perform "5" (journeyman) skill level tasks in the field. A description of Air Force training and skill levels is given in Section VII of this report.

The airmen assigned AFSC 322X1R will service, inspect, adjust, and align, functional test, remove and replace, and troubleshoot the F-111A Radar Set (attack radar), Lead Computing Optical Sight Set, and other related aerospace ground equipment on the flight line. The job does not include shop maintenance.

The Air Force Specialty represented by AFSC 322X1R fits the pattern of high-cost training for a job that has been simplified by self-test features and maintenance concept that restricts the line maintenance job to troubleshooting to, and replacing, only a few line-replaceable units (LRU's). This AFS, therefore, appears to lend itself to a clear-cut and dramatic demonstration of the magnitude of savings that can be achieved through application of modern training technology.

The training course will be developed within the environment of the weapon system (aircraft) development cycle, using data available during that time period and meeting the demanding time schedules of the weapon system test. The course will emphasize apprentice job experiences with which the airmen must deal in the operational setting. Since the course objectives will be derived from a detailed job behavioral analysis with very little emphasis on theory, it is anticipated that the LCI course will be of shorter duration than the principles-centered control course. It should not be construed to mean, however, that the LCI course development will consist of "telescoping" an existing course, or that an armchair curriculum operation will be performed to remove miscellaneous hours devoted to front-end principles instruction. If the objectives indicate that certain theoretical concepts or principles are required to effectively perform a task, then these will be taught in the proper sequence. A concerted effort will be made to integrate cognitive and motor skills to the greatest degree possible. Thus, any required electronics principles will not be taught in isolation from the performance aspects of maintenance tasks.

PROVIDING FOR INDIVIDUAL DIFFERENCES

To gain entry into electronics maintenance training courses, airmen usually must achieve above average scores (sometimes no lower than the 80th percentile) on the Electronics Aptitude Index of the Airman Qualifying Examination (AQE). Although airmen may score high on the Electronics Aptitude Index, there is no assurance that all of them will be able to equally cope with abstract training course content. A perusal of grades in traditionally taught courses usually shows a wide range in student achievement. Of course, in a similar training environment,

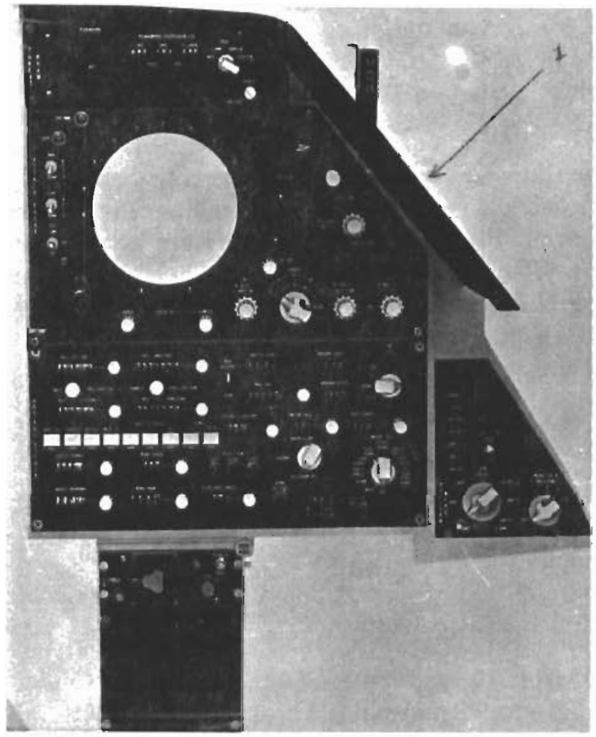


Figure 3. Portion of an F-111 Aircraft Crew Station (A)
1 — Indicator-Recorder of the Attack Radar Set

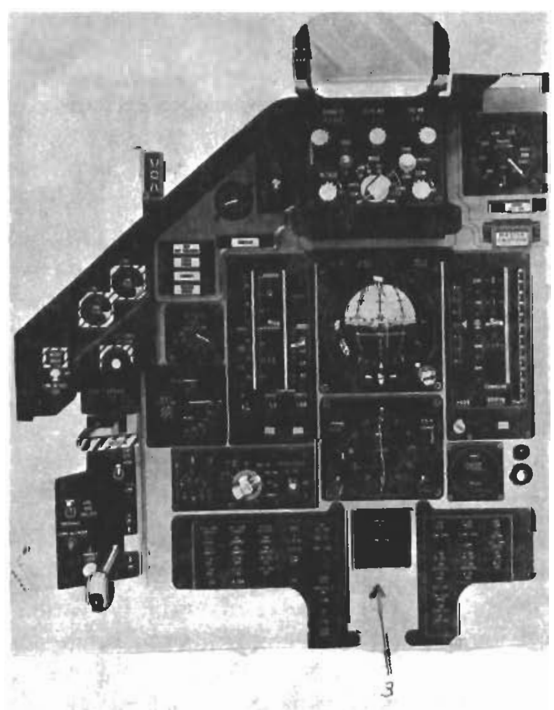


Figure 4. Portion of an F-111 Aircraft Crew Station (B)
2 — Sight Assembly, Optical Display; 3 — Dual Bombing Timer

medium aptitude trainees, may achieve a similar distribution of scores and, perhaps, at a lower level of achievement, especially if the instruction remains constant for both high and lower aptitude groups. However, by developing job-specific courses and providing for individual differences in learning, it should be possible to train lower electronics aptitude airmen (60-75 percentiles) as well as those with higher aptitude (80-95 percentiles) to a high level of job performance achievement.

An effort should be directed toward the development of training courses which present materials in a sequenced functional context which will facilitate optimum learning. Stolurow (ref. 110) has said that "The learner is the focal point of the training system in that all other components are to be understood in relation to their effect upon him." A training course, then, should be adapted to the learning abilities of the selected trainees. Often, the reverse is practiced, that is, students must adapt to a course content which is not based upon optimum learning principles of current training technology. It is acknowledged that most high aptitude students will learn the course content anyhow, but the process is more difficult and usually more time consuming.

JOB MOTIVATION

Motivation is often a problem in the training and operational situation. The problem may become particularly acute when airmen do not intend to make the military service their career. Since this group represents the vast majority of first-term airmen, some effort should be directed toward making the training and operational job both challenging and rewarding. In describing the traditional electronics fundamentals training, Foley (ref. 33) said:

"The traditional electronic technician program, being very similar to engineering courses, is usually started with an extensive study of electronic fundamentals beginning with the electron and atom itself. In this program, the student builds his knowledge of theory background through an abstract study of the nature of electricity, direct current, alternating current, electron tubes, and later, design problems in radio transmitters, receivers, and other electronic equipment. The emphasis in this part of the electronic training is of course, on building and designing."

In general, airmen who can successfully cope with the abstract verbal content of extensive front-end electronics principles training plan civilian technical careers after discharge from the Air Force. When these airmen are assigned to duties such as on-aircraft maintenance, they find little or no challenge in the black box scope of the job. On the other hand, medium aptitude airmen may be able to perform such jobs to a high degree of proficiency and thus find satisfaction in their accomplishments. They should be tested on their ability to use test equipment and perform job tasks effectively, rather than be required to verbalize the job by means of paper and pencil tests. It is possible to train airmen with a minimum of theory to efficiently perform flight line maintenance tasks. However, their ability to speak *electronese* fluently may result in bias against them which could affect their job motivation. On the subject of such biased attitudes, Pickering and Anderson (ref. 88) in describing a Navy experimental electronics technician (ET) performance-oriented course, said:

"Preliminary follow-up results indicate that the experimental ET graduates have been generally well received in the fleet. However, it is also clear that subtle but widespread bias against them exists. For example, several supervisors have made comments similar to this: 'X is a good man. He's done everything I've asked him to do. Of course, I wouldn't assign him to a really difficult job because he hasn't had enough theory.' Judgments of limited capabilities are being made independent of objective evidence. Regular ET A School graduates have successfully completed a complex and difficult training program that has placed emphasis on the attainment of knowledge about theoretical concepts and a demonstration of capacity to manipulate electronic relationships mathematically. ET's, as a group, are justly proud of their accomplishments. The experimental ET School graduates are not considered a part of this group. What effect these attitudes will have on the careers of the experimental ET's is not yet evident, but the attitudes are real enough."

THE TESTING PROBLEM

The primary purpose of a maintenance training course is to prepare the trainees to perform tasks on equipment in the operational setting. Therefore, it seems desirable to evaluate the behaviors they are expected to perform on the job. Since performance tests are more time consuming and difficult to administer, training programs usually rely on multiple-choice verbal tests to measure behaviors that are believed to be related to the performance requirements of the job. Although performance evaluation may require more time, since it is accomplished on an individual basis, perhaps the time spent would be minimal as compared to additional on-the-job training required if the graduates cannot perform the job behaviors satisfactorily. In the case of evaluation by multiple-choice measurements, the trainees may become so absorbed in the process of choosing the right answer required by the test constructor, that they lose sight of the relationship of the test to the real job situation. However, as Highland (ref. 55) noted there are good and bad performance tests just as there are good and bad written tests (Figure 5). It also can be inferred that a good paper-and-pencil test may evaluate or predict job behaviors more effectively than a poorly constructed performance test.

Just as training media should be selected according to desired learning objectives, so should tests be selected to evaluate the acquisition of learning outcomes. There are a variety of tests and measurements which may be used to evaluate educational and training achievement. For example, if it is desired to measure trainee ability to discriminate abstract concepts, multiple-choice tests may be selected for the purpose. In driver training, multiple-choice or recall tests may evaluate trainee knowledge of state laws and road signs, but to be sure that the trainee has acquired the necessary motor skills to operate an automobile, the instructor must observe and evaluate the trainee's performance under specific conditions.

It should not be concluded from the foregoing discussion on written and performance measurements that the two types of tests are always completely different. Rather, the implication is that paper-and-pencil tests are most suitable for measuring cognitive (knowledge) items and that performance tests are best used to evaluate job tasks. Some written tests can elicit performance responses very similar to the requirements of job tasks. The ATC pilot navigation course tests represent an example of such measurements. Although the tests are multiple-choice, they require the students to plan and "fly" a mission and use plotters, charts, weather data, and dead reckoning computers to plot course lines, use chart symbols and information, and make dead reckoning computations similar to actual flight planning, pilotage, and dead reckoning navigation. Perhaps it would be more appropriate to refer to achievement tests as cognitive versus performance instead of paper-and-pencil versus performance. A performance test is generally considered to be one that elicits a response by the trainee to stimuli provided by the test administrator. The trainee is observed while performing a task on real or simulated equipment, and his performance is quantitatively or qualitative recorded by the test administrator. A cognitive test may be written or oral, and measures knowledge about jobs or academic subject matter; and it requires student responses to multiple-choice, recall, matching, or other items.

The Air Force Specialty Knowledge Test (SKT), is a cognitive test which includes multiple-choice items on theory and knowledge about the job. There is nothing inherently wrong in using

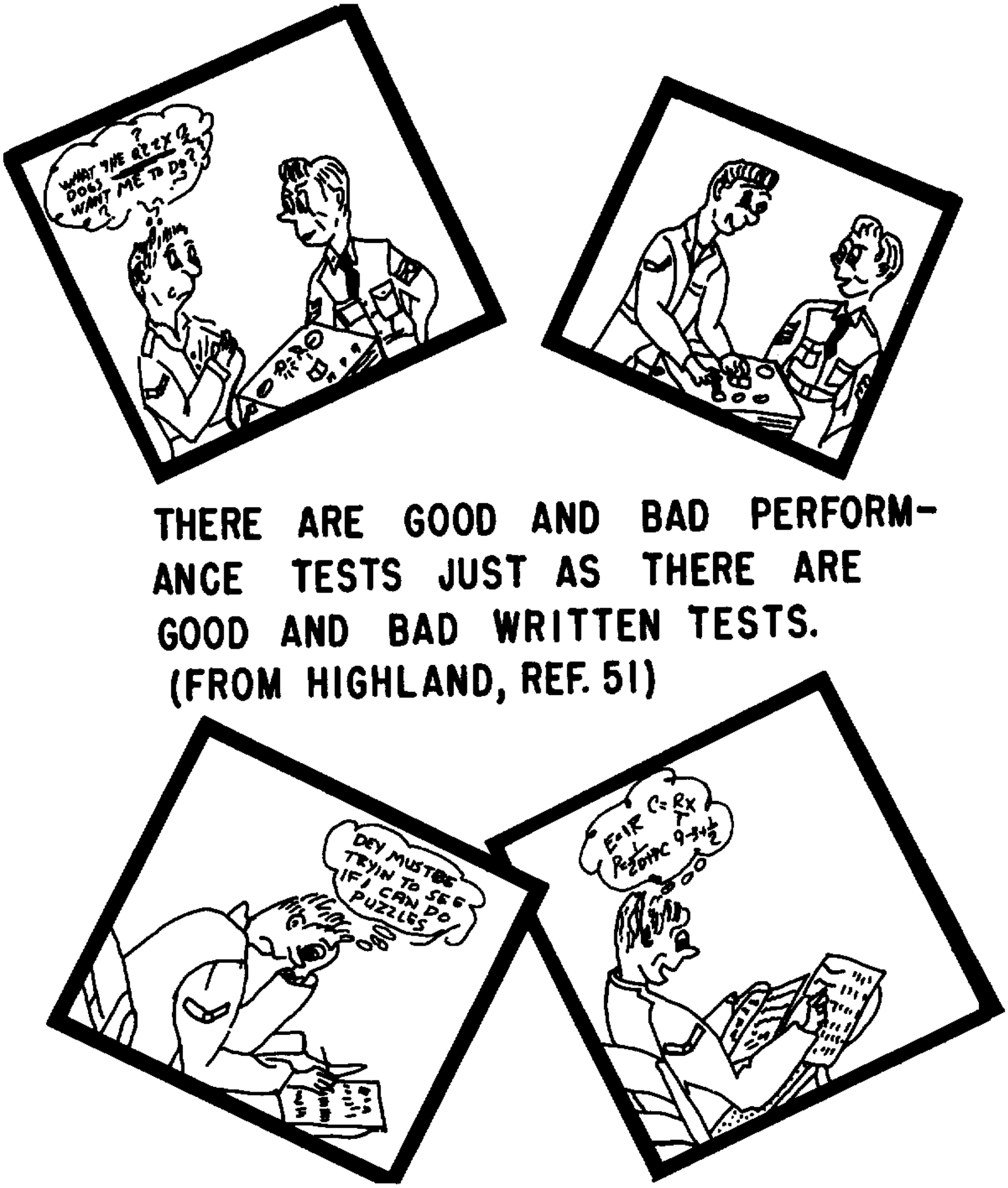


Figure 5. Illustration of Good and Bad Written Tests

Researchers	*Type of Job Task Performance Test (JTPT)*	*Theory Tests*	*Job Knowledge Tests*	*School Marks*
Anderson (ref. 6)	Test Equipment JTPT			.18-.33
Evans and Smith (ref. 32)	Troubleshooting JTPT	.24 & .36	.12 & .10	.35
Mackie and Others (ref. 67)	Troubleshooting JTPT	.38		.39
Saupe (ref. 95)	Troubleshooting JTPT		.55	.56
Brown and Others (ref. 16)	Troubleshooting JTPT		.40	
	Test Equipment JTPT		.29	
	Alignment JTPT		.28	
	Repair Skills JTPT		.19	
Williams and Whitmore (ref. 115)	Troubleshooting JTPT			
	(Inexperienced Subjects)	.23		
	(Experienced Subjects)	.15		
	Adjustment JTPT			
	(Inexperienced Subjects)	.02		
	(Experienced Subjects)	.21		
	Acquisition Radar JTPT			
	(Inexperienced Subjects)	.03	.36	
	(Experienced Subjects)	.14	.22	
	Target Tracking Radar JTPT			
	(Inexperienced Subjects)	.24	.33	
	(Experienced Subjects)	.20	.38	
	Missile Tracking Radar JTPT			
	(Inexperienced Subjects)	.09	.15	
	(Experienced Subjects)	.19	.32	
	Computer JTPT			
	(Inexperienced Subjects)	.08	.24	
	(Experienced Subjects)	.06	.14	
	Total JTPT			
	(Inexperienced Subjects)	.14		
	(Experienced Subjects)	.20		
Crowder and Others (ref. 20)	Troubleshooting JTPT	.11	.18-.32	

Figure 6.* Correlations between Job Task Performance Tests and Paper and Pencil Electronics Theory Tests; and Paper and Pencil Job Knowledge Tests

*Data from Foley, J. P., Jr. *Critical Evaluation of Measurement Practices in Post-High School Vocational Electronic Technology Courses.* A doctoral dissertation, University of Cincinnati, 1967.

this type of test if its limitations are understood. Too often, however, achievement on the test, or lack of it, is equated with motor skill ability to perform a job. This viewpoint is as unrealistic as it is to believe that one can drive an automobile or fly an airplane based upon the results of a multiple-choice test. Research to date generally has shown very low correlation between job performance and job cognitive tests (see Figure 6). Perhaps the SKT could serve as one criterion for competive selection to supervisory ranks after the second enlistment, but job performance should be the primary criterion for all first-term airmen. The LCI Job Performance Test (JPT) will serve as the criterion measure of the Weapon Control Systems Mechanic based upon task and equipment analysis of job requirements. It is expected that further information on the validity of airman test procedures will be obtained as a result of the LCI program.

Because of the traditional use of cognitive tests for upgrading purposes, attitudinal problems are anticipated in this area. However, the LCI program proposes to demonstrate how well the airman can *perform* the job; not how well he can *verbalize* the job.

OPERATIONAL EQUIPMENT VERSUS SIMULATORS

The Behavioral Sciences Laboratory of the Aerospace Medical Research Laboratories used the Maintenance Task Simulator (MTS) successfully in training and testing experimental subjects in electronics maintenance tasks (ref. 31). The front-panel section of the MTS is shown in Figure 7. Approximately 10 years ago, a number of maintenance training and testing devices were built and tried out by the Air Force Personnel Research and Training Center (AFPTRC) personnel (ref. 112). Although the devices did not receive general acceptance at that time, the MTS has demonstrated that the concept is fundamentally sound.

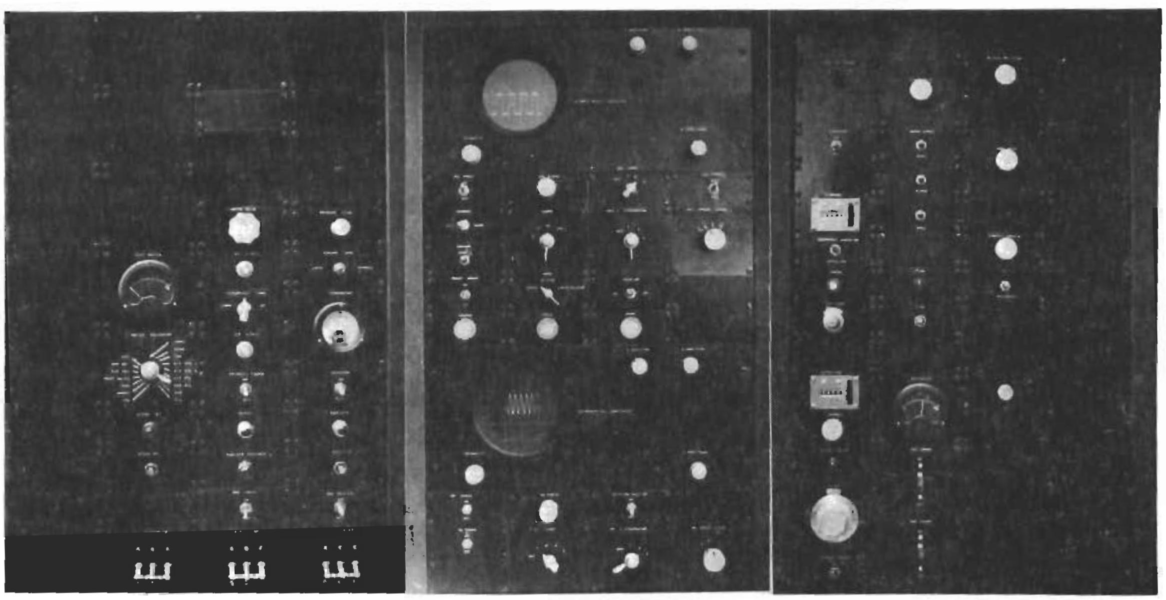
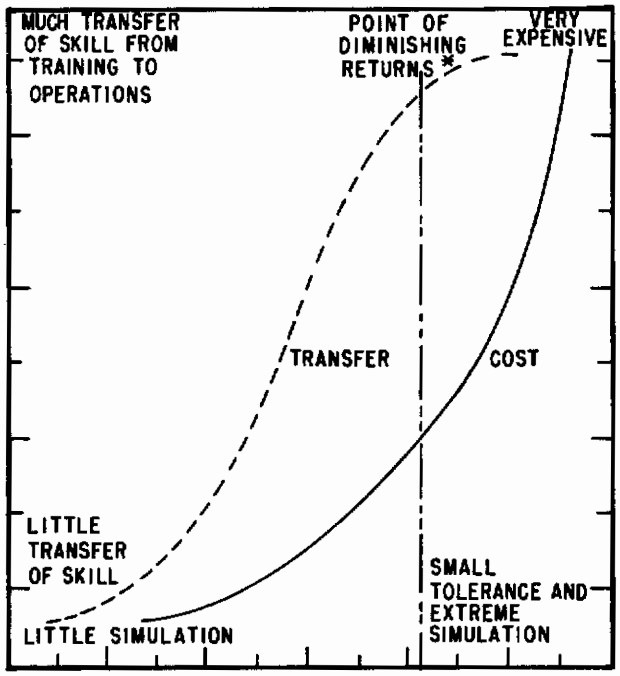


Figure 7. Front-Panel Sections of the MTS

Although operational components may be generally considered the most valid types of maintenance training equipment, this is not necessarily true. Operational training and testing have several disadvantages, which include: (1) high cost of equipment, (2) scarcity of equipment during weapon system test, (3) malfunctions are difficult to insert, and (4) within-equipment and between-unit variability. Thus, a tradeoff in favor of a simulator to try out the performance test is considered the best solution to the problem of the lack of available operational equipment. In addition, a maintenance task environment simulator may serve also as an economical prototype training medium during the conduct of the experimental course.

Miller (ref. 76) distinguished between engineering simulation and psychological simulation. That is, engineering simulation duplicates the functional characteristics of the operational equipment within very close tolerance specifications, while psychological simulation is related to transfer of training from the simulator to the operational equipment. As the degree of engineering simulation increases, the costs rise at an increasing rate. An oversimplification of the relationship between the degree of engineering simulation, cost, and transfer of training value by Miller (ref. 76) is shown in Figure 8. Thus, practical decisions about training media must depend upon compromises between economic and training objectives. The development of a simulator for performance testing and possible course training is described in Section III.



This is the point the designer wants to determine.

It is getting the most training value per dollar cost.

Figure 8. Schematic Relationship between Degree of Engineering Simulation, Cost, and Transfer of Training Value — Motivation assumed to be constant and high (From R. B. Miller)

COURSE DEVELOPMENT DURING WEAPON SYSTEM TEST

The weapon system test consists of three phases (Category I, II, and III) in which the system is tested before operational use:

1. *Category I, Subsystem Development Tests and Evaluation* consists of the various components and subsystems of a system and the testing provides for qualification or any necessary redesign and refinement.

2. *Category II, System Development Test and Evaluation* consists of development testing and evaluation of integrated subsystems. Among the other objectives, this test offers familiarization experience, and limited training to the prime major air command (using agency) and Air Training Command personnel.

3. *Category III, System Operational Test and Evaluation.* During this test, the using major air command tests and evaluates, under operational conditions, the operationally configured systems with all components, support items, and personnel skills.

The development of a training course during the testing of a weapon system is not a simple task, since many problems arise which must be resolved by data revision, media and real equipment tradeoffs, and judgmental factors. The reliability of the system may be less than desired for operational use, and this may result in configuration changes. One major problem is the limited number of aircraft available during the test phases. Since the few aircraft are used to the maximum extent, it is difficult to schedule on-aircraft task analysis or tryout of troubleshooting techniques.

Stackfleth (ref. 107) made clear the difficulties to be encountered in the effort to validate predicted personnel requirements during the weapon system test:

"1. System design may vary during the test situation. For example, ground support equipment may not be developed so that it can be used in conjunction with the prime equipment. The use of substitute equipment may drastically change the duties and tasks which are to be performed during the test period. Likewise, equipment reliability at this time may not be representative of the reliability which can be expected after operational use, so that the frequency of duty task performance is likewise not representative. The few available items of equipment are being fully utilized for hardware test, so they are difficult to obtain for testing the human component.

"2. Personnel who actually participate in the test may not be similar in skills to the operational personnel. During the early phases of testing, equipment test is handled by contractor personnel already stationed at the test site. During Category III tests, the individuals sent from the operational squadrons may not be representative in skills or knowledge to those airmen who will eventually be expected to operate the system in the operational context.

"3. Learning factors can be expected to increase the time required in performing jobs both in the test and early operational phases of the system."

Data Collection Problems

The data for the AFSC 322X1R Job Behavioral Description were collected during Category II testing and some of the foregoing problems were encountered, which included:

1. Limited number of aircraft at any one site.

2. Limited number of prototype technical orders or manuals for the subsystems.

3. Changes in aircraft configuration.

During the job behavioral analysis, it was decided that a maintenance task environment simulator should be developed to simulate maintenance tasks that do not require the actual equipment configuration. Simulated equipment will be valuable in validating the performance test. This will release the aircraft for other needed tests. The simulated environment to be developed under this program should be of value as a prototype for future task analyses, evaluation of performance tests, and training purposes.

COURSE DEVELOPMENT PLAN

In the experiment to be conducted at Lowry Air Force Base, Colorado, 50 trainees with electronics aptitudes of 80 and above will be trained in the selected current electronics training course. The same number, with equal electronics aptitude scores, will receive training in the experimental course. Another 50 students with lower aptitude scores ranging from 60 through 75 will be trained in the experimental course. Airmen with electronics aptitude scores lower than 80 will not be entered in the current electronics course, since the training is oriented toward students with aptitude percentiles in the 80-95 range. The experimental course will be designed to provide for individual differences in the 60 through 95 aptitude range. The overall course program development will consist of three major areas:

1. *Criterion Development*

   The LCI criterion development is discussed in Section III. It consists of two phases:
   Phase I — Behavioral Job Description.
   Phase II — Development of a Job Performance Task.

2. *Development and Conduct of Course*

   The development and conduct of the LCI course is presented in Section IV. This effort will include three phases:
   Phase I — Development of Plan of Instruction.
   Phase II — Prepare Electronics Training Course (LCI).
   Phase III — Conduct Training Course.

3. *Program Evaluation*

The evaluation of the total program will compare the effectiveness of two approaches to training: the LCI approach, and the principles-oriented concept. The program will be evaluated in terms of student criterion achievement, cost effectiveness, timeliness of the LCI effort conducted during the weapon system development, validity of the prediction of field job requirements, and the applicability of the procedures used to other weapon systems. The job performance test, to be prepared during Phase III of the Criterion Development, and the Air Force Specialty Knowledge Test (SKT) will serve as measurement criteria of achievement by the control and experimental groups. A more detailed description of the proposed evaluation is contained in Section V of this report.

Section II.

ARMED FORCES STUDIES RELATED TO INSTRUCTIONAL SYSTEMS DESIGN

TASK ANALYSIS STUDIES

Task analysis is a technique used by training analysts to describe behaviors required of a job. If meaningful, the task analytic approach can be a powerful tool in predicting job behaviors which can be converted to relevant training objectives. However, a training course may contain highly irrelevant objectives, even when based upon a competent job behavioral analysis. Sometimes a high degree of judgment is required in the development of objectives based upon a simple task. The problem becomes more difficult when an effort is attempted to bring together many of the various facets of electronics theory considered by the course developer to be required, in contrast to behaviors actually required on the job. Two Army studies (ref. 5, 104) adequately cover the development and derivation of training objectives.

Training Philosophies

In the Armed Forces, two distinct training philosophies exist concurrently as follows: (1) formal training should teach the trainee *about* his job and he can learn to *do* his job later in the field; and (2) the trainee should be taught on-the-job skills and knowledges in formal training. Task analysis and behavioral description have received impetus from the latter philosophy since it is necessary to know what behaviors are required of a job in order to teach them in formal training.

Air Force

In the early 1950's, the Air Force recognized the need to train personnel during the developmental stages of new equipment to reduce the time lag between the availability of equipment and trained personnel required for maintenance and operation. Contractual efforts were sponsored to devise procedures whereby training requirements could be reasonably predicted from systems data obtained during the developmental cycle. This research attempted to determine what a trainee *needs* to know as opposed to what he *ought* to know.

In 1950, Miller (ref. 78) described a systems function analysis for anticipating maintenance job requirements from early stages of systems development. The following year, Miller and Folley (ref. 80) reported methods for determining maintenance skill, knowledge and ability requirements, and recommendations for designing electronic equipment for the maintenance job. In follow-on studies, Miller, Folley, and Smith (refs. 81, 82, 83) applied procedures developed in the above studies to the AN/APQ-24 radar and K-1 bombing-navigational subsystems. The purpose of the application was to validate the procedures for anticipating the maintenance job requirements of electronic equipment from data available during the prototype stage of equipment development. In further research studies for the Air Force, Miller (refs. 72, 74, 77, 78) describes various approaches to task analysis; however, his guide to position-task description (ref. 74) perhaps represents the most complete treatment of his task analysis methodology. Later studies included a symbolic system of task classification which described general properties of stimuli, responses and their interactions, and the use of task analysis information in establishing training requirements, selecting training equipment, and developing proficiency measurements.

Army

Shriver (ref. 98) described two methods for analyzing electronic weapon systems. One method was used for the operator task and one for the maintenance task. Both methods identify a set of skills and knowledges which should finally lead to effective operation and maintenance of the system. Sets of skill, knowledges, cues and responses suitable for operation and maintenance of the M-33 Anti-aircraft Fire Control System were obtained by use of the two methods. The M-33 cues and responses obtained from the two analyses were combined into skills and knowledges for a 12-week experimental electronic repair course. Although the experimental group training time was less than half the conventional training time, there were no significant differences in proficiency between the experimental and control groups.

Navy

Folley (ref. 37) presented guidelines to be used in task analysis which contained some basic ideas that the analyst should understand about analyses and described the stages of the task analysis method essentially in the order in which they normally would be performed. The study also includes examples to illustrate the type of data required and discussions of special problems. Folley (ref. 36) also reported a study concerning the development of an improved method of task analysis for the Training Situation Analysis (TSA) program of the Naval Training Device Center. The task analysis is the first phase of the TSA, followed by the systems analysis which has the objective of identifying priorities of tasks for training. During the design of operational equipment, Gradijan, Gebhard, and Brooks (ref. 50) investigated the various aspects of training functions. The definition of when, where, and how training provisions should be incorporated into new operational military system designs was prepared in the form of a handbook for systems designers (ref. 38). Chenzoff (ref. 18) reviewed the literature during this research effort and he and Folley (ref 19) prepared the guidelines for the Training Situation Analysis.

ARMED FORCES ELECTRONICS MAINTENANCE TRAINING STUDIES

Rationale for the Studies

Many Armed Forces studies have been made in an effort to improve the effectiveness of electronic maintenance by the use of various media to obtain greater transfer of training and by performance as paper-and-pencil testing. Also, considerable research effort has been expended in the development of more efficient troubleshooting techniques, performance aids, and training analysis. Concurrently, research sought better means to utilize lower aptitude personnel, improve performance aids, and devise a more efficient training technology. Since electronics maintenance training is expensive, it has been a choice problem area for cost reduction research for years. One approach to the problem, the functional context method, is very useful in the development of training designs for more meaningful courses for both high and lower aptitude personnel. The concept of the functional context method is that the theory taught is restricted to that which is considered to be directly applicable to the performance of the job. The rationale for using the functional context, in addition to possible course length reduction, is that when properly sequenced the material can be learned easier by both high and lower aptitude trainees. In describing the functional context method in late 1965, a Human Resources Research Office (HumRRO) bulletin* contained the following statement:

"In the functional context method, instruction in basic electronics and electronic fundamentals is integrated into the total course sequence rather than being given at the outset.

"Conventionally-trained students on the other hand, begin their course with instruction on basic electronics after which they learn to read schematic diagrams. Eventually, they work their way up to field radar equipment.

*"What HumRRO Is Doing" — Human Resources Research Office, The George Washington University, Vol. 2, No. 3, Fall, 1965.

"A major contrast, then, between the two approaches is one of whole-to-part vs. part-to-whole sequencing."

The concept of training for a restructured or simplified job represents a radical departure from the traditional training methodology. The trainees are taught the necessary skills and knowledges required to troubleshoot equipment by means of proper use of performance aids. Some of the materials (nomenclature, color code, test equipment, etc.) which are taught in traditional electronics courses also are presented in the restructured course. However, the materials are presented in the proper sequence as the trainee requires them to accomplish the tasks prescribed in the performance aids.

The selected Armed Forces studies considered in this section may be classified into three categories:

1. Functional context maintenance training for one system without modifying the maintenance job.
2. Functional context maintenance training for transfer to a wide range of current jobs without modifying maintenance jobs.
3. Training for a restructured or simplified job.

Functional Context Maintenance Training for One System

In this category of training, only those skills and knowledges required by one system are taught. The current job performance aids are not modified.

Air Force

The Lowry LCI Project described in this report can be included under this category. The development of the course for the Weapon Control System Mechanic, AFSC 322X1R, however, will include various techniques used in all three categories, with the exception that the job will not be restructured for the purpose of the experiment.

Army

HumRRO Task Radar and Task Maintrain I were two similar studies concerning maintenance training for M-33 fire control technicians. In Task Radar (ref. 57) the standard electronic fundamentals subcourse was modified so that test equipment was taught in the laboratory instead of by lecture. The amount of theory and circuit analysis was reduced, and mathematics instruction was eliminated. Also, 1 week of system practice was added at the beginning of the course. As a result, the course length was reduced from 12 weeks to 5 weeks.

The 20-week equipment phase was not reduced, but instructional emphasis was greatly changed. The standard length was 32 weeks and served as the control group. In addition, the experiment included one experimental group trained in the new revised 26-week course, and one experimental group trained in a course consisting of the standard 12-week equipment course for a total of 33 training weeks. A proficiency test (ref. 10) developed as a result of an analysis of field requirements, was administered to all groups. The results showed that the experimental 26-week course students achieved significantly higher than the other two groups.

Task Maintrain (ref. 56) used a two-group design (experimental and control). The experimental course consisted of 27 weeks of training (an additional week was added to the M-33 basic electronics course), and the control course was the standard 32-week course used in the Task Radar experiment. The experimental group achieved significantly better than the control group, but a different criterion test was used to measure trainee proficiency upon graduation, and the instructional emphasis differed from that in Task Radar. While similar, Task Maintrain was, thus, not a replication of Task Radar.

HumRRO Task Hawkeye: is a joint Army Air Defense School-HumRRO Project. A full-scale study is being undertaken to determine if the functional context method of instruction can improve student achievement and reduce academic attrition in air defense electronic maintenance. The 24-week course was designed for the Air Defense Missile CW Radar Mechanic (Hawk). An evaluation of the experimental course will be made to determine how well the graduates perform maintenance tasks. A standard test will be administered to students in both the conventional and experimental courses (ref. 93).

Functional Context Maintenance Training for Transfer to a Wide Range of Jobs

All three services have developed and experimentally explored this type of training course. In training for transfer, the student receives instruction only on typical equipment, with the expectation that he will transfer the gained knowledge and skill to the repair of all equipment found on the job.

Air Force

Functional Fundamentals for Electronics Maintenance Personnel. Although reported in 1964, this study (ref. 33) was conducted between 1953 and 1956 at Scott Air Force Base, Illinois. It was designed to include the fundamental tasks and concepts pertaining to all of the existing electronic communication equipment. Specially designed trainers were used, and considerable practice with test equipment was provided. Students with electronics aptitude stanine scores of 7, 8, and 9 were entered in the "high" control and experimental groups while those with scores of 4, 5, and 6 were entered in the "average" control and experimental courses. The results showed that the standard control and experimental courses were equally successful in training students with aptitude scores of 7 through 9. The experimental course, however, was more successful than the standard course in training students with aptitude scores of 4 through 6. The results also showed that in the experimental course, the job success of the average aptitude graduates of the experimental course was equal to that of the higher aptitude graduates.

Army

HumRRO Task Repair (ref. 15, 16) was conceived to assist the Army Signal School, Fort Monmouth, New Jersey in the development and evaluation of an improved training program for field radio rapairmen. The course was based upon information obtained from a field survey, and the purpose of both the experimental and standard course was to train personnel to perform field and depot maintenance of radio and associated equipment. Primary emphasis was given to fault finding and repair of the most common malfunctions encountered in equipment pertaining to the radio repairman specialty.

A maintenance-oriented frame of reference was used to teach the course subject-matter, and the trainees were provided a systematic troubleshooting procedure which included the use of technical publications. The 20-week functional context experimental course was compared with the 20-week standard course. Although the two courses were of equal length (5-week fundamentals phase and 15-week equipment phase), each differed greatly in content and in the instructional emphasis. The evaluation consisted of a battery of 7 proficiency tests, which included 4 performance tests and 3 paper and pencil tests.

The results showed that the experimental course graduates were significantly superior to the standard group in troubleshooting, repair skills, and the use of test equipment. Neither group was significantly superior in the use of manuals, schematics and alignment procedures.

HumRRO Task Limit (ref. 49) study concerned the application of the functional context method to the first 3 weeks of instruction in basic electronics, or front-end electronics principles, at Fort Gordon, Georgia. The content of the instruction was not changed, but the sequence of presentation was modified. The purpose of the course was to develop and evaluate methods and techniques of instruction that might make electronics training easier for men with barely acceptable aptitudes and men with unacceptable submarginal aptitude scores which excluded their entry into the standard training. A 252-item multiple-choice basic electronics test battery was used to evaluate the experiment.

The trainees in the functional context method group answered an average of about 5 percent more of the test items correctly than did the trainees in the standard group. The training was particularly effective for trainees with average and lower levels of aptitude. Trainees with marginal and submarginal aptitude scores did as well, on the average, as higher aptitude trainees trained by the standard method. As stated previously, the trainees were evaluated on the basis of a paper-and-pencil test. If the functional context trainees are also low in verbal ability, such tests are difficult for them. However, low aptitude in electronics does not necessarily indicate low verbal aptitude. If both verbal and electronics aptitude scores are low, tests of actual performance should be included in the evaluation of the experiment for comparison purposes. In performance-oriented electronics courses where instructional and evaluation emphasis is placed upon troubleshooting actual equipment and the use of tools and test equipment, verbal ability is less important than it is in the traditional setting. Hooprich (ref. 59) found no significant correlations between reading ability and achievement in an experimental performance-oriented electronics course.

HumRRO Task NICORD (ref. 70) investigated methods for training ordinance guided missile maintenance specialists based upon field job requirements. The methods were developed and applied to a representative ordinance military occupational specialty (MOS), Nike Track Radar Repairman. The analysis of the job specialty included: (1) Systems Analysis, (2) Task Analysis, (3) Knowledges and Skills Analysis, and (4) Determination of Training Objectives.

The foregoing analytic methods were applied to the selected job specialty, and resulted in a training content substantially different from that of the standard Nike Track Radar Repairman Course. In the experimental course, emphasis was given to maintenance procedures, location and identification, indication of part failure, normal equipment output tolerances, signal flow, relative failure potential, specific symptom-cause relationships, adjustment and repair skills, and troubleshooting logic. Less emphasis was given to complex theory operation, and theory included in the course was limited to fundamental electronics, circuit resistance, DC circuitry, and qualitative characteristics of circuit operation. A 22-week course was developed to include the training content modifications, and it was compared with the 37-week standard course. The evaluation results showed that the experimental group achieved significantly better performance than the standard course group. Also, the experimental group performed almost equally as well as an experienced group in troubleshooting radar components.

Navy

The Navy Electronics Technician Experimental Course (ref. 88) was developed by the Navy Training Research Laboratory, San Diego, California. The approach to training emphasized practical work with standard electronic equipment. Mathematics and electronics theory were only applied to the requirements of actual job performance. The objectives of the study were: (1) train personnel with aptitudes lower than those typically acceptable for entry into the standard course training, (2) train them in a shorter period of time, and (3) train them to perform maintenance skills immediately upon graduation.

The study indicated that the trainees were trained in approximately 30 weeks, compared to 38 weeks for the high aptitude trainees in the standard course. A field evaluation utilizing actual performance tests, rating scales, interviews, proficiency rankings, and written tests indicated no significant differences in the overall proficiency of the experimental and standard group graduates (ref. 87).

TRAINING FOR A RESTRUCTURED OR SIMPLIFIED JOB

Most of the previous studies considered in this section have been based primarily on the use of traditional job performance aids. The maintenance manual is one example of the traditional aids to performance. It usually contains schematics, pictorial diagrams, a parts list, a discussion of the theory of equipment operation and, sometimes, a sketchy troubleshooting procedure. Generally, the experimental training programs utilized electronics fundamentals instruction preceding the equipment phase, although the fundamentals were taught in a functional rather than traditional context.

One major purpose of extensive traditional electronics theory training is to provide the trainee with information which may help him troubleshoot and repair all types of equipment that he may encounter in the equipment phase of training as well as later on the job. Recent research, however, indicates the possibility of first-term airmen electronics training based upon the actual requirements of the job. More use is being made of a variety of job performance aids and other information storage devices than ever before. The restructured or simplified job has emerged as a result of the research and development in the area of performance aids.

Air Force

A considerable amount of research has been accomplished in the restructure of the electronics technician job by means of job performance aids. Some of the important research findings to date are:

1. *Presentation Format.* No significant differences in effectiveness between the manual and automatic retrieval of visual information. However, both were superior to audio presentation of job aid information (ref. 28).

2. *Level of Detail.* Increasing the level of detail, beyond the minimum essential, interferes with both speed and accuracy of between-stage troubleshooting task performance. The implication is that block diagram presentations of information flow data is superior to schematic presentations if the task is to troubleshoot down to the block (ref. 29, 30).

3. *Structure of Content.* High electronics aptitude (70-90) subjects perform between stage troubleshooting tasks better than medium electronics aptitude (40-60) subjects when using decision-type aids. However, medium aptitude subjects perform as well as high aptitude subjects when using nondecision or fully proceduralized job performance aids (ref. 30).

b. It was demonstrated that high (70-90) and medium (40-60) aptitude subjects with only 12 hours of training can solve both between and within stage troubleshooting problems when fully proceduralized methods are used (ref. 30).

Army

HumRRO Task Forecast (ref. 99) represents a complete break with all traditional training content. The development of the experimental course was based upon an analysis in terms of cues and responses. A primary objective of this study was to shorten training time by the re-structure of the Army M-33 fire control technician job. The task involved three major problems: (1) the development of a troubleshooting-oriented course based upon a cue-response paradigm (model), (2) the development of training and job aids, and (3) providing for transition from obsolete to new equipment.

The program was accomplished by the development of improved decision job performance aids for both between-stage and within-stage troubleshooting. A special training program was developed to teach trainees how to use the performance aids, and the trainee received no traditional electronics theory instruction. The training time was reduced in FORECAST I study from 30 weeks to 12 weeks.

HumRRO also conducted three follow-on FORECAST studies: (1) the Base Line Study, (2) Mock-up, and (3) Transfer of Training. Due to the small number of subjects used for the studies, they should be considered only as pilot studies.

The Base Line Study taught the use of the FORECAST performance aids on only one of the four M-33 subsystems, but tested the subjects on all four subsystems. These subjects did almost as well as FORECAST I subjects who were trained to use the performance aids for all four subsystems.

In the Mock-up study, instead of 30 hours of real equipment training given in FORECAST I, 24 hours of mockup plus 29 hours of real equipment training were given for a total of 53 hours. Subjects performed maintenance tasks much better than FORECAST I subjects, but they spent 14 more hours in training.

In the Transfer of Training study, subjects were taught to use FORECAST-type performance aids on an old model of the M-33 fire control system. After only 9 hours on the new model M-33, subjects were able to do better on the criterion test than FORECAST I subjects using the actual equipment.

Section III.

CRITERION DEVELOPMENT

PERFORMANCE TESTING

The job performance assessment of technicians who maintain modern military weapons systems represents a complex and continuing problem in the Air Force. In fact, mission effectiveness and success depend upon the ability of the technician* to maintain the system in an optimum status of operational readiness. Thus, the evaluation of job performance should be based upon the actual work performed by the technician in the real job environment. However, current Air Force upgrading procedures rely heavily upon paper-and-pencil knowledge tests to evaluate competency rather than upon tests which measure ability to perform actual maintenance tasks. Perhaps reliance upon cognitive testing techniques is due to the costly and time-consuming aspects of performance testing. Performance testing is generally limited to only one individual at a time; whereas, paper and pencil techniques permit testing of large groups in a relatively shorter period of time (ref. 34).

At present, job knowledge tests do not adequately measure the technicians' ability to troubleshoot or to use test equipment and tools on the job, except, perhaps, on a correlational basis. Such tests may be used, however, to evaluate certain technical knowledge related to maintenance tasks; but in proficiency evaluation, a distinction should be made between knowledge about the job and actual job performance.

Since tests about job knowledge do not adequately assess the qualitative aspects of maintenance tasks, a job performance test will be developed as a criterion for evaluation of the LCI course. Cognitive tests may be used to evaluate technical knowledge if the behavioral analysis indicates that such information is necessary for job performance.

The development of a performance test involves several complex problems. One of the most difficult of these is the problem of achieving adequate test lengths to get reliable scores while keeping the duration of the test within reasonable limits. The solution of realistic troubleshooting problems is a slow process. Therefore, it is almost impossible to obtain sufficient problems to reliably evaluate troubleshooting ability within a few hours.

Scoring presents a second problem since the scoring of test problems implies a criterion or correct answer. While it is easy to identify a correct answer for a troubleshooting problem in terms of which component is malfunctioning, this gross measure is not sensitive enough to obtain an adequate assessment of the mechanics' ability. Since the gross measure is nondiagnostic, it is necessary to obtain some other, more sensitive scores for evaluative purposes. One alternative is to determine the number of checks that the technician makes in solving a troubleshooting problem. This method of scoring has two disadvantages:

1. The number of checks is not really relevant unless it reflects the amount of time spent. This is because all checks do not take the same amount of time and, thus, the number of checks without regard to the time per check is not a useful score.

2. The second difficulty is that the number of checks is not diagnostic. The mechanic who takes an abnormally large number of checks may do so for a variety of reasons such as: not knowing troubleshooting logic and, therefore, not choosing efficient checks; it may be that he

*In this report, "technician" also includes "mechanic."

uses his test equipment ineffectively and so obtains incorrect readings which mislead him; or it may be that he does not know how to read a data flow diagram.

A third problem in performance testing is the apparatus. Operational personnel may be reluctant to permit the research team to insert malfunctions into equipment. Conversely, if some kind of simulation is used, the question of validity is raised. Of course, validity can still be questioned, even when operational equipment is used.

DEVELOPMENT OF THE SIMULATED MAINTENANCE TASK ENVIRONMENT

The development of the job performance test requires that test items be tried out on appropriate equipment, and that realistic provisions be made for the equipment needed for the actual administration of the test after it has been developed. Since sufficient actual F-111A equipment will not be available for this purpose, a simulated maintenance task environment must be developed for the performance test tryout. Therefore, a fully transportable, full-size mockup of approximately a 14-foot section of the F-111A will be constructed. The section begins at about the rear of the cockpit and extends forward into the radome, which will be truncated. Physical, electrical and electronic features will be incorporated into the mockup or into accessory equipment and materials.

BEHAVIORAL DESCRIPTION

In this study, the behavioral description will form the structure upon which the job proficiency test will be based. Three problems must be solved in the development of the behavioral description:

a. The level at which the description of the job is prepared.

b. Obtaining an accurate description of certain parts of the job, chiefly troubleshooting.

c. Determining the relative importance of various parts of the job for emphasis in testing.

Level of Description

The approach to task analyses in the early 1950's was to record in great detail every step of the job, and even parts of the steps. An attempt was made to make explicit the exact behaviors required on the job, in contrast to other approaches which tended to avoid description of job behaviors and, thus, be cast in terms of presumed knowledges required to perform the job. While the very detailed job description served this purpose, the level at which the job should be described depends upon how the description will be used. In the proposed study, the problem is to find a level of description that provides adequate information to serve as a basis for the development of training objectives and as a job proficiency test, without including a significant amount of unusable detail.

Determination of Relative Importance of Parts of the Job

The relative importance of various parts of the job depends upon the answer to the question: Importance for what? If the problem is to determine relative emphasis in training, the definition of importance will be different from the question of determining relative importance for performance testing. In the former case, importance may be described in terms of difficulty to learn because, presumably, the more difficult to learn items should receive greater emphasis in training. To make decisions about performance testing, however, the definition of importance is somewhat different. One criterion of importance that can be used is frequency of occurrence of a given task. This is a reasonably good criterion to use in deciding on emphasis in performance testing. Presumably, if the technician can perform the most frequently occurring tasks, he can perform a higher proportion of the job than if he performs the less frequently occurring tasks. The performance test, therefore, should determine the extent to which the technician can perform the more frequent tasks.

The definition of importance, however, is partly dependent upon the level at which the tasks are described. For example, in the general function of troubleshooting, the frequent recurrence of a particular malfunction does not particularly mean that testing should include that malfunction as one of the problems. The reason is that the important part of the job for the technician to be able to perform may be an effective method for solving troubleshooting problems, rather than his knowledge of a particular answer to the problem which occurs often.

Obtaining an Accurate Appraisal of the Job

The determination of what the technician is doing while observing him troubleshooting is very difficult. Much of what he does is mental in terms of reasoning out what steps he should take. Furthermore, unless the subject being observed is known to be an expert by some independent measure, the information may reflect the way a novice, or at least, a nonexpert performs for job. Observations obtained under such circumstances, of course, should not serve as a basis for the development of performance tests.

GENERAL APPROACH TO THE LCI CRITERION DEVELOPMENT

A performance test will be developed to measure the job behaviors required of the F-111A Weapon Control Systems job on the flight line (organizational maintenance). The test will serve as a criterion measure of trainee achievement in the LCI program. Two major phases are proposed for this effort:

Phase I — Preparation of the Behavioral Description.

1. *Data Collection*
   - a. Obtain all pertinent documents, technical orders, QQPRI, technical reports, and other performance aids.
   - b. Prepare a first approximation to the job description from these documents.
   - c. Prepare field data collection instruments.
   - d. Collect data at F-111A sites.
2. *Behavioral Analysis*
   - a. Identify tasks.
   - b. Determine task activities.
   - c. Describe behavioral details.

Phase II — Development of the Performance Test

1. Preparation of test rationale and specifications.
2. Preparation of test items.
3. Development of maintenance task environment simulator for test tryout.
4. Formal test tryout.
5. Preparation of final form of test.

PHASE I — PREPARATION OF THE JOB BEHAVIORAL DESCRIPTION

1. *Data Collection.*

The contractor was furnished all required Quantitative and Qualitative Personnel Requirements Information (QQPRI) by the F-111A System Program Office (SPO) at Wright-Patterson

Air Force Base, Ohio. Prototype copies of all pertinent technical orders were provided by the F-111A manufacturer, General Dynamics, Fort Worth, Texas. Other pertinent documents and references were obtained by the contractor from various sources.

The first approximation to the job description (preliminary job description) contained all of the elements expected to be included in the final job description, but in less detail, and less authoritatively. To obtain first-hand information, a visit was made to General Dynamics prior to preparation of the preliminary job description.

The preliminary job description included:

a. Names of the fire control subsystems.
b. Definition of maintenance echelons used with this system.
c. The behaviors involved under each maintenance function as follows:

(1) *Checking:* Checking consists of following a sequence of steps which normally involve operating equipment controls, and observing displays for indications of proper or improper operation. In some cases, test equipment may be required, as in checking radar power and sensitivity.

(2) *Adjusting:* Adjusting is very similar to checking, except that it is normally used in the operation of certain controls that are not normally used in the operation of the system. Rather than merely observing a system or test equipment displays to determine proper or improper operation, the technician must operate the adjusting control until a particular indication is obtained on a specified display or displays.

(3) *Replacing:* This consists of using tools to remove items from the system and to install other items to replace the removed ones.

(4) *Repairing:* Because of the present trend toward corrective action by replacement, repairing has a relatively small role for AFSC 322X1R. Occasionally, however, it is necessary to repair a cable connector or a cable, or a mechanical part of some kind. Repairing consists of mending a broken part, component, or piece.

(5) *Servicing:* Servicing consists of recharging pneumatic and hydraulic systems, providing lubrication where required, and cleaning delicate parts of the system where required.

(6) *Troubleshooting:* Troubleshooting consists of operating system controls, observing system displays, making measurements with test equipment, and applying reason-process to identify malfunctioning components in the system.

In order to facilitate field data collection, various materials were devised. The following kinds of data collection instruments were used: (1) Task analysis forms to permit systematic collection of the types outlined above, and (2) Simulated maintenance problems for use in structured interviews.

Because of the limited number of aircraft available in the inventory, it was not possible to make as many data collection trips as desired. However, in addition to the visit to General Dynamics, data collection visits were made to Edwards AFB, California and Cannon AFB, New Mexico.

2. *Behavioral Analysis.*

Two classes of behaviors are associated with job performance and can be classified as: (1) Normal Repertoire Behaviors (NRB) which require no special skills or knowledges to perform, and (2) Special Behaviors (SB) which only the proficient technician using special skills and knowledges can perform (ref. 19). Anyone who can read and follow directions can perform an NRB; therefore, these behaviors do not discriminate between technicians and nontechnicians and, thus, were of little concern in the behavior analysis. However, the SB aspects received special consideration since these behaviors include very narrow discriminations, especially in rapid responses, knowledge of unfamiliar terms, and test equipment operation. The behavioral analysis consisted of three steps: (1) Identify tasks, (2) Determine task activities, and (3) Describe behavioral details.

a. *Identify Tasks*

The final list of maintenance functions were examined to determine a logical breakdown of maintenance job behaviors. Ten task blocks were identified which dealt with operational checkout and self-test troubleshooting of the major systems, troubleshooting the subsystem tie-in test set, removal and replacement procedures, locating and correcting wiring harness malfunctions, and boresighting the optical sight cradle. The task blocks were examined, and all subtasks associated with the blocks were identified.

b. *Determine Task Activities*

After all tasks within each task block had been identified, each task was examined to determine which class or classes of behavior were required in performing the task. The specific behaviors were matched against the definition of each activity. The identified activities were then listed under the task.

c. *Describe Behavioral Details*

After all activities were determined, a form taken directly from a report on the Task Analysis Method (ref. 19) was used as a guide for developing the behavioral details for each activity. The types of information used to describe the behavioral details included: procedure following, continuous perceptual motor activity, monitoring, communicating, decision making, and problem solving.

PHASE II — DEVELOPMENT OF THE JOB PROFICIENCY TEST

1. *Preparation of Test Rationale and Specifications.*

For each class of activity in the job behavioral description, there will be a prepared statement giving the following information:

a. The critical aspects of the behavior to be measured in the proficiency tests.

b. The type and nature of the test item or items to be used in measuring this behavior.

c. The kind of apparatus or equipment needed to the extent that this can be specified before the items are prepared.

d. The nature of the scoring of the item to the extent that this can be specified before the item is prepared.

e. An estimate of the time required to complete the item or this class of items.

2. *Preparation of Test Items.*

Items will be prepared in accordance with the specification and rationale previously prepared. One requirement of the test is that it must be diagnostic. To achieve this, subtests or test items will have part-task scores. For example, if the operation of a given item of test equipment is to be tested, scores might be obtained on:

a. Resetting the instrument.

b. Obtaining the proper display.

c. Evaluating the display.

If the subject's performance is poor, the subtest with three subscores will reveal to some extent just where his difficulties lie.

3. *Development of Maintenance Task Environment Simulator for Test Tryout*

The development of the job behavioral description revealed the extreme difficulty involved in obtaining an adequate performance test tryout, because of the limited number of aircraft at the test sites. To overcome this problem, a fully transportable, full-size mockup of approximately a 14-foot section of the F-111A aircraft will be built. The necessary physical, electrical, and electronic features for adequate simulation of the maintenance tasks of AFSC 322X1R will be incorporated into this mockup or into accessory equipment and materials.

The simulation would be designed to support the job performance test. The intention is to achieve the needed simulation with as simple a device as is necessary to obtain sufficient fidelity of simulation to provide, both, testing and potential training facilities for the tasks performed by the technician. The resultant simulator will permit performance of all maintenance tasks required of AFSC 322X1R at a level of fidelity judged adequate for testing or training, where these judgments are made in accordance with the established principles of task simulation.

The characteristics of the maintenance task environment will be determined from the job behavioral description and performance test requirements. The criterion of critical discriminations and control movements must be simulated to provide a realistic performance test. Since a significant part of the AFSC 322X1R is troubleshooting, the simulating of an adequate sample of realistic problems is necessary. Also, the replacement of line-replaceable units is another part of the job, and so provisions will be made for testing on these operations, as well as for other aspects of the job that will be tested and which require simulator support for that testing.

The principal element of the simulated maintenance task environment will be the mockup. It will be built on a transportable pallet base. The sidewalls of the pallet will be hinged to the base of the pallet to provide supplementary flooring when the mockup is set for use. The lid will be made in four triangular sections that serve as additional flooring when the mockup is in use. The sidewalls would be folded up and the lid placed on top for shipment (see Figure 9).

Most of the controls and displays in the cockpit would be represented by drawings or photographs. The controls and displays used by the weapon control system technician in the performance of his tasks would be operational to the extent necessary to provide adequate simulation for his maintenance job. Supplementary electronics required for the maintenance task environment simulator would be built into boxes conformed to simulate those electronic line-replaceable units in the forward electronics bay that are not used by the weapon control systems technician.

The majority of the tasks performed by the weapon control systems technician are procedural tasks. These tasks can be usefully viewed as consisting of two elements:

a. The sequence of steps.

b. The individual steps.

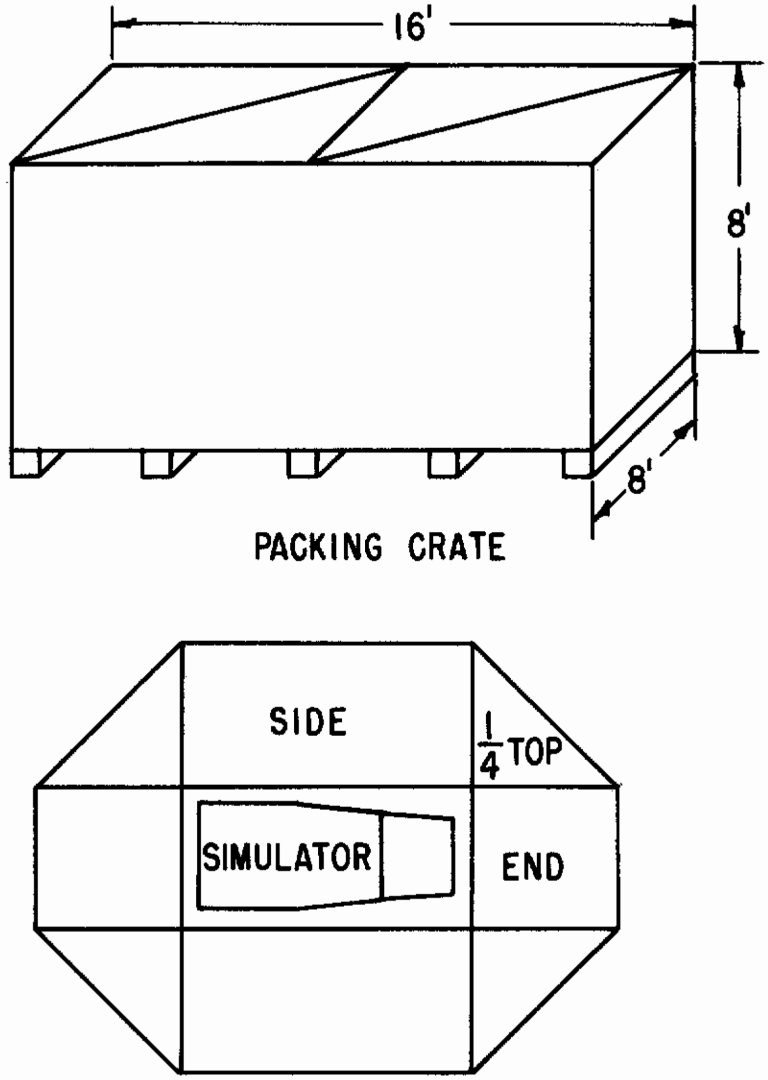


Figure 9. Maintenance Environment Task Simulator — Plan View, Packing Crate

The sequence in which the individual steps must be performed is entirely symbolic. That is, the sequence can be adequately described by a written list of steps, or names, or descriptions. The sequence part of a procedural task, therefore, in and of itself generates no requirement for either physical or functional equipment simulation. All of these requirements come from the individual steps in the procedure.

Accordingly, the functional characteristics of the simulated task environment will be determined as follows:

1. The individual steps of all the procedures will be listed.

2. Each step will be examined to determine the behaviors of the technicians.

3. A judgment will be made regarding the degree to which each behavior must be simulated.

4. The equipment characteristics needed to provide adequate simulation of maintenance behaviors will be specified. This will require combining the requirements from many parts of the task to arrive at a suitable and effective design.

Automatic sensing circuitry integral to the mockup is not contemplated at present. This function is to be handled by the performance test software. It may be desirable on second-generation models of this equipment, if such are later built, to incorporate some automatic recording features to enhance the instructional potential of the simulated task environment and to make the performance test in which it is used more nearly self-administering.

An important part of the technician's job is to isolate malfunctions. Malfunction symptoms are generally detected and reported by the flight crew, and only verified by the technician. Nonetheless, the technician must be able to discriminate reliability between in-tolerance conditions and out-tolerance conditions if his verification of reported symptoms or his performance of system checks is to be meaningful. This aspect of the job requires that the simulator be capable of providing out-of-tolerance indications as well as in-tolerance indications. The development of this capability requires that a sample of malfunctions be selected for the simulator.

4. *Formal Test Tryout*

The size of the sample on which the test can be evaluated will depend partly upon what administrative arrangements can be made with personnel of the F-111A test sites. Allowing for contingencies of the weapon system time schedules, probably between 30 and 40 subjects will participate in the test tryout. After all data are collected, an item analysis will be accomplished on the test and a profile of proficiency will be prepared on the sample tested.

5. *Preparation of the Final Test*

On the basis of the tryout, the test will be revised as necessary. An administration manual, scoring key, scoring instructions, equipment lists, and all other required documentation will be prepared so that a competent test administrator could administer the test if the necessary facilities were assembled.

Section IV.

DEVELOPMENT OF THE LCI COURSE

DEVELOPMENTAL CONSIDERATIONS

Various problems must be considered in the design of an instructional system. Those that deserve primary consideration are: (1) learning sets theory, (2) course content based upon the derived objectives, (3) sequencing of instruction, (4) instructional methods, and (5) selection of training media and equipment.

Learning Sets Theory

Gagné and Paradise (ref. 46) considered two hypotheses concerning individual differences: (1) the acquisition of successive frames of a learning program is basically determined by general intelligence, and (2) observed differences result primarily because individuals begin the task of learning with different levels and kinds of learning. Because of its possibilities in providing for individual differences in training, the second hypothesis will be emphasized in the development of the LCI course.

The term *learning set* means learning how to learn a particular type of problem. More specifically, the knowledge required to master any given terminal behavior is considered to be a set of subordinate capabilities, or learning sets, that are arranged in a hierarchical manner so that any learning set may have one or more subordinate sets. In the hierarchical arrangement of the learning structures, the terminal behavior is placed at the top. To determine the required learning sets, consideration must be given to the question: What must the student do in order to acquire the terminal behavior? The answer should provide a basis for the specification of the highest learning set. When this highest process is stated, determinations must be made as to the capabilities needed by the trainee to acquire other learning sets in descending order. A simple straight-line concept of the hierarchy of learning sets is shown in Figure 10.

It would be ideal if all tasks could be arranged, as shown in Figure 10, with all students entering at the same learning set block. Of course, this seldom, if ever, happens because most tasks require lateral knowledges that must be integrated into the task to be trained and because there are wide differences in the trainees' threshold (entry) knowledge. An analysis of a task can show the various ramifications of learning sets, and a threshold knowledge test (TKT) can detect the trainees' different levels of capability. A typical TKT includes the task criterion, as well as the entry level knowledge required to master the lowest learning sets established for the task to be trained.

Figure 11 shows a simplified schema, adapted from Gagné (ref. 45), of a terminal behavior with inputs from learning sets that must already be a part of the trainees' initial repertoire or be learned in the training situation before trainees can perform the task. The author believes that to achieve, at least, a close approximation to optimum learning on the part of trainees, a task diagnosis of a schematic nature is useful. The concept of optimum learning, invalidates the practice of awarding letter grades, standard score grades, and other competitive score results, but closely resembles the Air Training Command's programmed instruction goal of 90/90 (90% of the students should master 90% of the material).

The LCI course will be based upon *need to know* information as opposed to *nice to know* material. Some kind of distinction needs to be made as to whether the trainee is to be *educated* for the job, *trained* for the job, or possibly *both* (ref. 5). Because of the present low reenlistment

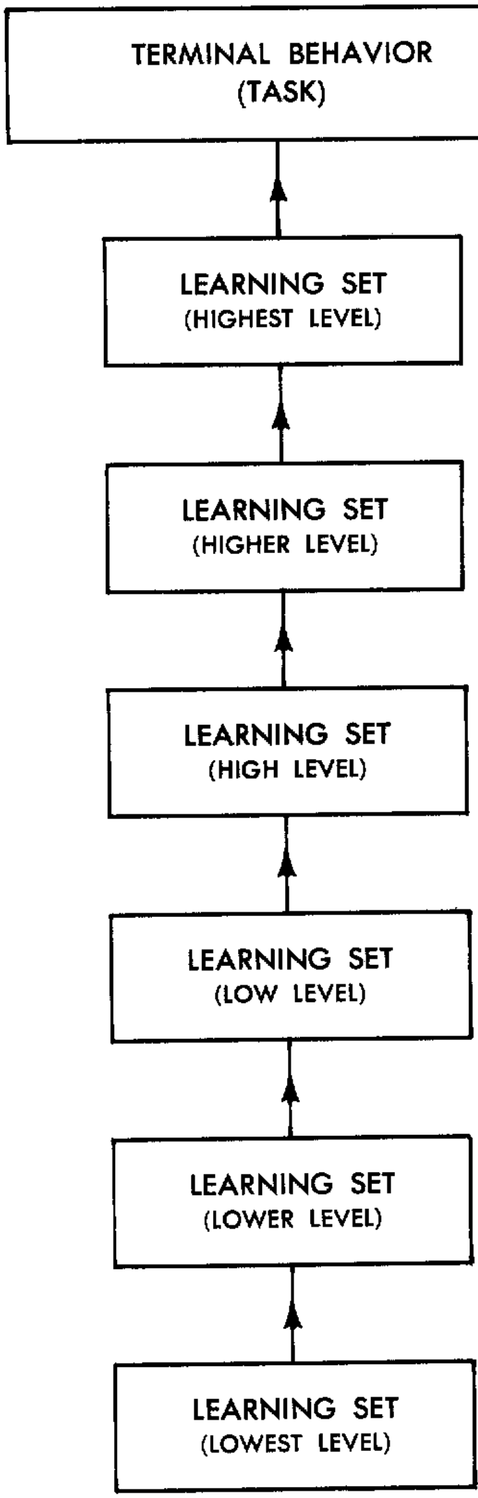


Figure 10. Straight-Line Concept of Learning Sets

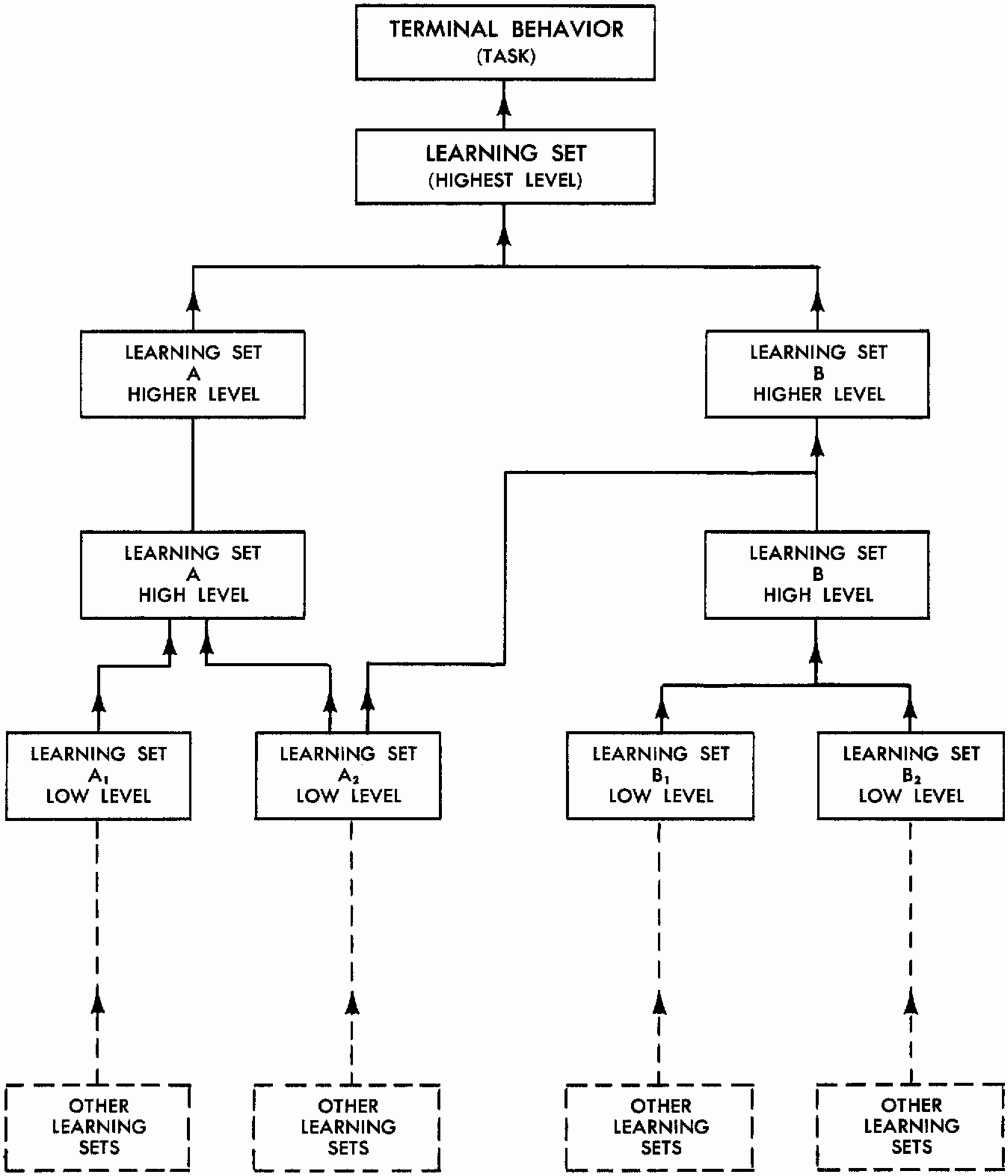


Figure 11. A Presentation of Various Learning Sets Leading to the Acquisition of Terminal Behavior

rate, it seems more economical in terms of costs, time, and materials to train first-term airmen to perform tasks, and reserve theoretical education for reenlistees. As can be determined by the schema in Figure 11, the addition of any instructional material, relevant or not, will be a cause for a proliferation of learning sets, accompanied by increased costs in student time, instructor time, course materials, and training media.

COURSE CONTENT BASED UPON DERIVED OBJECTIVES

Mager's (ref. 68) approach to the preparation of objectives for programmed instruction has served as a stimulus in the search for more effective means of describing the desired learning behaviors of students. However, Mager's work deals with a later stage in the development of course objectives. The first step considers the derivation of terminal behavior based upon analyses of performance or cognitive requirements.

Ammerman and Melching (ref. 5) gave the following rationale for student performance objectives: (1) The derivation of job performance requirements must be accomplished prior to the preparation of statements of objectives, (2) The preparation of formal statements of objectives, incorporating the desired performance requirements, is necessary for effective communication, and (3) The use of these statements of objectives in the design and preparation of instruction, as well as in its management, must occur to insure that the instruction is consistent with the stated objectives. The preparation of the formal Statements of Learning Objectives (SOLO's) for the LCI Plan of Instruction (POI) will be discussed later in this section.

SEQUENCING OF INSTRUCTION

When the SOLO's have been developed, consideration must be given to the order in which they should be presented to obtain optimum student learning. If various objectives in a course are discrete entities (that is, independent of each other to the extent that learning one does not facilitate learning any other one), sequencing will not affect the efficiency of the instruction. However, if the objectives are dependent upon each other, it is extremely important that they be arranged (sequenced) in a hierarchical structure.

INSTRUCTIONAL METHODS

In general, it is expected that extensive use will be made of task simulators and part-task trainers to provide substantial amounts of practice by every trainee. The instructor, rather than being primarily an information-transmitting medium (lecturer), will be utilized mainly in such activities as appraising trainee performance, providing individualized informative knowledge of results, or feedback, and providing enrichment of the program.

SELECTION OF TRAINING MEDIA AND EQUIPMENT

A multimedia approach will be taken in the development of the LCI course, and the selection of the media and equipment will be determined by the objectives. A great deal of research on the various types of training media has been sponsored by the Armed Forces (ref. 86, 112) which should be useful to course developers in their selection of media. However, in the development of the LCI course, the *software* (training content) will dictate the requirements for the training *hardware*.

THE LCI COURSE DEVELOPMENTAL PLAN

The proposed LCI research has as its goal the development of a 12-14 week systems-oriented, learner-centered course in electronics maintenance for the Weapon Control Systems Mechanic (AFSC 32231R). The course will be developed in accordance with the most recent instructional technology and will reflect both current systems design and available electronics maintenance training research. The development of the LCI course will consist of three major phases:

1. Phase I – Preparation of the Plan of Instruction (POI).
2. Phase II – Preparation of the course.
3. Phase III – Conduct the course.

PHASE I – PREPARATION OF THE POI

Four steps are planned as follows:

1. Preparation of Primary Statements of Learning Objectives (SOLO's).
2. Determination of subordinate learning objectives.
3. Determination of teaching sequence.
4. Selection of training media and equipment.

Preparation of Primary SOLO's

The primary learning objectives will be based upon the performance requirements of the job, taken directly from the behavioral job description, but supplemented with performance times and error specifications. The statements will specify what the trainees will be expected to do at the end of the training program. For example: Perform operational performance check on the Lead Computing Optical Sight in 10 minutes, assuming power on, and using T.O. No. IF-111 A-2-5-1.

Determination of Subordinate Learning Objectives

The subordinate Learning Objectives must be derived from the Primary Learning Objectives through identification of their behavioral components. One method of accomplishing this is to ask the question: What capabilities must the trainee possess to perform this task successfully given only a set of instructions? The answer to this question will identify one or more simpler and more general subordinate tasks. The exact outcome of this process depends, of course, upon the nature of the instructions given the trainee. In the case of the foregoing example, a subordinate learning objective might be "identify correct sighting picture and sighting picture dynamics in all modes of LCOS operation." The question is then repeated for each of these subordinate tasks. This process is continued until the answer is a task or tasks which the student can perform successfully without any learning being required. This process produces a hierarchically organized set of subordinate learning objectives, such that for any higher level task to be performed successfully, the trainee must be able to perform all lower level tasks.

If the primary learning objectives are specified, it can be assumed that the secondary objectives are not needed, because they are subsumed under the primary objectives. However, the behavioral components from which the secondary objectives are derived may be common to a number of primary objectives. This may affect the way in which these underlying skills, knowledges, and abilities should be presented, and the sequence of presentation of material or behaviors related to them. Thus, if it is necessary to identify the correct sighting picture, as mentioned above, as part of several primary learning objectives, it might be desirable to withdraw this and treat it as a part-task learning problem. The student could then learn to make this discrimination separate from the several contexts in which he must use it, and then simply apply this ability in achieving the broader primary learning objectives. The subordinate, or secondary objectives must be identified by an analysis of the primary SOLO's. The obtained result, as in all analyses, depends to a great extent upon the system, approach, or point of view of the analyst.

Determination of Teaching Sequence

In the present state of technology, the development of an effective course sequence for practically any subject-matter depends largely upon the judgment and insight of the person preparing the sequence, although it should be as systematic as possible. Of course, there are various procedures for sequencing course content, but the one selected for this effort will utilize a matrix for the primary and secondary SOLO's. The proposed approach will start out by identifying factors that affect the sequence in which the material ought to be presented. The total body of material will then be analyzed in the light of these factors, and a sequence established. The following exemplifies the proposed approach:

Factors Affecting Sequence:

1. *Prerequisites:* In a given body of material, to be presented in a course, the trainees very likely need knowledge of some of the material in order to learn other parts of it. This necessary order of presentation must be considered in setting up the overall course sequence.

The primary and secondary SOLO's will be set up in a matrix as shown in Figure 12 below:

Items of Course Content	*Items of Course Content*			
	Item 1	*Item 2*	*Item 3*	*Item n*
Item 1	X			
Item 2		X		
Item 3			X	
Item n				X

Figure 12. Matrix for Determining Prerequisites in a Course

Members of the research staff and selected Air Force personnel will be asked to evaluate this information and to determine which items are prerequisite to which other items. They will be asked to put the letter N in a cell if the item listed across the top of the matrix is a necessary prerequisite to an item listed down the left side of the matrix. The letter D will be put in the cell if the item on the top is a desirable prerequisite for any item on the left. After these data are collected, the items across the top of the matrix will be rank-ordered according to the number of Ns each was given. The item with the most Ns, that is, the items which are prerequisite to the greatest number of other items should occur earliest in the training program. Conversely, items prerequisite to the fewest other items should occur later in the training program.

The items will then be rank-ordered according to the Ds given. Professional judgment will be used in determining whether the order established by ranking the Ns should be modified on the basis of the ranking according to the Ds.

2. *Lead-In Subsequent Activities:* The training course to be developed is to prepare the trainee to perform the job as defined. The material at the end of the training course, therefore, will be selected so as to provide the smoothest transition into job performance. This will be done through increasingly realistic practice.

3. *Recency of Critical Material:* Because of the phenomenon of forgetting of learned material, either due to the passage of time or in the interpolation of other activities, materials most important to success in subsequent activities should be presented near the end of the course, to the extent that is possible in conjunction with the other criteria of course sequence being used.

4. *Beginning on Familiar Ground:* The material at the beginning of a training program should be selected for its closeness to material already familiar to the subject. Learning proceeds by building on previously learned material.

The research staff will again analyze the total content of the course and make judgments on the familiarity of each item of content to the input trainees. The concept of NRB activities, used in previous studies, will be used in making these judgments. The items judged more familiar to the input trainee group will be placed at the beginning of the course.

The sequence of the course, as determined from the four factors listed above, or from other factors which may later be included, may be in some conflict. Compromises based on professional judgment must be made to arrive at the most suitable solution to the problem of sequences, basing this judgment upon the results of the foregoing type of analysis.

Selection of Media and Training Equipment: This step involves two processes: (1) Determining what media to use, and (2) Stating what media are to be used. The particular medium that is most suitable for a given segment of training should be determined by several factors in addition to the available learning principles that relate medium to learning. Among these factors are:

a. Nature of the behavior change to be produced.

b. Number of students to be trained at one time, and the total number.

c. Proficiency level required on the behavior at the end of training.

d. The manner in which the medium is to be used.

Considering these factors and the related principles of learning, it is necessary to determine, in considerable detail, just how various media are to be used, and for what purpose, in order to specify what media are to be used. Making gross judgments that a "procedures trainer" ought to be used in achieving learning objectives of "performance checkout procedure" tells too little about the actual plan of instruction. Too much latitude of interpretation is possible. The instructor could demonstrate to the class how to perform the procedure, and the class could memorize the steps from the book, never having a chance to practice the operations. Or it may mean that every student will practice on the trainer until he reaches criterion.

PHASE II — PREPARE ELECTRONICS MAINTENANCE COURSE

This phase will be devoted to the development and preparation of detailed lesson plans, actual training materials, and training media and equipment to be used in the conduct of the course, include orientation of the Air Force instructors to be used in the experimental course.

Instructor Orientation

Each instructor will teach the whole course to his class, with the exception of scheduled breaks. Each instructor will, therefore, teach 6 hours per day, 5 days per week, for about 12 weeks, minus relief periods. Maximum effectiveness of the orientation should be achieved if the instructors are assigned (and present) at Lowry approximately 2 months prior to the start of the experimental course. During these 2 months, the instructors will be oriented to the approach and given experience with the course materials, procedures, and training media.

Composition of the Experimental Group Classes

The experience gained in training high school students in experimental work sponsored by the Air Force (ref. 30) demonstrates that the higher aptitude subjects should be separated from the medium aptitude subjects, that is, any one class should contain only high aptitude or only medium aptitude subjects. Thus, to maximize the effectiveness of the experimental course and make it truly learner-centered, the two levels of aptitude should be in separate classes to facilitate adjusting the training program to the needs of the two different types of students.

Preparation of Training Materials

Detailed plans, procedures and materials for every learning unit of the course will be prepared. These materials will state what points the instructor will present in his lecture material, the activities the trainees are to practice, the criteria they are to achieve, and the role the instructor should take during the practice sessions. Specific problems for the students to work will be prepared.

The manner in which the training materials are to be organized for a given course segment will be determined partly by the training media to be used. For example, the use of a part task simulator will imply differences not only in the content of the segment, but a different level of detail in the instructor's presentation, or a different sequence, or emphases on different parts of the content, in contrast to a segment in which the training medium is a programmed tape-slide presentation.

Use of Up-To-Date Instructional Technology

In addition to emphasizing practice and the learning of job performance rather than theory, the experimental course can go a step further toward the learner-centered orientation. It may be possible to individualize the pace and character of the learning process by limited application of the concepts of computer-assisted instructional techniques. An effort will be made to provide a branching program for each student in which the branches he will take and the rate of progress would depend upon his level of achievement in the various learning units. However, within the constraints of the proposed level of effort, it will not be possible to apply this concept to the entire course, but some innovations in this direction are anticipated.

Training Media and Training Equipment

It is expected to make full use of the simulated training environment, described in Section III of this report, wherever justified by the course objectives. If, after the initial developmental costs, the simulated task environment can be reproduced economically, a number of them would be fabricated for use in the experimental training program. Should it prove costly to reproduce several copies of the simulated maintenance task environment, a simpler part-task trainer would be selected for those parts of the task which lend themselves to these simpler media.

The television facilities at Lowry are expected to be available for developing part of the course content and for monitoring the instruction. Also, if trainees can be provided with television presentations of actual performance, it may help them relate their simplified practice to performance of the actual task. Some exploration in video recorded self-confrontation techniques (ref. 25), adapted to maintenance training, may be undertaken. Motion pictures will be made of the performance of actual maintenance tasks on the F-111A aircraft, because an actual aircraft will not be available for the students to work on or to observe.

PHASE III — MONITOR THE LCI COURSE TRAINING

To maintain the planned content and methods of instruction, contractor representatives must monitor a large sample of the training. It is proposed to accomplish this as follows:

a. Maintain a schedule of actual attendance in the classroom. The schedule will be prepared after the exact course length, sequence, and other matters are known more specifically than they are known at the present.

b. By conferences with the Air Force instructors.

c. By use of television facilities.

Television can be used in monitoring the conduct of the LCI course as follows:

1. For on-site monitoring of the conduct of the classes. This would eliminate the disruptive effect of an observer in the classroom.

2. For making video recordings of some of the class sessions for later evaluation. This makes it possible to be self-critical about teaching some of the course material. Also, various critical incidents could be recorded along with other recording samples.

Section V.

EVALUATION

JOB PERFORMANCE CRITERIA

The ultimate value of an airman training program should be its ability to prepare trainees to perform required behaviors to a certain level of job proficiency (see Section VII) on the job. If this assumption is acceptable, it follows that criteria must be used that will adequately measure trainee job performance. The results of such performance measures would provide training personnel with valuable feedback as to the effectiveness of their training programs. Concerning this subject Wilson (ref. 117) said:

"Unfortunately, this has not been the case. Historically, except for ratings and other gross measures, relatively little attention has been paid to the real problem of measuring how well a man can perform the actual task for which he is trained. Applied psychologists, educators and training specialists have produced great numbers of reports on training assessment, but the vast majority use school graduation or classroom measuring instruments. To all intents and purposes one finds only isolated attempts to measure performance on the job by other than rating methods when that performance was intended to serve as a measure of the effectiveness of the training that preceded it. Put another way, the amount of such measurement research in proportion to the amount of training is discouragingly small."

Generally, field evaluation of the effectiveness of training programs consists of supervisory ratings of the job performance of the graduates after assignment to operational units. However, the lack of specificity, halo effect, errors of central tendency, and errors of standards intervene which seriously reduce the value of such rating devices. For example, in one of a series of studies by Wilson, Mackie, and Buckner (ref. 118, 119), the only items, rated or tested, scored were those tasks that the raters stated they had recently and personally observed the ratees performing. Although the raters said that they were absolutely sure that they had checked the performance, as indicated by their observed scores, the correlations between their ratings and an actual job performance test were very low.

PERFORMANCE TESTING AREAS

To be able to perform his job in the most effective manner, the weapon systems control technician must be proficient in troubleshooting techniques, in the use of tools and test equipment, and in the performance of safety practices pertinent to his job. He must not only *know* about such techniques and equipment, he must be able to *use* them on the job. Therefore, to insure that the trainee receives training relevant to actual job needs, the trainee must be evaluated based upon observation of his skills ability.

Troubleshooting

Troubleshooting is one of the most important responsibilities of the maintenance technician. Training research has shown that the simplification of troubleshooting techniques will improve maintenance at less cost. These approaches to troubleshooting include block diagrams, waveform guides, blocked schematics, the Bayesian model, simplified maintenance manuals, and other techniques (ref. 60). Although these innovations have been demonstrated to be effective in reducing the costs of electronics maintenance, they have not been generally adopted in the Air Force. It is anticipated that such aids will eventually be incorporated into the overall maintenance concept, but the maintenance technician must demonstrate that he can effectively employ the aids. Meanwhile, the technician must be trained in conventional techniques accompanied by sufficient practice to enable him to structure the various troubleshooting problems. However, aids that will enable the technician to learn how to troubleshoot more efficiently should not be overlooked in the training program.

Use of Tools

The maintenance technician must be able to use a variety of tools. This portion of electronics training is seldom given sufficient emphasis, and often the technician is tested only upon his ability to recognize the tools of his job. Williams and Whitmore (ref. 115) reported a study in which Army technicians at all levels of experience were unable to use good soldering techniques in the field. This indicates a training need for more practice plus performance testing in the use of hand tools.

Test Equipment

Modern electronics technology reflects a trend in the direction of special types of test equipment for specific electronic components. The complexity of the theoretical aspects of such sophisticated test equipments as oscilloscopes, subsystem tie-in test sets, and pressurization test sets challenges the ingenuity of most engineering students. The question arises, then, as to whether or not it is necessary for first-term airmen to learn *why* these test equipments work. The practical, primary consideration is that he must be able to *use* the equipment and to demonstrate his ability to do so. Pickering and Anderson (ref. 88) found Navy Class A Electronics School graduates deficient in such fundamental skills as soldering, troubleshooting, and care and use of test equipment required in the performance of their jobs.

Safety Practices

Most electronic components generate enough electrical energy to be potentially harmful to maintenance personnel. Not only should the maintenance technician be taught *why* electrical energy is dangerous, but he should *demonstrate* a safety-conscious approach to his work; i.e., there may be a distinct difference between knowing what should be done and performing what should be done in the area of job safety.

Variables in the Operational Situation

The evaluation of the LCI experiment perhaps presents one of the most controversial portions of the project. The question arises as to how the evaluators will be able to cope with the multitude of variables that intervene between graduation and the final follow-up in the operational situation. Also, what effect will on-the-job training, career development courses, initiative, or other factors have on the results of the field evaluation? In addition, there may exist some suspicion that the evaluators may manipulate the data to favor the experimental course.

Doubtless, the many variables will present various problems in the evaluative process. However, the LCI course proposes to train airmen for the real world and certainly the current operational environment includes on-the-job training and other means of job improvement which will influence follow-up test scores. LCI will not be an aseptic laboratory experiment; instead, it will be an applied training research program designed to prepare airmen (in the school setting) for actual job behaviors in the operational environment. Therefore, it would be impractical to create, even if it were possible, some kind of vacuum between graduation and the field follow-up evaluation. The variables do exist in the real world, but it seems reasonable to expect that both the control and experimental groups will be equally affected by these variables.

One variable would be unilateral, however, and that is any unfavorable supervisory attitudes toward the minimally theory trained experimental group as discussed in Section I. But an assumption that such attitudes will prevail (before such a determination is shown by the LCI field evaluation) is considered to be premature.

Program Evaluation

The total program will compare the effectiveness of two approaches to training: (1) the LCI or systems-oriented approach, and (2) the principles-oriented training concept. As stated in Section I, the total program will be evaluated in terms of cost effectiveness and timeliness of work conducted within the context of the development of weapon systems, applicability of procedures used to efforts in other systems, and validity of the prediction of field requirements.

The following steps are proposed to be undertaken in the evaluation of the LCI program:

1. Administer Job Performance Test and Specially Knowledge Test to graduates of the control and experimental courses.
2. Repeat testing after graduates are on the job at least four months.
3. Validate predictions for field job requirements.
4. Compare time required for control and experimental course training.
5. Compare washback and washout rates for both courses.
6. Compare training costs for both courses.

A controlled experiment will be conducted according to the following schematic of the design:

	Job Prof. Test	*SKT*	*Job Prof. Eval.*	*SKT*
Control Course				
Electronics Principles – 10 weeks	X	X	X	X
Equipment Training – 14 weeks				
Experimental Course				
LCI Electronics Maintenance	X	X	X	X
Course – 14 weeks				

The training time for both courses are given as estimates only. The length of the experimental course will be determined by the requirements derived from the behavioral analysis of the job.

The cells for the experiment will be arranged as follows:

Electronic Aptitude Scores (Percentiles)	*Control Course*	*Experimental Course*
High (80-95)	(1) 40	(2) 40
Low (60-75)		(3) 40

Section VI.

EQUIPMENT DESCRIPTION

The weapons control system mechanic (AFSC 32251R) performs on-aircraft maintenance of various electronic sub-subsystems and uses pertinent tools and test equipment. Some of the most important of these include: (1) attack radar sub-subsystem, (2) lead computing optical sight sub-subsystem, (3) dual bombing timer, (4) subsystem tie-in test set, and (5) pressurization test set. The following equipment descriptions, including the Offensive Fire Control Trainer (T-1) are extracted from the F-111A QQPRI and pertinent technical orders.

ATTACK RADAR SUB-SUBSYSTEM

The attack radar sub-subsystem (Figures 13 and 14), provides all-weather, day or night, radar operation for ground mapping, navigational fix-taking, air-to-air search, acquisition and range tracking, and synchronous and fixed-angle bombing. Self-test circuitry is used for most organizational level maintenance. The attack radar sub-subsystem consists of indicator/recorder unit, antenna-indicator control, radar set control, receiver-transmitter-modulator (RTM) unit or alternate receiver-transmitter-modulator (ARTM) unit, antenna pedestal, antenna unit, antenna control unit, synchronizer unit, and radome. Each of these are packaged as a line replaceable unit (LRU).

Indicator/Recorder Unit

The indicator/recorder unit (I/RU) furnishes the displays required for use of the attack radar set in navigation, bombing, and air-to-air interception. A 7-inch, high-resolution cathode ray tube (CRT), with all necessary radar scope controls, provides the visual information to the operator. A permanent photographic record of radar scope returns is made automatically at preset intervals or on command of the operator. The radar scope camera magazine, which is replaceable in flight, contains 85 feet of 35mm film. A meter on the I/RU indicates degree of antenna tilt. During air-to-air operation, lights on the I/RU indicate the presence of threats which may be outside the sector being scanned.

Radar Set Control

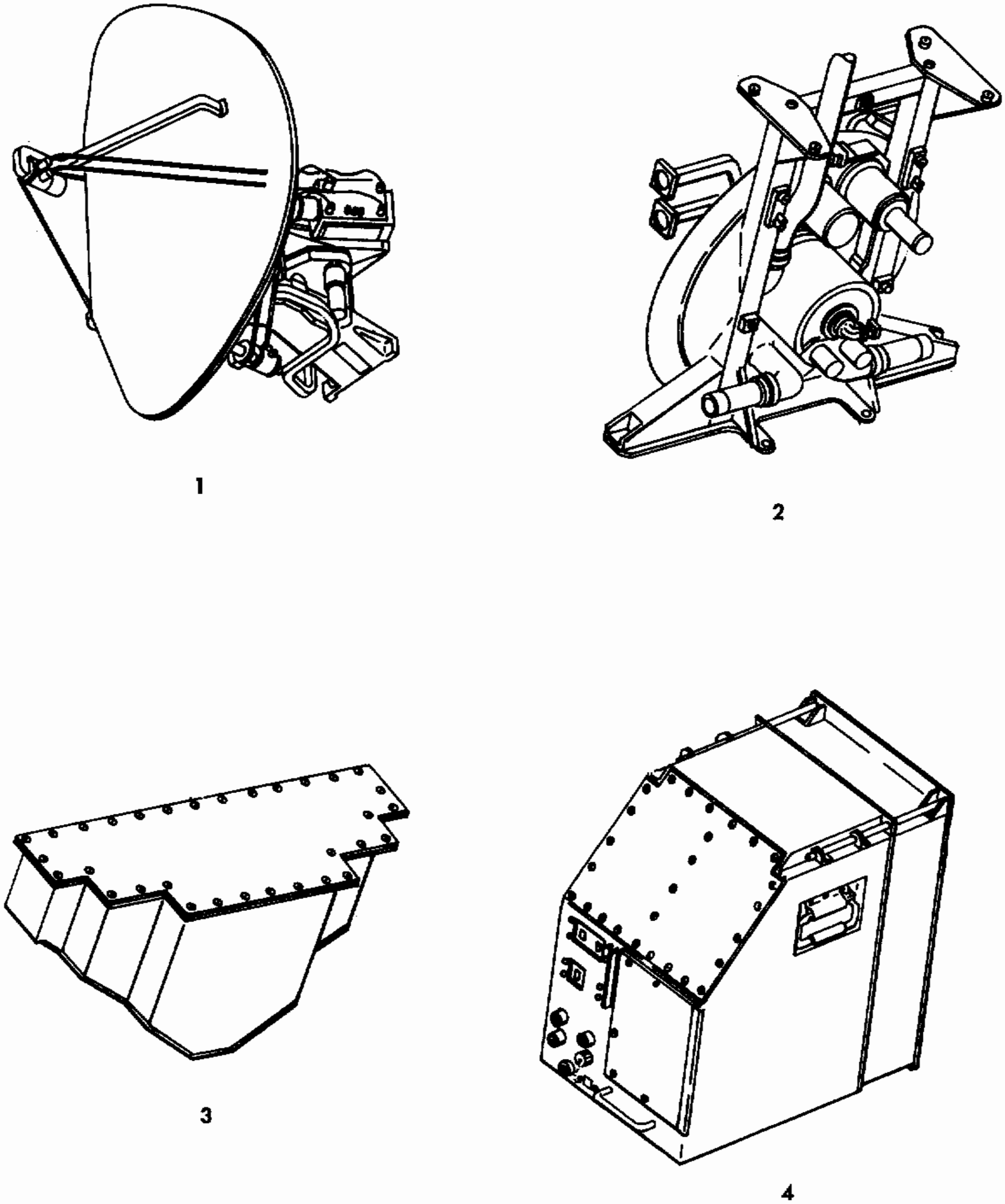
The radar set control contains switches to: (1) control system power, (2) select mode of operation, (3) select automatic or manual frequency control, (4) select side lobe concellation and/or circular polarization when required, (5) select pulse length discrimination or fast time constant when required, and (6) provide antenna attitude stabilization. A test position on the power switch, in conjunction with regular system controls and displays, provides a go-no-go confidence test of attack radar operational capability.

Antenna-Indicator Control

The antenna-indicator control permits the operator to supply: (1) commands to the antenna, (2) correction signals to the computer display unit, and (3) cursor positioning commands. The top switches provide: (1) control of antenna azimuth sector width, and, in AIR mode, range search, and (2) over-ride of the automatic range search and break lock. A side push-to-actuate switch must be depressed for the antenna-indicator control to be operative.

Receiver-Transmitter-Modulator (RTM) or Alternate RTM (ARTM)

The RTM or ARTM, which are physically and electrically interchangeable, provide circuitry to generate, transmit and receive pulsed RF power. The RTM provides pulse-to-pulse transmitter frequency agility and the ARTM provides tuneable transmitter frequency.



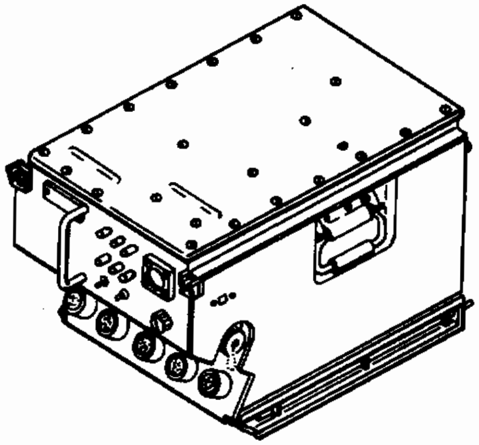
1 — Antenna Assembly

2 — Pedestal, Antenna

3 — Control, Antenna

4 — Receiver-Transmitter-Modulator

Figure 13. Attack Radar Set — AN/APQ-113 (A)



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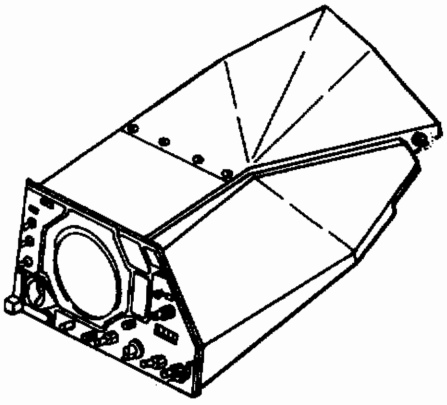

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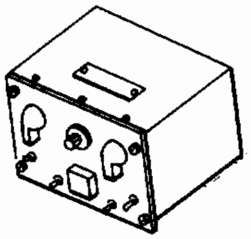

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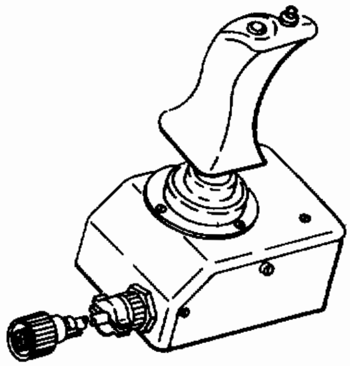

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5 — Synchronizer, Electrical

6 — Indicator-Recorder

7 — Control, Radar Set

8 — Control, Antenna-Indicator

Figure 14. Attack Radar Set — AN/APQ-113 (B)

Synchronizer Unit

The synchronizer unit is the master synchronizing source for the attack radar set and also contains additional circuitry including I/RU low voltage power supply and self-test logic. External controls and indicators are used in conjunction with radar set control and I/RU controls and indicators to provide isolation of malfunctions to an LRU.

Antenna Pedestal and Antenna Unit

The antenna pedestal is a roll-stabilized mount for the attack radar antenna unit and for the two antenna-receiver units. Precision mounting bosses for the antenna units on the antenna pedestal and for the antenna pedestal on the aircraft bulkhead permit removal and replacement of the antenna pedestal, antenna control unit, and/or antennas without need for organizational or intermediate level boresighting. The antenna unit is pitch stabilized to ground track or aircraft heading, depending on mode of operation.

Antenna Control Unit

The antenna control unit provides amplifier circuitry for antenna positioning serves and antenna scan programming.

Radome

The radome is a solid-laminate, filament-wound, half-wave unit with a thermally reflective and rain-erosion-resistant coating. The radome is hinged to the forward bulkhead and opens horizontally to provide access to unit mounted on the forward side of the bulkhead.

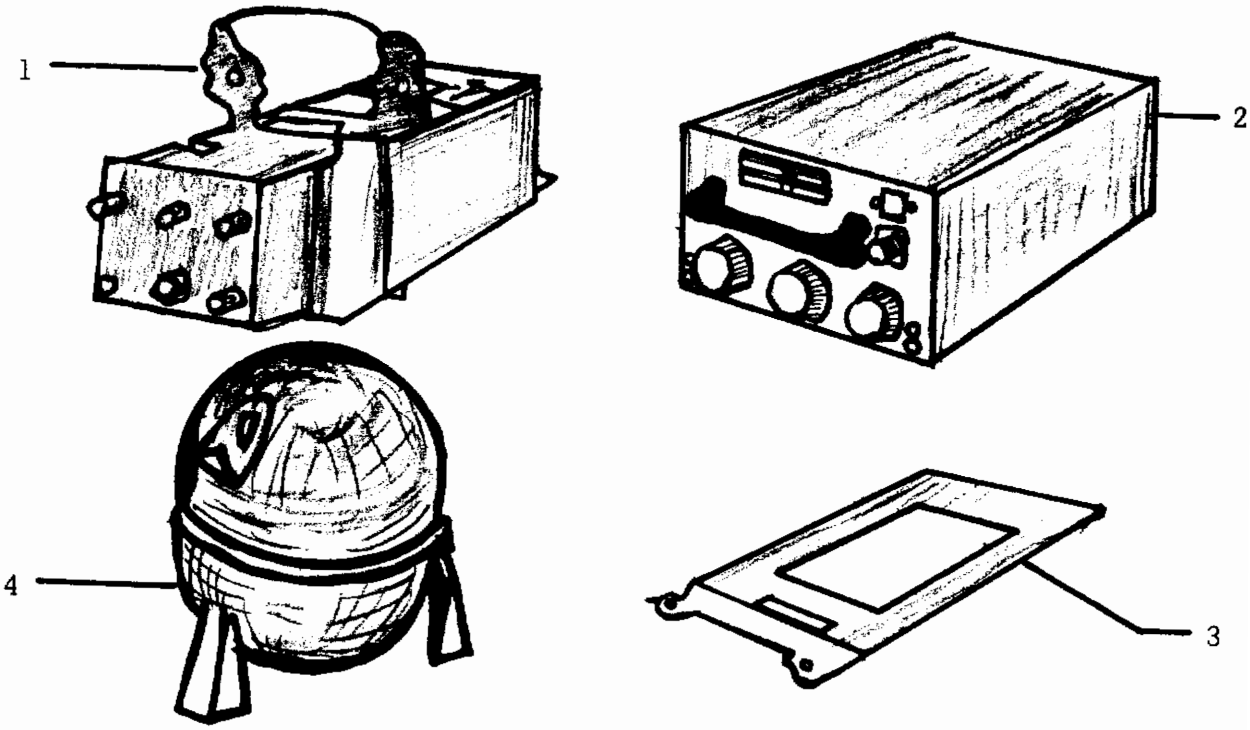
LEAD COMPUTING OPTICAL SIGHT SUB-SUBSYSTEM

The lead computing optical sight sub-subsystem (LCOS set) computes and displays gunnery lead angles and AIM-9B (GAR-8) missile firing envelope for air-to-air attacks (Figure 15). The depressible, collimated reticle is also used for air-to-ground visual weapon delivery. A command display provides steering commands identical in function to the steering commands on the attitude-director indicator. The LCOS set consists of optical display sight, lead and launch computing amplifier (LLCA), lead computing gyro (LCG), and LLCA rack LRU's.

The optical display sight is located in the pilot's line-of-sight. A combining glass through which the pilot looks displays a collimated reticle which is depressible for air-to-ground attack and displaceable by computed lead angle for gunnery. The combining glass also displays deviation from preset values of dive angle and airspeed, aircraft roll, an analog bar comparison of computed range to release or firing range, azimuth and pitch steering commands, and a flag which serves as an instantaneous command pertinent to the mode being used. Controls and displays on the aft side of the optical-display-sight control power, mode selection and self-test, allow insertion and display or range, depression angle, and desired airspeed.

The lead and launch computing amplifier (LLCA) performs missile launch computing functions to determine maximum firing range and minimum firing/breakaway range for the AIM-9B missile, and furnishes control to the lead computing gyro (LCG) for use in generating azimuth and elevation lead angles for use in air-to-air gunnery. The LCG also provides a normal acceleration signal for instrumentation of AIM-9B "G" limit signals.

Self-test features of the LCOS set provide malfunction isolation to a defective LRU at the organizational level. Mechanical alignment of the mounting pads of the optical display sight requires use of a boresighting kit. Intermediate level maintenance is accomplished with a computer test station, attitude and rate test station, and servo and indicator test station.



1 — Sight Assembly, Optical Display

2 — Amplifier Assembly, Lead and Launch Computing

3 — Mounting Assembly, Amplifier

4 — Gyroscope Assembly, Lead Computing

Figure 15. Lead Computing Optical Sight Set, AN/ASG-23

DUAL BOMBING TIMER

The dual bombing timer is an independent LRU which is used in conjunction with the LCOS set for loft or dive bombing. The timer allows independent setting and digital readout of time-to-time release and time-to-pull-up. Each counter has a setting range of 0.2 to 30.0 seconds in 0.1-second increments. The dual bombing timer is maintained at intermediate level with the indicator and controls test station. The dual bombing timer is shown in Section I, Figure 4.

SUBSYSTEM TIE-IN TEST SET

This test set (Figure 16) is connected into aircraft harnesses to check interface signals. It also generates signals to simulate the outputs from the navigation subsystem and the central air data computer. The test set is used with the following systems and subsystems:

a. Attack radar subsystem

b. Terrain following radar subsystem

c. Central air data computer

d. Navigation and attack subsystem.

e. Flight control system

f. Radar homing and warning subsystem

The test set is a portable, suitcase-type tester, housed in two aluminum cases. The test unit contains the controls, indicators, and circuitry of the test set. The accessory unit is compartmented and provides storage for the accessories supplied with the test set.

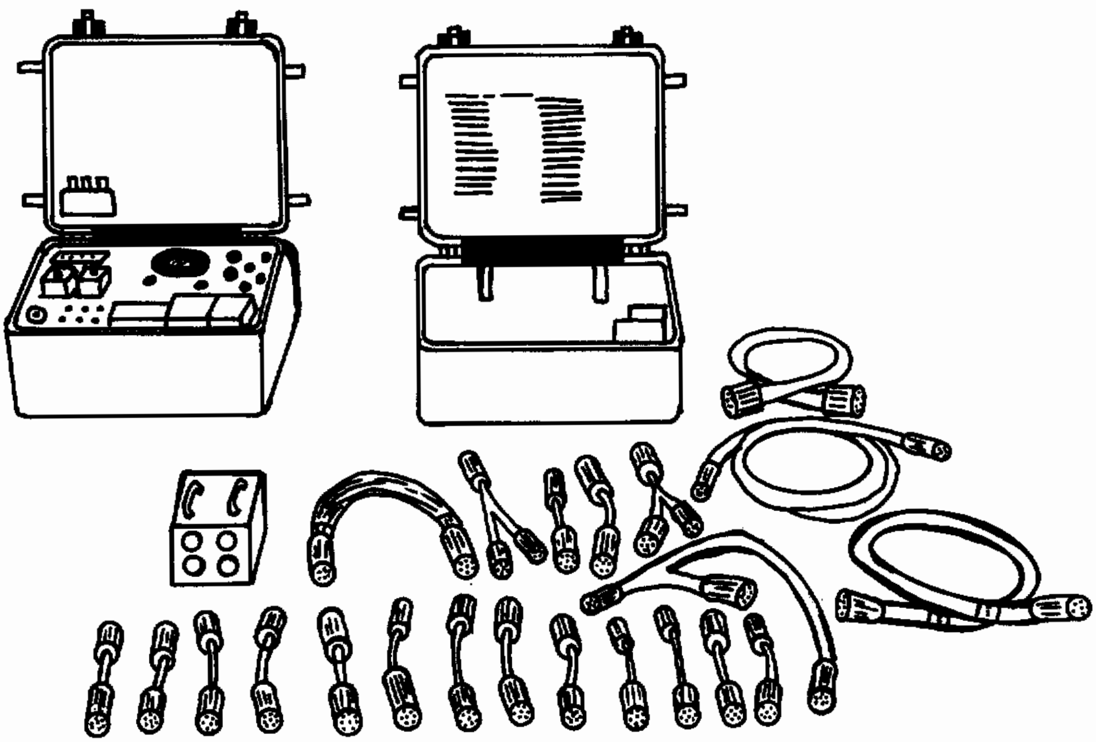
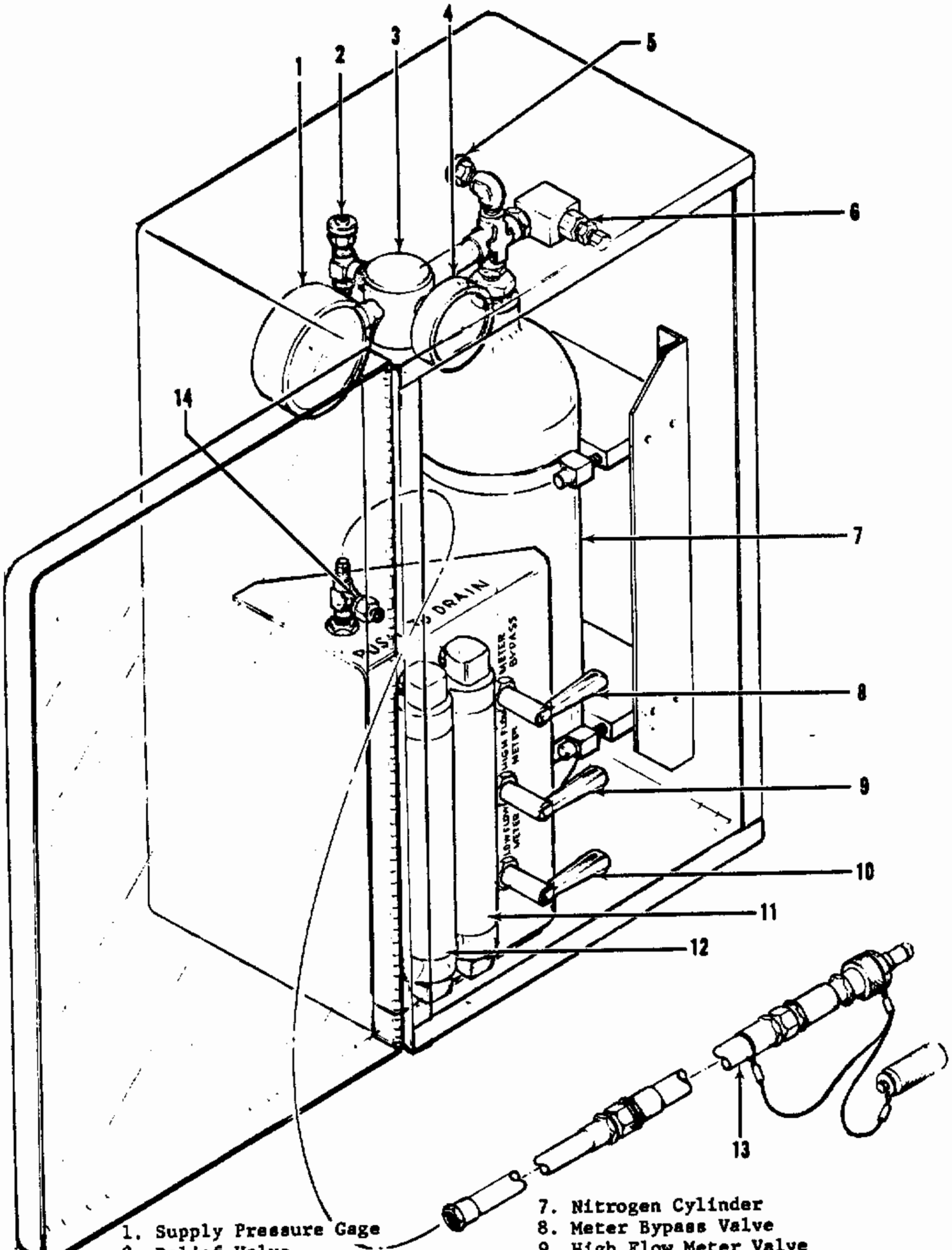


Figure 16. Subsystem Tie-In Test Set



1. Supply Pressure Gage
2. Relief Valve
3. Pressure Regulator
4. Output Pressure Gage
5. Safety Head (with rupture disc)
6. Nitrogen Cylinder Charging Valve
7. Nitrogen Cylinder
8. Meter Bypass Valve
9. High Flow Meter Valve
10. Low Flow Meter Valve
11. Nitrogen (High) Flow Meter
12. Nitrogen (Low) Flow Meter
13. Hose Assembly
14. Drain Valve

Figure 17. Pressurization Test Set

PRESSURIZATION TEST SET

The pressurization test set (Figures 17 and 18) is used in conjunction with the ultrasonic translator to perform leak tests of the waveguides of the attack radar and terrain following radar systems. The test set provides the necessary pressure supply, controls, and interconnecting hose to obtain the desired pressurization of the waveguides. The set consists of regulated nitrogen pressure supply mounted in a portable aluminum chest. A hose assembly is provided for connecting of the test set to the waveguide under test. The nitrogen supply cylinder is provided with a charging valve, a cylinder pressure gage, and a protective burst disc. Two flowmeters are incorporated in the test set to provide a high-leakage and low-leakage measurement capability.

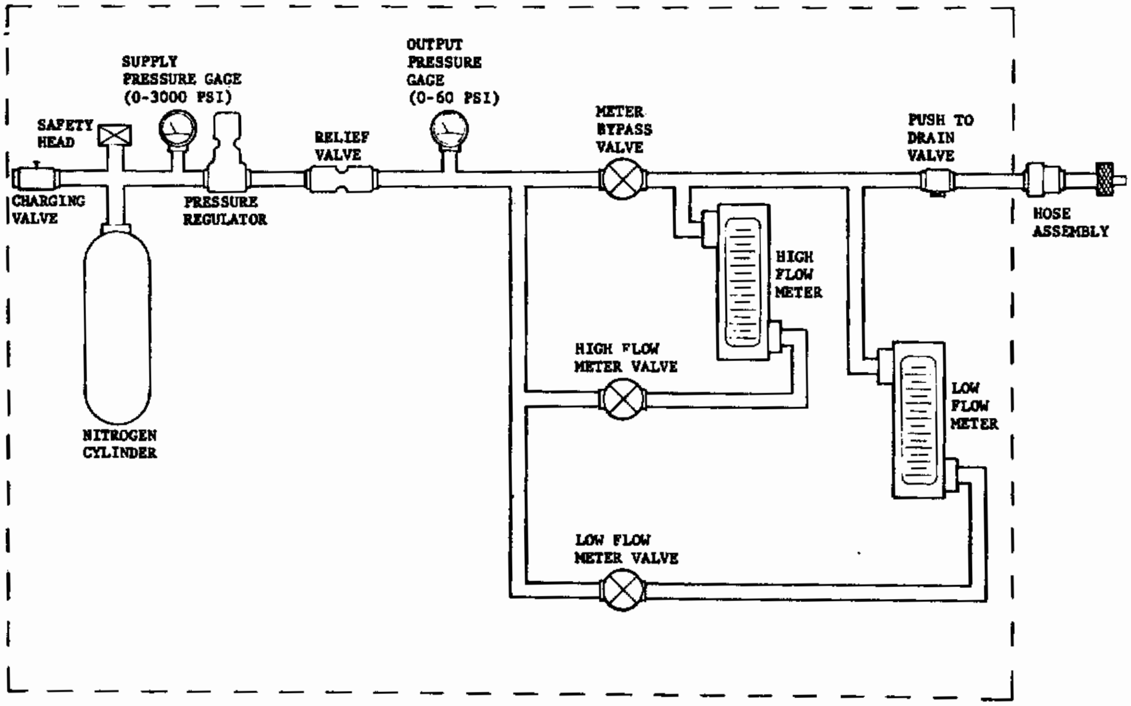
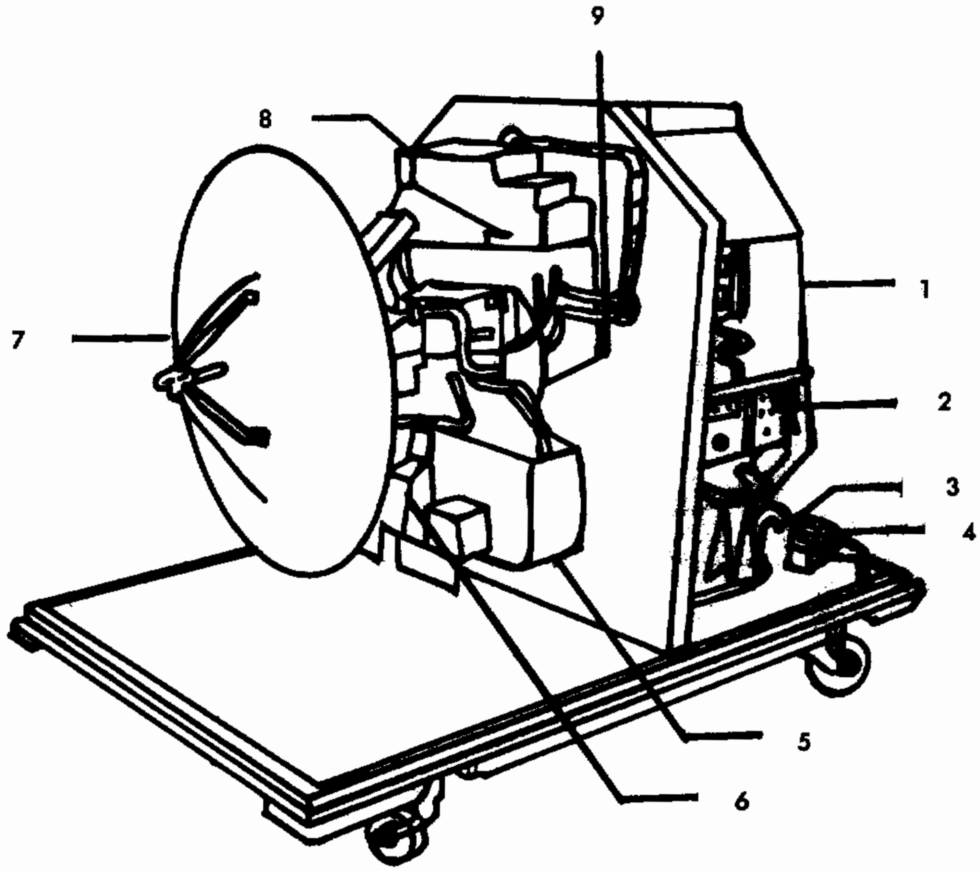


Figure 18. Pressurization Test Set Simplified Pneumatic Schematic Diagram

THE OFFENSIVE FIRE CONTROL TRAINER (T-1)

The offensive fire control trainer (Figures 19 and 20) presents an operational display of the offensive fire control system of the aircraft. The trainer consists of two panels. Panel 1 contains the attack radar antenna, simulated antennas, attack radar receiver, transmitter-modulator, and attack radar synchronizer unit. Panel 2 contains the indicator/recorder unit, lead computing optical sight set, associated aircrew indicators and controls, and function generator. The Offensive Fire Control Trainer (T-1) is one of the 21 trainers that make up the F-111A Mobile Training Unit (MTU).



1 — RTM

2 — Synchronizer

3 — Pressure Regulator

4 — Dehumidifier

5 — TFR Antenna Assembly (Dummy) LH

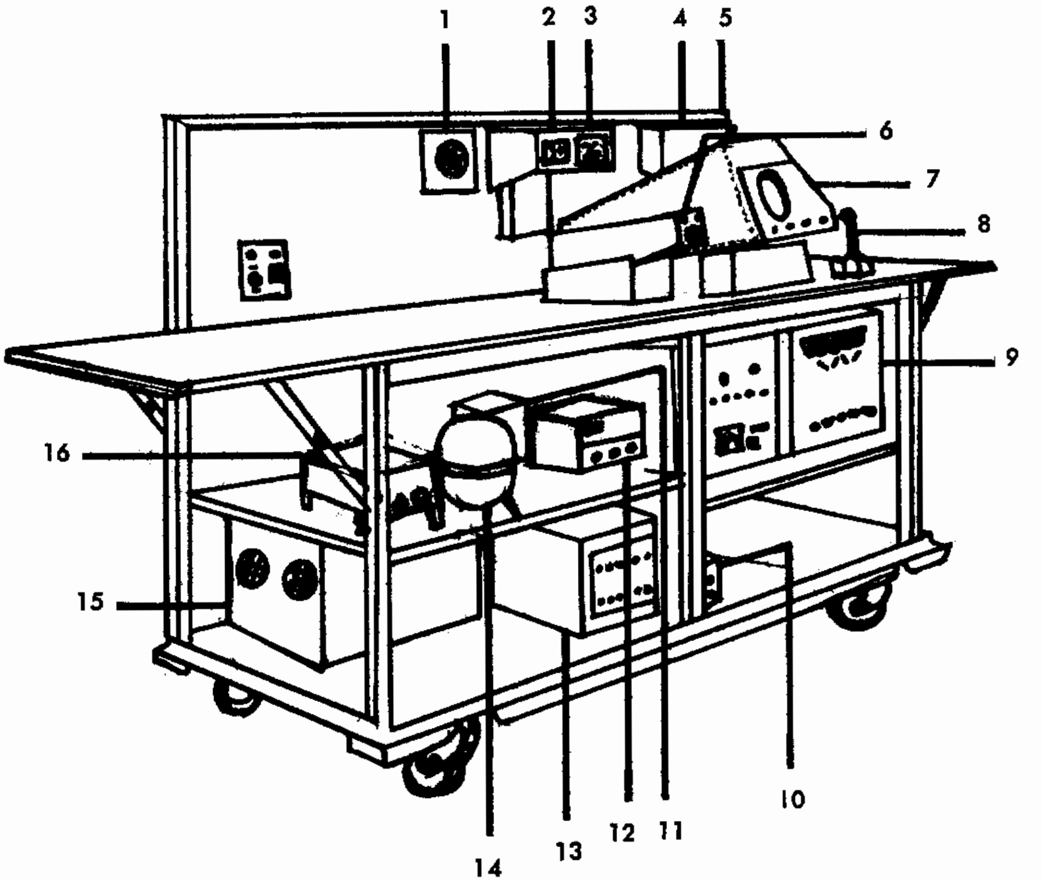
6 — TFR Antenna Assembly (Dummy) RH

7 — Antenna Unit

8 — Antenna Control

9 — Antenna Pedestal (Roll Platform)

Figure 19. Offensive Fire Control System Trainer — Panel 1



1 — Speaker	9 — Function Generator
2 — Bombing Timer Indicator	10 — Pressure Switch
3 — Radar Set Control Panel	11 — Tone Generator
4 — DC Power Panel (LCOS)	12 — Audio Amplifier
5 — DC Power Panel (Attack Radar)	13 — Power Junction Box
6 — LCOS	14 — LC Gyro
7 — Indicator-Recorder	15 — Frequency Changer
8 — Tracking Control Handle	16 — Lead and Launch Computing Amplifier

Figure 20. Offensive Fire Control System Trainer — Panel 2

Section VII.

TYPES OF TRAINING AND DEVELOPMENT PROCEDURES FOR AIRMAN TRAINING COURSES

INTRODUCTION

This section* provides information on course development procedures and types of training in the Air Force. Since LCI will be an Air Force course of instruction, the information relates LCI to the overall Air Force training program. For the reader who is unfamiliar with Air Force training procedures, this section includes terms and training procedures cited in this, and subsequent, reports on the LCI course development.

TRAINING OBJECTIVE

The principal objective of Air Force technical training is to prepare airmen to perform the required tasks of a job. The success or failure of the training mission depends upon the achievement of this objective by the various technical training centers. For this reason, the Air Force has developed procedures for translating job and equipment information into realistic training courses. In general, these procedures are described in the training regulations of Air Training Command (ATC) and other Air Force training agencies.

TRAINING STANDARDS

The two major training standards are Job Training Standards and Course Training Standards. They are the official specification documents which describe the qualifications of an ATC course graduate in terms of specific performance skills and knowledges acquired and the proficiency level of each.

Job Training Standard

A job training standard describes an Air Force job specialty in terms of tasks and knowledges which airmen trained in that specialty should possess to perform an Air Force job. The JTS indicates: (1) the extent to which personnel should be trained on each knowledge and task to qualify for upgrading to a higher skill level, and (2) the extent to which a given course provides training on each of the listed knowledges and tasks.

Preliminary job training standards which have been developed by the responsible training centers are coordinated with the major command headquarters. Each command annotates the standard and makes recommendations for change if desired. Thus, a definite attempt is made to base course development on the actual job requirements of the airman after he graduates from the course.

The input to the list of knowledges and tasks may come from various sources such as the Personnel Equipment Data (PED), Quantitative and Qualitative Personnel Requirements Information (QQPRI), visits and discussions with developmental engineers at the contractor's site when new equipment or weapon systems are involved, and information obtained from field evaluation of courses. In addition to providing criteria for the development of resident courses, job training standards are used as criteria for on-the-job training, special field and mobile training courses and for evaluation of Air Training Command course graduates. Air Force Regulation 50-34 prescribes the job training standards used in technical training. An example of a job training standard is shown in Appendix II.

*Adapted from: Foley, J. P., Jr. *Summary of Types of Training and Procedures for Developing Training Courses in the Air Force.* Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio, March 1966 (an unpublished report).

Course Training Standard

Most airman resident training courses are based upon job training standards as discussed above. However, officer courses and some airman courses are not adaptable to the job training standard concept. Examples are basic military training and special training courses on new equipment or systems. Technical course training standards (prescribed by ATC Regulation 52-17) are very similar to job training standards but do not include an entire career field. Also, course training standards are limited to a description of the military or technical tasks and knowledges for which the course is designed. An example of a course training standard is shown in Appendix III. Course training standards are not used for airman courses described in job training standards.

COURSE CHART

The course chart is developed at the same stage as the training standard and plan of instruction (see Figure 21). It is a qualitative course control document (prescribed by ATC Regulation 52-6) which specifies concisely the location of training, course duration, content, blocks of instruction, security classification, and major items of training equipment. A block of instruction is a grouping of homogeneous, related major subjects and each block represents closely related units of instruction. A course chart is prepared for each military, medical, foreign language, and technical course established by the Air Training Command. An example of a course chart is shown in Appendix IV.

PLAN OF INSTRUCTION

TRAINING STANDARD

COURSE CHART

INSTRUCTIONAL MATERIALS

1. STUDENT STUDY GUIDE
2. STUDENT WORK BOOK
3. INSTRUCTOR GUIDE
4. OTHER

TRAINING MEDIA

1. CLASSROOM DEMONSTRATIONS
2. INDIVIDUAL STUDENT TRAINERS
3. GRAPHICS

Figure 21. General Procedure for Course Development

PLAN OF INSTRUCTION

The plan of instruction (POI) prescribes the qualitative requirements of a given technical course in terms of statements of learning objectives (SOLOS) which are behavioral and measurable and presented in the preferred teaching sequence. The POI indicates the teaching level, time allocation, type of presentation, study references, training standard correlation, and major equipment and training media used. Also, the POI controls the internal course planning, organization, and operation required to produce graduates who will meet the specifications established by the training standard and course chart. The POI (prescribed by ATC Regulation 52-7) has replaced the syllabus of instruction in technical training. An example of a part of a POI is shown in Appendix V.

Statements of Learning Objectives (SOLO's)

The most important function of the POI is to list the SOLO's upon which the instruction is to be based. All student study guides, work books, training media, instructor guides, and student handouts are developed from the SOLO's.

Instructional Materials

Instructional materials are furnished to support each SOLO. These may include commercial publications such as text books, periodicals, manufacturers handbooks, brochures, trade journals, programmed texts, and other references sources; Air Force and other service manuals, pamphlets, technical orders, and stock lists; pertinent regulations or other directives; technical and training media publications, such as handbooks, parts catalogs, illustrated materials, and other informative materials used in preparation of technical orders or technical data manuals for maintenance, operational and training use on a given equipment or weapon system; locally prepared materials developed for instructional purposes such as student study guides and student workbooks, instructor guides, television scripts, tests, transparencies, recordings, decks of punched cards, programmed instructional materials, and input to electrical data processing equipment.

STUDENT TESTING AND GRADING

The Plan of Instruction and Course Chart reflect the time required or allotted for testing in a technical Air Force resident course. Air Training Command grading practices are controlled by ATC Regulation 52-3. This regulation provides for both written and performance tests. Percentiles are computed from the raw scores of both types of tests and the percentiles are assigned ATC scores. A grade profile chart is prepared for each course of instruction and it lists the blocks of instruction found on the course chart and the percentage weight to be given to the performance and written tests for each block of instruction.

COURSE EVALUATION

Figure 22 shows two types of evaluation, external and internal. ATC Regulation 52-1 prescribes the overall evaluation program. Training evaluation is defined as the process of determining whether the objectives of a training program express the current qualitative requirements of the Air Force, whether the objectives are being attained, and whether training capability is being maintained. Internal evaluation is performed within the school or course by ATC personnel and does not involve graduates or the agencies using the graduates. External, or field evaluation is based on information provided by graduates or graduate using organizations to assist ATC in determining the degree to which a training program is meeting field requirements.

Internal Evaluation of Courses

Internal evaluations are usually obtained by observations of instruction. The procedures for accomplishing classroom or laboratory evaluations are prescribed by ATC Regulation 52-4. This regulation states that evaluations will be made by the supervisor often enough to give him a complete and intimate knowledge of the ability of each instructor and to assure each instructor that his supervisor has an adequate basis for suggestions and constructive criticisms. The length of such observations is varied. The regulation suggests that one hour should be considered as a

EXTERNAL EVALUATION (ATC Reg. 52-1)

JOB AND EQUIPMENT OR SYSTEM INFORMATION

TRAINING STANDARD (AF Reg. 50-34, ATC Sup. 1 to AFR 50-34)

PLAN OF INSTRUCTION (ATC Reg. 52-7)

COURSE MATERIALS (ATC Reg. 52-18) AND EXAMINATIONS (ATC Reg. 52-3)

COURSE OPERATION

COURSE CHART (ATC Reg. 52-6)

INTERNAL EVALUATION (ATC Reg. 52-4)

Figure 22. Course Development, Preparation, and Evaluation Sequence of Air Force Technical Training Courses

minimum. If possible, a complete lesson should be observed. The scope of this type of evaluation usually includes only instructor performance. Provisions for more extensive internal evaluations are provided by ATC Regulation 52-1, which provides for internal evaluation projects that can evaluate all aspects of the training environment.

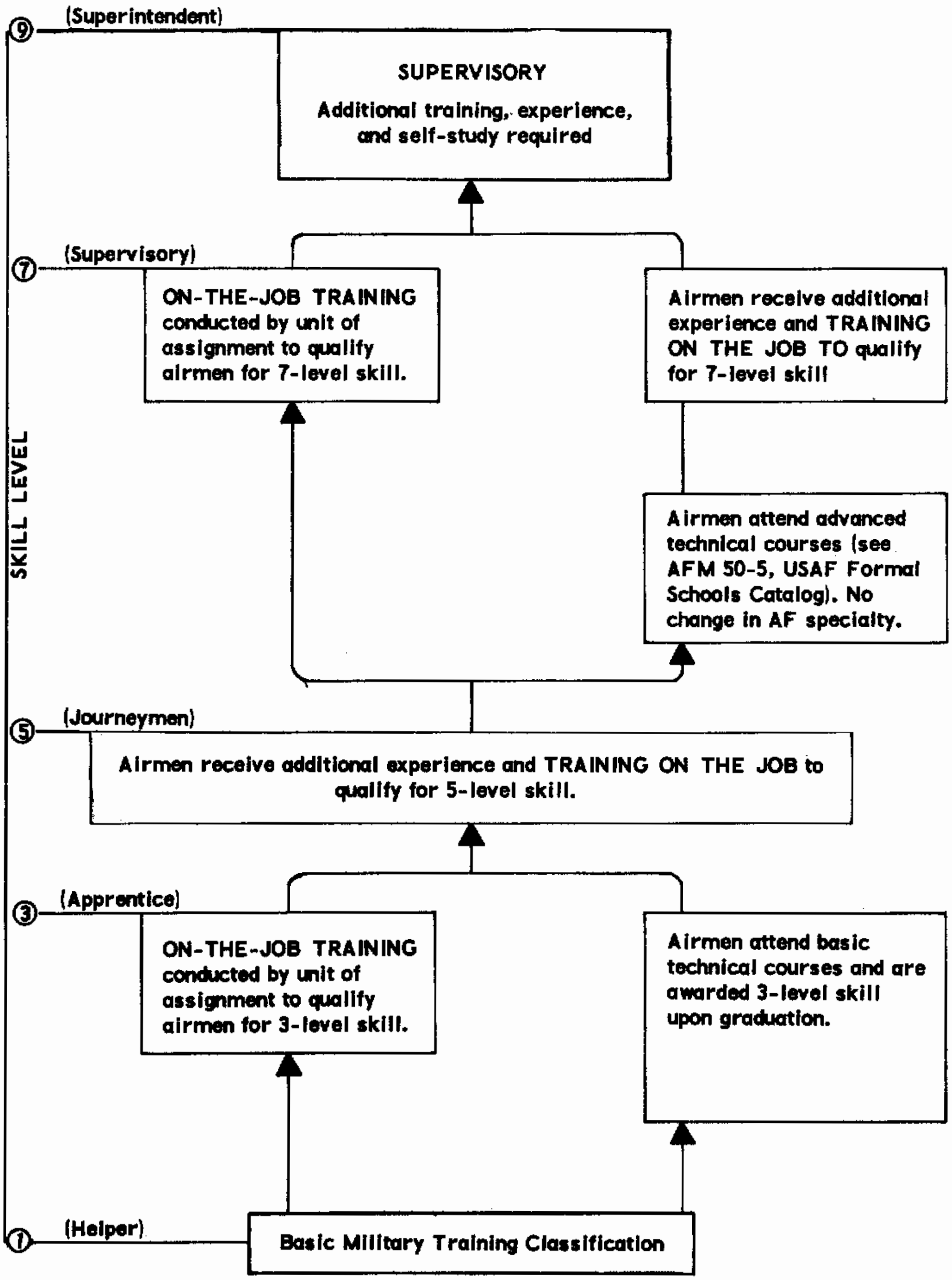
External Evaluation of Courses

External evaluations can be initiated either by using agency or by ATC. Course evaluations initiated by ATC are normally of two types, questionnaire evaluation or field visit evaluation. When the questionnaire type evaluation is used, two types of questionnaires are usually sent to the field; one to be used by the graduate for evaluating the course that he completed, and the other to be accomplished by the graduate's supervisor. The questionnaires are based upon the knowledges and tasks listed in the training standard applicable to the course being evaluated.

When the visit-type evaluation is made, representatives of ATC training agencies visit the using organizations to interview both the graduates and their supervisors. The type of information gathered is similar to that obtained by a questionnaire, and it is based on the training standard requirements. Both the adequacy of the training standard and the adequacy of the graduates are investigated. An example of supervisor's and graduate's field evaluation questionnaires are shown in Appendixes VI and VII.

CAREER PROGRESSION AND TRAINING

The Air Force requires many types of training to meet its requirements. Various types of airman courses will be described in this section of the report; however, the presentation will be limited to the types of airman training, most of which are technical or maintenance training and



(From ATC Pamphlet 52-1, Patterns of Technical Training, 25 April 1966)

Figure 23. Skill Progression in Formal and On-the-Job Training

support items of Air Force equipment or weapon systems. No attempt is made to include officer or civilian training programs. Figure 23 indicates the skill progression of an airman from the time he enters basic military training at Lackland Air Force Base (AFB), Texas, until he becomes a Chief Master Sergeant. Before a recruit is enlisted, he takes the Airman Qualifying Examination (AQE) from which his aptitude scores are determined. The aptitude areas include electronics, mechanical, general, and administrative. All new recruits entering the Air Force are required to take the basic military course at Lackland AFB. Approximately 65 to 70 percent of the airmen are selected for technical school training on the basis of their aptitude and the current requirements of the Air Force for such training. The remaining airmen are given directed duty assignments (DDA), which means that after completing basic military training, the airman is assigned directly to a field organization for duty as a helper in some career field.

Airmen selected to attend technical school training are sent to a technical school following basic military training. Airmen assigned to technical schools receive AFSC's at the "1" skill level when they are shipped from Lackland AFB to a technical training center. The directed duty assignees (DDA's) receive the "1" skill level when they depart Lackland for their first duty assignment. The "1" skill level is the helper level.

Upon completion of the basic technical course for the particular specialty for which the airman has been selected, he receives a "3" level (apprentice) in his specialty. The DDA is assigned to an operational unit and he receives training under the immediate supervision of a specialist or technician in the DDA's area of assignment. This training process is called on-the-job training (OJT). He also receives a Career Development Course, or an OJT Study Package, from which he obtains his technical study materials. After his supervisor certifies that he has accomplished all items of his job training standard at the "3" level, the airman is given a Skill Knowledge Test (SKT). If he passes the test, and meets the other personnel requirements for the "3" skill level, he is awarded that skill level. At this point, the DDA airman who has completed his "3" level OJT, and the technical school graduate airman are at equivalent levels in their career progression.

All "3" level airmen receive OJT to the "5" level (journeyman) while on the job. It normally requires approximately six months from the time the airman receives the "3" level until he is trained to the "5" level. With the approval of his supervisor, he takes the "5" skill level SKT and is awarded that skill level if he receives a passing score.

After an airman has worked in a field assignment for a considerable length of time, if he has demonstrated his proficiency and there is a need for "7" level airmen in his specialty, he begins an OJT program for that level. He must take the "7" level SKT before being awarded that level. When a staff sergeant obtains a "7" skill level, he is eligible for a technical sergeant and later a master sergeant rating provided there are vacancies in his career field and that he meets such requirements as time in grade and adequate effectiveness reports. The "9" skill level (superintendent) is held by Senior and Chief Master Sergeants.

TYPES OF TRAINING

Each year the Air Training Command publishes the Program Technical Training (PTT) for the Department of the Air Force. The PTT defines the types of training offered by various Air Force agencies. It also outlines and schedules the formal aspects of the training. The most common types of airman training are outlined below.

Military Training – Instruction provided in an officially designed course to develop military skills, knowledges, and attitudes essential for effective duty as a member of the United States Air Force. Example: ABM 00010, Basic Military Training.

Technical Training – All formal and OJT required to enable airmen to perform one or more of the tasks contained in Air Force Specialty descriptions. The types of technical training are as follows:

1. *Airman Basic Training* – A formal technical course, normally entering helper level (1), or preparatory course graduates, which trains toward apprentice (3) level Air Force specialty descriptions. Airmen at the journeyman (5) level, or higher, may also be entered where re-training is necessary. Graduates are awarded a 3-level AFSC. Example: Course Number ABR 40230, Photographic Repairman.

2. *Airman Advanced Training* – A formal technical course designed to train airmen toward a supervisor or technician level Air Force specialty. No AFSC is awarded; however, successful completion is shown on the airman's personnel record. Example: Course Number AAR 42171, Aircraft Propeller Technician.

3. *Special Training* – A formal technical course designed to qualify skilled level or supervisor/technician level personnel in the operation and/or maintenance of a new item of equipment or in new operational techniques and procedures. No AFSC is awarded upon graduation. The types of special training are as follows:

a. *Type I – Contract Special* – Formal training, either technical or flying, contracted with civilian, industrial, or educational institutions.

b. *Type II – Air Training Command Special* – Formal training conducted by ATC instructors at an ATC installation, contractor facility, or other designated sites.

c. *Type IV – Field Training Special Course** – Special courses provided by ATC field training detachments.

d. *Type V – Other Special* – Special training conducted (at the request of ATC) by other governmental and Air Force agencies.

e. *Traveling Team* – A form of Type II training conducted by a team of ATC instructors at the using commands' or other selected sites. Traveling teams are normally used to satisfy special training requirements when training equipment is not available at the training center or when it is undesirable to send students to a training center. Training by traveling team is a joint effort whereby ATC provides instructors, training materials, and the using command provides the training equipment and facilities.

Airman Supplemental Training – A formal airman technical course which trains toward a portion of the duties of an Air Force specialty description and does not result in a change of AFSC. This training is similar to special training except that it does not provide training on new items of equipment or new operational techniques.

Field Training – Training conducted in the field by ATC as opposed to training conducted in resident technical schools or OJT given by the major commands.

Airman Lateral Training – A formal technical course designed to qualify airmen for movement laterally from one ladder of a career field to another as provided in the airman career structure. The training may also be used to provide temporary personnel support which is lateral in

*Type III training is not special training but regular resident career training such as Airman Basic Training and Airman Advanced Training.

nature. Graduates are awarded a 3-level AFSC. Example: Course Number ALR 29131, Cryptographic Operator.

Crew Training – Consolidated instruction whereby individuals and/or teams of personnel qualified in their respective specialties are trained together to perform simultaneous and sequential duties and tasks involved in the accomplishment of an assigned operation or set of related operations.

Unit Training – Training given an organized and designated military unit to enable it to achieve unit proficiency in conducting assigned missions.

Reserve Refresher Training – A course for reserve officers and airmen (not on extended active duty) designed to provide refresher training in a major subject area or major item of equipment associated with an Air Force Specialty. This type of training acquaints reservists with the latest developments in the fields in which they have had experience. It is assumed that the students taking this training will possess the AFSC pertinent to the particular course.

USAF EXTENSION COURSES

These courses are prepared by technical writers of the training centers for publication by the Extension Course Institute (ECI) of the Air University for use by individual Air Force students enrolled in the ECI program. Extension courses are written in two general areas: (1) General Military Education, and (2) Specific Career Fields.

ON-THE-JOB TRAINING (OJT)

On-the-job training is designed to qualify an airman through self-study and supervised instruction to perform in a given Air Force Specialty while actually working in a duty assignment of the AFS. The airman's OJT progress is recorded on AF Form 623 (see Appendix IX). Currently, there are two forms of OJT programs: (1) Dual Channel, and (2) OJT Package Program. The new Dual Channel OJT is gradually being phased into the Air Force. During this implementation, the old OJT packages will be phased out. Both the new Dual Channel concept and the old OJT Package Program are described below.

New Dual Channel OJT Concept – This concept (Figure 24) is based on the premise that in career development there are certain knowledges that the airman must acquire if he is to have the versatility required to move from one kind of equipment or system to another and to progress in his career field. There are two separate channels identified in this concept:

1. *Career Development Courses (CDC)* – These are self-study courses designed to present the knowledge considered to be necessary for versatility and they contain the information necessary for the airman to pass the appropriate Specialty Skill Test.

2. *Job Proficiency Guides (JPG's)* – These guides "will be used to assist supervisors in developing their trainees' job proficiency. The primary purpose of the JPG is to provide the airman with a specific reference in an authoritative publication for each task he performs in his current duty assignment." Current USAF Job Standards contain most of the essential elements of the JPG's.

Old OJT Packages – A training publication technically designed to guide both the individual trainee and his supervisor in conducting on-the-job training for an individual in a specific AFSC or shred-out of the AFSC.

1. *Basic OJT Package* – For qualification to "3" skill level. See block (4) on Chart 2. Example: JB 30130, Aircraft Radio Apprentice.

2. *Proficiency OJT Package* – For qualification to the "5" skill level. See block (5) on Chart 2. Example: JP 30150, Aircraft Radio Repairman.
3. *Advanced OJT Package* – For qualification to the "7" level. See block (7) on Chart 2. Example: JA 30170, Aircraft Radio Maintenance Technician.
4. *Lateral OJT Package* – For qualification to the "3" skill level to another career field (JL).
5. *Combined OJT Package* – For qualification to the "3" or "5" skill level in career fields for which no formal resident *Airman Basic Training* is given.
6. *Special Category OJT Package (JS).*

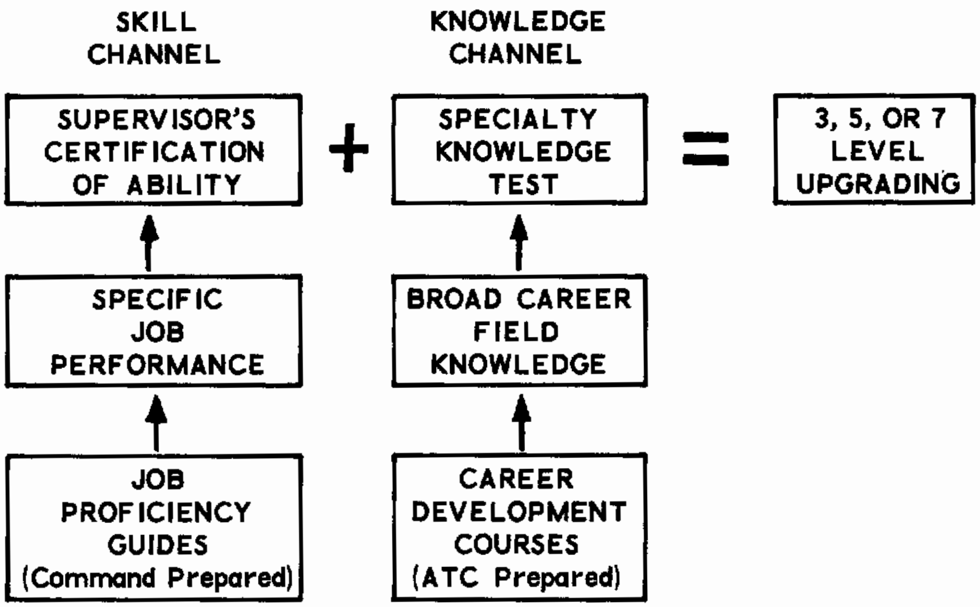


Figure 24. Dual Channel Concept of On-the-Job Training

COURSE NUMBERING SYSTEM

All technical courses, either controlled or utilized by the Air Force, are identified by a five-digit number preceded by a three-letter prefix. The three-letter prefix indicates whether the course is for officer or for airmen, the type of training given, and by whom. The number in most cases identifies the Air Force specialty for which training is given. For example, in ABR 30130, Aircraft Radio Repairman, the "A" indicates first of all that it is an airman course. The "B" indicates that it is a basic course, and the "R" indicates that it is a resident course conducted on Training Command facilities. The 30130 indicates that it trains for the Air Force Specialty 30130 Aircraft Radio Repairman apprentice or semi-skilled. Although there are some exceptions, the following explanation covers most cases.

First Letter – The *First Letter* is always either A or O indicating an Airman or Officer course.

Second Letter – The *Second Letter* may indicate location of course or its classification as shown in Figure 25.

APPLIES TO

SECOND LETTER	MEANING	C* Type I	S* Type II	R* Type III	F* Type IV	M* Military	L* Language	Other* Type V
A	Advanced			X	X			X
B	Basic			X	X	X		X
C	Contractor's Facility	X	X					
D	ATC Traveling Team Course		X					
F	Air Crew				X			
G	Air National Guard					X		
I	Instructor			X	X	X		
J	OJT Supervisor			X	X			
L	Lateral			X				X
M	Maintenance				X			
O	Operator				X			
Q	Preparatory or Fundamental			X				
R	Reserve			X		X		X
S	Special				X			X
T	Technical School	X	X					
U	USAF Language School						X	
W	WAF					X		
X	Any Location except "Cort"	X	X					
Y	Precommission					X		
Z	Supplemental (or Intermediate			X	X			X

Third Letter – The *Third Letter* indicates the "Type" of training.

1. *C* – indicates Special Training by contractor (Type I).
2. *S* – indicates Special Training by Air Training Command (Type II).
3. *R* – indicates ATC Resident Course (Type III).
4. *F* – indicates courses conducted by Air Training Command Field Training Detachment (MTD) (Type IV).
5. *M* – indicates a Military Training Course.
6. *L* – indicates an English Language Course.
7. *All Other Letters* – indicate courses conducted by government agencies other than Air (FTD) or Mobile Training Detachment (MTD) (Type IV).

   A – Army

   G –Other Government Agencies

   K – USAF Security Service

   N – Navy

   X – Other USAF Agency

   Y – Medical Courses conducted by Air Force Systems Command

   Z – Foreign Language Training

Example:

Course No. AAR 42171 means an airman, advanced, residence course designed to train airmen for duty as Aircraft Propeller Technicians. The Air Force Specialty Code (AFSC) for this job is AFSC 42171.

Appendix I.

QQPRI POSITION DESCRIPTION FOR THE WEAPON CONTROL SYSTEMS MECHANIC/TECHNICIAN, AFSC 322XIR

GENERAL FEATURES

The Weapon Control Systems Mechanic/Technician will service, inspect, and adjust and align, functional test, remove and replace, and troubleshoot the F-111A Radar Set (attack radar), Lead Computing Optical Sight Set and related aerospace ground equipment.

Position Summary

a. The scope of responsibilities of this position will include servicing, inspection, adjustment and alignment, functional testing, removal and replacement, and troubleshooting of the Radar Set (attack radar), Lead Computing Optical Sight Set and related aerospace ground equipment. Responsibilities of this position are limited to organizational level maintenance. Servicing includes loading of the film magazine into the attack radar indicator/recorder and cleaning the combining glass of the optical display sight. Adjustment and alignment includes boresighting the optical display sight mount to the aircraft reference axes.

b. The duties of this position will be performed on the flight line, in the hangar, or in the periodic docks during hourly postflight and periodic inspections.

c. The equipment to be maintained by this position will consist of the AN/APQ-113 Radar Set (attack radar), Lead Computing Optical Sight Sets, the dual bombing timer, related antennas, waveguide and interconnecting wiring, and related aerospace ground equipment.

d. Association of this position with other workers will include Electronic Warfare Repairman/Technician, AFSC U301X3; Aircraft Inertial and Radar Navigation Systems Control Systems Specialist/Technician. AFSC U325X0A.

e. Team interaction with other workers will be required when troubleshooting and functional testing this equipment and the equipment maintained by AFSC U301X4. The accomplishment of certain tasks will require two men of this position. The Weapon Control Systems Mechanic/Technician will coordinate and perform his duties with Aircraft Electronic Navigation Equipment Repairman/Technician, AFSC U301XIB; Automatic Flight Control Systems Specialist/Technician, AFSC U325X0A; Instrument Repairman/Repair Technician, AFSC U422X0; Aircraft Mechanic/Maintenance Technician, AFSC U431X1C, and Weapons Mechanic/ Maintenance Supervisor, AFSC U462X0.

f. The nature of work to be performed by this position will vary from simple to complex. The more complex tasks will be associated with functional testing and troubleshooting. These will involve moderate mental demands including memory for details, decision making, concentration, mechanical aptitude, and the ability to make abstractions and to interpolate test equipment indications.

g. Maintenance procedures to be employed by the Weapon Control Systems Mechanic/Technician will be both fixed and variable. Fixed procedures will be utilized in servicing, inspection, adjustment and alignment, and removal and replacement of the Radar Set (attack radar), Lead Computing Optical Sight Set, and related aerospace ground equipment. Variable procedures will be required when functional testing and troubleshooting.

Environment

The Weapon Control Systems Mechanic/Technician will be required to perform tasks on the flight line, in docks, and in hangars. Since some of the maintenance operations will be performed in the climatic environment of the flight line, climatic conditions may, on occasion, be such as to seriously hamper the accomplishment of both scheduled and unscheduled maintenance.

High noise level will be present when tasks are performed on the flight line concurrently with engine operation. In addition to high noise level, engine blast and intake area dangers and temperatures developed during engine operations may also present extreme hazard to personnel. Some tasks at the aircraft may be performed within rather confined work spaces which will require maintenance personnel to assume stooping, bending, crawling, or other awkard positions. The presence of high voltage and RF energy will present sources of special danger to personnel during the performance of several maintenance activities.

Relation to Existing Air Force Specialties

This position type falls within the scope of the Weapon Control Systems Mechanic/Technician, AFSC 322X1. The equipment for which this position is responsible has been developed specifically for the F-111A aircraft. Additional specialized training is necessary to qualify personnel of this position for the F-111A aircraft. Utilizing an offensive fire control system trainer, transparencies, and film, this additional specialized training has a recommended duration of 100 hours.

Appendix II.

JOB TRAINING STANDARD

JOB TRAINING STANDARD
NUMBER 32231P/51P/71P

DEPARTMENT OF THE AIR FORCE
WASHINGTON, 15 November 1966

WEAPON CONTROL SYSTEMS MECHANIC AND WEAPON CONTROL SYSTEMS TECHNICIAN (F4, AMCS)

1. Purpose. This JTS, prepared IAW AFR 50-34:

a. States general tasks, knowledges and study references (GSR) necessary for airmen to perform duties in the Weapon Control Systems ladder of the Airman Armament Systems Maintenance and Operator Career Field (column A). These are based on Specialty Descriptions effective 1 September 1966 in AFM 39-1K.

b. Shows proficiency attained in Course ABR32231P described in AFM 50-5, "USAF Formal Schools Catalog" (column B).

c. Indicates minimum proficiency recommended for each task or knowledge for qualification at the 3, 5 and 7 level AFSCs (columns C, D and F).

d. Provides basis for supervisors to plan and conduct individual OJT programs.

e. Provides a convenient record of on-the-job training completed when inserted in AF Form 623, and maintained IAW AFM 50-23.

2. Qualitative Requirements. Attachment 1 contains the Proficiency Code Key and lists tasks and knowledges referenced above. AFM 50-23 contains the authority to change the proficiency level where the local requirement is different from the level shown in this JTS.

3. Recommendations. Report unsatisfactory performance of individual graduates or inadequacies of this JTS to Hq ATC (ATTDC). Refer to specific items of this JTS. See AFR 50-10.

4. Index and Distribution. See AFR 0-8.

BY ORDER OF THE SECRETARY OF THE AIR FORCE

OFFICIAL

J. P. McCONNELL
General, U. S. Air Force
Chief of Staff

R.J. PUGH
Colonel, USAF
Director of Administrative Services

1 Attachment
Qualitative Requirements

*This Standard supersedes JTS 32231P/51P/71P, 4 January 1965.

THIS BLOCK IS FOR IDENTIFICATION PURPOSES ONLY		
TRAINEE		
NAME	INITIALS (IN WRITING)	GRADE
ORGANIZATION		
TRAINER'S NAMES AND INITIALS (In Writing)		
N/I	N/I	
N/I	N/I	

QUALITATIVE REQUIREMENTS

PROFICIENCY CODE KEY		
	SCALE VALUE	DEFINITION: The Individual
TASK PERFORMANCE LEVELS	1	Can do simple parts of the task. Needs to be told or shown how to do most of the task. (EXTREMELY LIMITED)
	2	Can do most parts of the task. Needs help only on hardest parts. May not meet local demands for speed or accuracy. (PARTIALLY PROFICIENT)
	3	Can do all parts of the task. Needs only a spot check of completed work. Meets minimum local demands for speed and accuracy. (COMPETENT)
	4	Can do the complete task quickly and accurately. Can tell or show others how to do the task. (HIGHLY PROFICIENT)
* TASK KNOWLEDGE LEVELS	a	Can name parts, tools, and simple facts about the task. (NOMENCLATURE)
	b	Can name the steps in doing the task and tell how each is done. (PROCEDURES)
	c	Can explain why and when the task must be done and why each step is needed. (OPERATING PRINCIPLES)
	d	Can predict, identify, and resolve problems about the task. (COMPLETE THEORY)
** SUBJECT KNOWLEDGE LEVELS	A	Can identify basic facts and terms about the subject. (FACTS)
	B	Can explain relationship of basic facts and state general principles about the subject. (PRINCIPLES)
	C	Can analyze facts and principles and draw conclusions about the subject. (ANALYSIS)
	D	Can evaluate conditions and make proper decisions about the subject. (EVALUATION)

– EXPLANATIONS –

* A task knowledge scale value is used alone or with a task performance scale value to define a level of knowledge for a specific task. (Examples: b and 1b)

** A subject knowledge scale value is used alone to define a level of knowledge for a subject not directly related to any specific task, or for a common subject related to several tasks.

\- This mark is used alone instead of a scale value to show that the individual needs no training in task performance, task knowledge, or subject knowledge at this skill level.

X This mark is used alone in ATC course columns to show that training is not given due to limitations in ATC resources.

Attachment 1

(A)	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION (B)	(C)			(D)			(E)	(F)		
GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	Crs (3) Lvl	AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	Crs (7) Lvl	AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
NOTE: This JTS provides the training standards for the F-4C/D configurations. Items 1 thru 20 pertain to the F-4D AMCS; items 21 thru 24 identify equipment and publications peculiar to the F-4C.											
Career Development Courses 32003 and 32211 are applicable study references for AFSC 32251P and 32271P.											
1. AIR FORCE MISSION AND ORGANIZATION											
GSR: AFM 1-1; AFM 26-2; AFR 1-1; AFR 55-43											
a. The overall mission of the Air Force	A	A			B				B		
b. The Air Force organizational structure	A	A			B				B		
c. The airman classification system											
GSR: Chap 1-8, AFM 35-1; Part One, Vol I, AFM 39-1; Part Two, Vol II, AFM 39-1; AFVA 39-1											
(1) The Air Force career program	A	A			B				B		
(2) Airman Armament System Maintenance and Operator Career Field (AFSC 32XXX)	B	B			B				B		
(3) Weapon control systems ladder											
(a) Duties of the Fire and Weapon Control Systems Superintendent, (AFSC 32290)	A	A			B			NO ADVANCED COURSE	B		
(b) Duties of the Weapon Control Systems Technician (AFSC 32271)	A	A			B				B		
(c) Duties of the Weapon Control Systems Mechanic (AFSC 32251)	B	B			B				B		
(d) Duties of the Apprentice Weapon Control Systems Mechanic (AFSC 32231)	B	B			B				B		
2. OBSERVE SECURITY PROCEDURES AS DIRECTED IN AF SECURITY REGULATIONS, MANUALS, DIRECTIVES, AND SECURITY SYSTEMS	1a	1a			2b				3c		
GSR: Chap 1, 2, 3, 4, 5, 6, 7, 9, 10, and 14, AFR 205-1; AFR 205-2											
3. SAFETY											
a. Principles of general safety procedures	B	B			B				C		
GSR: Chap 1, 2, 5, and 11, AFM 127-101; AFM 92-1											
b. Handling of radioactive equipment	A	A			B				C		
GSR: TO 00-110A-1											

Attachment 1

(A) GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	(B) Crs (3) Lvl	(C) AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(D) AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(E) Crs (7) Lvl	(F) AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
3c. First aid procedures for electrical shock and other emergencies	B	B			C				D		
GSR: Chap 6 and 10, AFM 127-101											
d. Apply precautions during job performance											
(1) Around aircraft	b	3c			4c				4d		
GSR: Chap 8, AFM 127-101											
(2) Around electronic equipment	2b	3c			4d				4d		
GSR: Chap 10, AFM 127-101											
(3) Around ground power equipment	b	3c			4c				4d		
GSR: Chap 8 and 10, AFM 127-101											
(4) Around armed aircraft	b	3c			4c				4d		
GSR: Chap 8, AFM 127-101											
4. PUBLICATIONS								NO ADVANCED COURSE			
a. Scope and application of the technical order system	B	B			C				C		
GSR: Sec I thru VII, TO 00-5-1											
b. Use indexes to locate TO numbers and titles	2b	2b			3c				4c		
GSR: Sec II, TO 00-5-2; and TO 0-1-01, TO 0-1-11-1, TO 0-1-33-1, TO 0-2-1, TO 0-4-1, TO 0-4-2											
c. Procedures involved in obtaining TOs and commercial publications	A	A			B				C		
GSR: Sec VII, TO 00-5-2											
d. Procedures involved in maintaining TOs and commercial publications	A	A			B				C		
GSR: Sec I thru VIII, TO 00-5-2											
e. Report technical order deficiencies	1b	1b			3c				4c		
GSR: Para 8 thru 17, Sec VIII, TO 00-5-1											
f. Use 1 - category technical publications											
(1) TO 0-1-1	1b	1b			3b				4c		
(2) TO 0-1-1-4	1b	1b			3b				4c		
(3) TO 1F-4C-01	1b	1b			3b				4c		
(4) TO 1F-4D-2-19	2b	2b			3b				4c		
(5) TO 1F-4D-2-33	2b	2b			3b				4c		

(A) GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	(B) Crs (3) Lvl	(C) AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(D) AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(E) Crs (7) Lvl	(F) AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
4f(6) TO 1F-4D-2-19CL-1	2b	2b			3b				4c		
(7) TO 1F-4D-2-33CL-1	2b	2b			3b				4c		
g. Use 5 - category technical publications	1a	1a			3b				4c		
GSR: TO 5N1-3-15-2											
h. Use 11 - category technical publications	2b	2b			3b				4c		
GSR: TO 11F1-ASG22-2											
i. Use 12 - category technical publications	2b	2b			3b				4c		
GSR: TO 12P2-2APQ109-2-1 thru TO 12P2-APQ109-2-8, TO 12P2-2APA165-2											
j. Use 33 - category technical publications	1b	1b			3b				4c		
GSR: 0-1-33 series and test equipment technical orders as indicated in paragraph 11 of this JTS											
5. AIR FORCE SUPPLY DISCIPLINE											
GSR: Part 2, Vol I, AFM 67-1											
a. Supply procedures to include classification and identification	B	B			B			NO ADVANCED COURSE	C		
b. Use indexes and supply catalogs	2b	2b			3b				3c		
c. Use tags, issue slips and turn-in slips	2b	2b			3c				4c		
d. Property accountability and responsibility	A	B			B				C		
6. SUPERVISION AND TRAINING											
a. Personnel											
GSR: AFM 50-20											
(1) Evaluate performance of personnel and completes appropriate rating forms	-	-			1b				4c		
GSR: AFM 39-62											
(2) Orient newly assigned personnel and makes work assignments	-	-			1a				4c		
(3) Correspondence and SOPs concerning maintenance activities	-	A			B				C		

(A) GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	(B) Crs (3) Lvl	(C) AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(D) AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(E) Crs (7) Lvl	(F) AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
6b. Training											
GSR: AFM 50-5; AFM 50-23; AFR 39-4; AFR 50-9											
(1) Air Force training resources, programs, and training assignment procedures	A	A			B				B		
(2) Recommend personnel for training	-	-			1b				3c		
(3) Conduct personnel training	-	-			2b				3c		
(4) Maintain appropriate training records	-	-			2b				4c		
7. MAINTENANCE MANAGEMENT											
a. Functions and responsibilities of the Chief of Maintenance	A	A			B			NO ADVANCED COURSE	B		
GSR: Chap 1, AFM 66-1											
b. Basic functions of management units that make up the Chief of Maintenance staff	A	A			B				B		
GSR: Chap 1, AFM 66-1											
c. Man-hour reporting system	A	A			B				B		
GSR: Chap 8, AFM 66-1											
d. Work order numbering	A	A			B				B		
GSR: Chap 2, AFM 66-1; TO 1F-4D-06											
e. Work order processing	-	A			B				B		
GSR: Chap 2, AFM 66-1											
f. Maintenance data collection	A	A			B				B		
GSR: Chap 9, AFM 66-1											
g. Processing and control of materiel	A	A			B				B		
GSR: Chap 3, AFM 66-1											
8. MAINTENANCE AND INSPECTION SYSTEM AND FORMS											
a. Inspection and maintenance systems	B	B			B				B		
GSR: TO 00-20-series											
b. Use man-hour reporting forms	2b	2b			3b				3c		
GSR: Chap 8, AFM 66-1											

(A) GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	(B) Crs (3) Lvl	(C) AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(D) AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(E) Crs (7) Lvl	(F) AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
8c. Use maintenance data collection forms	2b	2b			3b				3c		
GSR: TO 00-20-2-1											
d. Materiel deficiency reporting system	A	A			B				B		
GSR: Chap 7, AFM 66-1											
e. Check reports to determine methods for improving procedures at local activity	-	-			2b				3c		
GSR: Chap 9, AFM 66-1											
9. ELECTRONIC PRINCIPLES											
a. DC circuits: Orientation and study habits; safety and first aid; electrostatic principles; fundamentals of DC; series resistive circuits; parallel resistive circuits; series-parallel resistive circuits; resistive bridge circuits; principles of magnetism, relays, and vibrators; meter movements and circuits	B	B			B			NO ADVANCED COURSE	C		
GSR: Chap 2, Vol I, AFM 52-8											
b. AC circuits: Generation of AC and DC; frequency spectrum; inductance, inductive reactance, and transformers; capacitance and capacitive reactance; use of the oscilloscope; series RC, RL, RCL and resonance; parallel RC, RL, RCL and resonance; solid state diodes and rectifier circuits	B	B			B				C		
GSR: Chap 2, Vol I, AFM 52-8											
c. Solid state devices: Filters and power supplies; transistor triodes and special purpose devices; amplifier principles; audio amplifiers; push-pull amplifiers; video amplifiers; voltage regulators	B	B			B				C		
GSR: Chap 8, Vol I, AFM 52-8											

(A) GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	(B) Crs (3) Lvl	(C) AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(D) AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(E) Crs (7) Lvl	(F) AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION										
9d. Vacuum tubes: Diodes and rectifier circuits; triodes; amplifier principles; audio amplifiers, tetrodes, pentodes, and multipurpose tubes; video amplifiers; cathode-ray and special purpose tubes; gas tubes voltage regulators; handtools, soldering techniques, and kit construction; cathode followers	B	B			B				C		
GSR: Chap 4, Vol I, AFM 52-8											
e. Oscillators: Limiter and clamper circuits; RF and IF amplifiers; oscillators; amplitude modulation; detection	B	B			B				C		
GSR: Chap 7, Vol I, AFM 52-8											
f. Receiver principles: Synchroscope; heterodyning; schematic interpretation and troubleshooting; frequency modulation; discrimination; single sideband; transmission lines; antennas	B	B			B			NO ADVANCED COURSE	C		
GSR: Chap 9, 10, 13, Vol II, AFM 52-8											
g. Motors and servomechanisms: Saturable reactors and magnetic amplifiers; motors; synchros; servomechanisms and servo amplifiers	B	B			B				C		
GSR: Chap 14, Vol II, AFM 52-8											
h. Waveshaping circuits: Transients; blocking oscillators; pulsed oscillators; free-running multivibrators; one-shot multivibrators; bi-stable multivibrators; phantastron circuit; sawtooth generators; trapezoid generators	B	B			B				C		
GSR: Chap 6 and 7, Vol I, AFM 52-8											
i. Microwave principles: Artificial lines; pulse amplitude modulation; Doppler principles; waveguides; cavity resonators; UHF and microwave oscillators; magnetrons	B	B			B				C		
GSR: Chap 10, 11, 12, and 15, Vol II, AFM 52-8											
10. USE HAND AND SPECIAL TOOLS	2b	2b			3c				4c		
GSR: Chap 3, AFM 32-3											

(A) GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	(B) Crs (3) Lvl	(C) AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(D) AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(E) Crs (7) Lvl	(F) AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
11. DEMONSTRATE PROPER TECHNIQUES IN THE CONNECTION, INITIAL SETTING AND USE OF THE FOLLOWING TEST EQUIPMENT OR APPLICABLE ALTERNATES IN ACCORDANCE WITH APPROPRIATE TECHNICAL ORDERS											
a. Multimeter	2b	2b			3c				4c		
<u>GSR</u>: TO 33A1-12-2-1 (PSM-6)											
b. Electronic multimeter	2b	2b			3c				4c		
<u>GSR</u>: TO 33A1-12-98-21(410B)											
c. Frequency counter	a	a			2b				4c		
<u>GSR</u>: TO 33A1-5-5-1 (USM-26)											
d. Pressure gauge (Schrader)	a	a			3b				4b		
<u>GSR</u>: TO 1F-4D-2-19											
e. Dummy Load DA-148/4	a	a			3b				4b		
<u>GSR</u>: TO 12P2-2APQ109-2-3											
f. Oscilloscope	2b	2b			3c			NO ADVANCED COURSE	4c		
<u>GSR</u>: TO 33A1-13-258-1 (AN/USM-105)											
g. Impedance bridge	a	a			2b				4c		
<u>GSR</u>: TO 33A1-6-32-1 (URM-90)											
h. Insulation test set	a	a			2b				4c		
<u>GSR</u>: TO 33A1-4-5-11 (PSM-2)											
i. Radar signal generator	2b	2b			3c				4c		
<u>GSR</u>: TO 33A1-3-10-31 (UPM-10B)											
j. Radar spectrum analyzer	2b	2b			3c				4c		
<u>GSR</u>: TO 33A1-5-3-1 (UPM-33)											
k. Antenna position simulator	a	a			3c				4c		
<u>GSR</u>: TO 33D5-12-181-1 (SM 211)											
l. Tube tester	b	b			3c				4c		
<u>GSR</u>: TO 33AA21-4-11 (TV-2U)											
m. Digital meter (Fluke)	a	1a			3c				4c		
<u>GSR</u>: TO 33A1-12-199-1 (803B)											

(A) GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	(B) Crs (3) Lvl	(C) AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(D) AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(E) Crs (7) Lvl	(F) AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
11n. Audio oscillator GSR: TO 33A1-8-82-1 (TS-382)	a	a			3b				4b		
o. Radar modulation test set GSR: TO 33D7-44-87-2 (AN/APM-84B)	2b	2b			3b				4c		
p. Radar test set GSR: TO 33D7-44-78-1 (AN/APM-130A)	2b	2b			3b				4c		
q. Radar test harness GSR: TO 33D7-44-79-3 (AN/APM-131)	a	a			3b				4c		
r. Fire control system test set GSR: TO 33D5-12-168-2 (TS-2416)	2b	2b			3b				4c		
s. Fire control system test set GSR: TO 33D5-12-158-1 (AN/AWM-19)	b	1b			3b				4c		
t. Fire control system test set GSR: TO 33D5-12-158-1 (AN/AWM-20)	2b	2b			3b			NO ADVANCED COURSE	4c		
u. Transistor tester GSR: TO 33D9-115-4 (219B)	a	a			3b				4b		
v. Fill and bleed unit GSR: TO 33D5-12-181-1 (OS-45)	a	1a			3b				4c		
w. Fill and bleed station GSR: TO 34Y2-70-1	a	1a			3b				4c		
x. RF power test set GSR: TO 33D5-12-181-1 (TS-2059)	2b	2b			3b				4c		
y. Missile control system test set GSR: TO 33D5-12-181-1 (AN/AWM-26 cart)	1a	1a			3b				4c		
z. Fire control system test set GSR: TO 33D5-12-153-1 (TS-2434)	a	1a			3b				4c		
aa. Analyzer bombing computer set GSR: TO 33D7-10-28-1 (AN/ASM-237)	2b	2b			3b				4c		
ab. Analyzer lead angle computing set GSR: TO 33D7-10-29-1 (AN/ASM-238)	2b	2b			3b				4c		

(A)	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION										
	(B)	(C)			(D)			(E)	(F)		
GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	Crs (3) Lvl	AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	Crs (7) Lvl	AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
11 ac. Missile interface test set (MITS)	2b	2b			3b				4c		
GSR: (TO pending)											
ad. Missile adapter test set (MATS)	a	1a			3b				4c		
GSR: (TO pending)											
ae. Electronic equipment maintenance kit	1a	1a			3b				4c		
GSR: TO 33D7-44-80-3 (MK-495)											
af. Weapon release computer set test console	a	1a			3b				4c		
GSR: TO 33D7-3-66-1											
12. LOCATION AND IDENTIFICATION OF ALL MAJOR COMPONENTS OF THE AMCS											
GSR: TO 1F-4D-2-19											
a. Description and functions of each major component	B	B			B			NO ADVANCED COURSE	B		
b. Locate and identify each major component on the aircraft	a	1b			3b				4b		
13. AMCS TIE-IN WITH RELATED AIRCRAFT SYSTEMS											
GSR: TO 1F-4D-2-19 and TO 1F-4D-2-33, TO 1F-4D-2-22											
a. Electrical system	A	A			B				C		
b. Hydraulic system	A	A			B				C		
c. Pressurization and cooling	A	A			B				C		
d. Air data computer (ADC)	A	A			B				C		
e. Inertial navigation system (INS)	A	A			B				C		
f. Attitude reference bombing computer set (AN/AJB-7)	A	A			B				C		
g. Weapons release related switches, controls and indicators	A	A			B				C		
h. Missile launchers	A	A			B				C		
14. AN/APQ-109 RADAR											
GSR: TO 1F-4D-2-19; TOs 12P2-2APQ109-2-1 thru 12P2-2APQ109-2-8											
a. Power supplies											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(2) Perform all applicable checks and alignments	2b	2b			3c				4d		

(A) GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	(B) Crs (3) Lvl	(C) AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(D) AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(E) Crs (7) Lvl	(F) AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
14a(3) Isolate malfunctions to								NO ADVANCED COURSE			
(a) Major components	2b	2b			3c				4d		
(b) Modules or pluggable components	2b	2b			3b				4d		
(c) Solderable components	a	1a			3b				4c		
(4) Correct malfunctions by replacing											
(a) Major components	b	2b			3c				4d		
(b) Modules or pluggable components	b	1b			3c				4d		
(c) Solderable components	a	1a			3b				4c		
b. Transmitting system											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(2) Perform all applicable checks and alignments	2b	2b			3c				4d		
(3) Isolate malfunctions to											
(a) Major components	2b	2b			3c				4d		
(b) Modules or pluggable components	2b	2b			3b				4d		
(c) Solderable components	a	1a			3b				4c		
(4) Correct malfunctions by replacing											
(a) Major components	b	2b			3c				4d		
(b) Modules or pluggable components	b	1b			3c				4d		
(c) Solderable components	a	1a			3b				4c		
c. Receiving system											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(2) Perform all applicable checks and alignments	2b	2b			3c				4d		
(3) Isolate malfunctions to											
(a) Major components	2b	2b			3c				4d		
(b) Modules or pluggable components	2b	2b			3b				4c		
(c) Solderable components	a	1a			3b				4c		
(4) Correct malfunctions by replacing											
(a) Major components	b	2b			3c				4d		
(b) Modules or pluggable components	b	1b			3c				4d		
(c) Solderable components	a	1a			3b				4c		
d. Electrical frequency control											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		

(A) GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	(B) Crs (3) Lvl	(C) AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(D) AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(E) Crs (7) Lvl	(F) AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
14d(2) Perform all applicable checks and alignments	2b	2b			3c				4d		
(3) Isolate malfunctions to											
(a) Major components	2b	2b			3c				4d		
(b) Modules or pluggable components	2b	2b			3b				4d		
(c) Solderable components	a	1a			3b				4c		
(4) Correct malfunctions by replacing											
(a) Major components	b	2b			3c				4d		
(b) Modules or pluggable components	b	1b			3c				4d		
(c) Solderable components	a	1a			3b				4c		
e. Receiver gain control system											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(2) Perform all applicable checks and alignments	2b	2b			3c				4d		
(3) Isolate malfunctions to											
(a) Major components	2b	2b			3c				4d		
(b) Modules or pluggable components	2b	2b			3b				4d		
(c) Solderable components	a	1a			3b				4c		
(4) Correct malfunctions by replacing								NO ADVANCED COURSE			
(a) Major components	b	2b			3c				4d		
(b) Modules or pluggable components	b	1b			3c				4d		
(c) Solderable components	a	1a			3b				4c		
f. Air-to-air range track											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(2) Perform all applicable checks and alignments	2b	2b			3c				4d		
(3) Isolate malfunctions to											
(a) Major components	2b	2b			3c				4d		
(b) Modules or pluggable components	2b	2b			3b				4d		
(c) Solderable components	a	1a			3b				4c		
(4) Correct malfunctions by replacing											
(a) Major components	b	2b			3c				4d		
(b) Modules or pluggable components	b	1b			3c				4d		
(c) Solderable components	a	1a			3b				4c		
g. Air-to-ground range track											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		

(A) GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	(B) Crs (3) Lvl	(C) AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(D) AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(E) Crs (7) Lvl	(F) AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
14g(2) Perform all applicable checks and alignments	2b	2b			3c			NO ADVANCED COURSE	4d		
(3) Isolate malfunctions to											
(a) Major components	2b	2b			3c				4d		
(b) Modules or pluggable components	2b	2b			3b				4d		
(c) Solderable components	a	1a			3b				4c		
(4) Correct malfunctions by replacing											
(a) Major components	b	2b			3c				4d		
(b) Modules or pluggable components	b	1b			3c				4d		
(c) Solderable components	a	1a			3b				4c		
h. Antenna servo system											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(2) Perform all applicable checks and alignments	2b	2b			3c				4d		
(3) Isolate malfunctions to											
(a) Major components	2b	2b			3c				4d		
(b) Modules or pluggable components	2b	2b			3b				4d		
(c) Solderable components	a	1a			3b				4c		
(4) Correct malfunctions by replacing											
(a) Major components	b	2b			3c				4d		
(b) Modules or pluggable components	b	1b			3c				4d		
(c) Solderable components	a	1a			3b				4c		
i. Display system											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(2) Perform all applicable checks and alignments	2b	2b			3c				4d		
(3) Isolate malfunctions to											
(a) Major components	2b	2b			3c				4d		
(b) Modules or pluggable components	2b	2b			3b				4d		
(c) Solderable components	a	1a			3b				4c		
(4) Correct malfunctions by replacing											
(a) Major components	b	2b			3c				4d		
(b) Modules or pluggable components	b	1b			3c				4d		
(c) Solderable components	a	1a			3b				4c		

(A) GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	(B) Crs (3) Lvl	(C) AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(D) AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(E) Crs (7) Lvl	(F) AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
14j. Built-in test											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(2) Perform operational checks using built-in test procedures	2b	2b			3c				4d		
(3) Correct malfunctions by replacing built-in test components	a	1a			3b				4c		
15. AN/APA-165 RADAR SET GROUP											
GSR: TO 1F-4D-2-19, TO 12P2-2APA165-2											
a. Modulator											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(2) Perform all applicable checks and alignments	2b	2b			3c				4d		
(3) Isolate malfunctions to											
(a) Major components	2b	2b			3c				4d		
(b) Modules or pluggable components	2b	2b			3b				4d		
(c) Solderable components	a	1a			3b				4c		
(4) Correct malfunctions by replacing								NO ADVANCED COURSE			
(a) Major components	b	2b			3c				4d		
(b) Modules or pluggable components	b	1b			3c				4d		
(c) Solderable components	a	1a			3b				4c		
b. Transmitter											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(2) Perform all applicable checks and alignments	2b	2b			3c				4d		
(3) Isolate malfunctions to											
(a) Major components	2b	2b			3c				4d		
(b) Modules or pluggable components	2b	2b			3b				4d		
(c) Solderable components	a	1a			3b				4c		
(4) Correct malfunctions by replacing											
(a) Major components	b	2b			3c				4d		
(b) Modules or pluggable components	b	1b			3c				4d		
(c) Solderable components	a	1a			3b				4c		

(A) GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	(B) Crs (3) Lvl	(C) AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(D) AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(E) Crs (7) Lvl	(F) AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
15c. Target intercept computer											
(1) Closing velocity (Vc) and simulated doppler											
(a) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(b) Perform all applicable checks and alignments	2b	2b			3c				4d		
(c) Isolate malfunctions to											
1 Major components	2b	2b			3c				4d		
2 Modules or pluggable components	2b	2b			3b				4d		
3 Solderable components	a	1a			3b				4c		
(d) Correct malfunctions by replacing											
1 Major components	b	2b			3c				4d		
2 Modules or pluggable components	b	1b			3c				4d		
3 Solderable components	a	1a			3b				4c		
(2) Range computer and interlocks								NO ADVANCED COURSE			
(a) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(b) Perform all applicable checks and alignments	2b	2b			3c				4d		
(c) Isolate malfunctions to											
1 Major components	2b	2b			3c				4d		
2 Modules or pluggable components	2b	2b			3b				4d		
3 Solderable components	a	1a			3b				4d		
(d) Correct malfunctions by replacing											
1 Major components	b	2b			3c				4d		
2 Modules or pluggable components	b	1b			3c				4d		
3 Solderable components	a	1a			3b				4c		
(3) Lead angle error (LAE) computer											
(a) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(b) Perform all applicable checks and alignments	2b	2b			3c				4d		
(c) Isolate malfunctions to											
1 Major components	2b	2b			3c				4d		
2 Modules or pluggable components	2b	2b			3b				4d		
3 Solderable components	a	1a			3b				4c		

Attachment 1

(A)	(B)	(C)			(D)			(E)	(F)		
	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION										
GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	Crs (3) Lvl	AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	Crs (7) Lvl	AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
15c(3)(d) Correct malfunctions by replacing											
1 Major components	b	2b			3c				4d		
2 Modules or pluggable components	b	1b			3c				4d		
3 Solderable components	a	1a			3b				4c		
(4) Allowable steering error (ASE) computer and interlocks											
(a) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(b) Perform all applicable checks and alignments	2b	2b			3c				4d		
(c) Isolate malfunctions to											
1 Major components	2b	2b			3c				4d		
2 Modules or pluggable components	2b	2b			3b				4d		
3 Solderable components	a	1a			3b				4c		
(d) Correct malfunctions by replacing											
1 Major components	b	2b			3c			NO ADVANCED COURSE	4d		
2 Modules or pluggable components	b	1b			3c				4d		
3 Solderable components	a	1a			3b				4c		
(5) Head aim computer and english bias circuits											
(a) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(b) Perform all applicable checks and alignments	2b	2b			3c				4d		
(c) Isolate malfunctions to											
1 Major components	2b	2b			3c				4d		
2 Modules or pluggable components	2b	2b			3b				4d		
3 Solderable components	a	1a			3b				4c		
(d) Correct malfunctions by replacing											
1 Major components	b	2b			3c				4d		
2 Modules or pluggable components	b	1b			3c				4d		
3 Solderable components	a	1a			3b				4c		
d. Tuning drive											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(2) Perform all applicable checks and alignments	2b	2b			3c				4d		

(A)	(B)	(C)	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION		(D)			(E)	(F)		
GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	Crs (3) Lvl	AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	Crs (7) Lvl	AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
15d(3) Isolate malfunctions to											
(a) Major components	2b	2b			3c				4d		
(b) Solderable components	a	1a			3b				4c		
(4) Correct malfunctions by replacing											
(a) Major components	b	2b			3c				4d		
(b) Solderable components	a	1a			3b				4c		
e. Airborne Missile Control Subsystem (Data Converter and Logic Control)											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(2) Perform all applicable checks	2b	2b			3c				4d		
(3) Isolate malfunctions to											
(a) Major components	2b	2b			3c				4d		
(b) Modules or pluggable components	2b	2b			3b				4d		
(c) Solderable components	a	1a			3b				4c		
(4) Correct malfunctions by replacing											
(a) Major components	b	2b			3c			NO ADVANCED COURSE	4d		
(b) Modules or pluggable components	b	1b			3c				4d		
(c) Solderable components	a	1a			3b				4c		
f. Built-in test											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(2) Perform operational checks using built-in test procedures	2b	2b			3c				4d		
(3) Correct malfunctions by replacing built-in test components	a	1a			3b				4c		
16. MISSILE FIRING CIRCUITS											
GSR: TO 1F-4D-2-19											
a. Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
b. Perform all applicable checks and alignments	2b	2b			3c				4d		
c. Isolate malfunctions to											
(1) Major components	2b	2b			3c				4d		
(2) Modules or pluggable components	2b	2b			3b				4d		
(3) Solderable components	a	1a			3b				4c		
d. Correct malfunctions by replacing											
(1) Major components	b	2b			3c				4d		
(2) Modules or pluggable components	b	1b			3c				4d		

(A) GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	(B) Crs (3) Lvl	(C) AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(D) AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(E) Crs (7) Lvl	(F) AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
16d(3) Solderable components	a	1a			3b				4c		
17. LEAD COMPUTING OPTICAL SIGHT SYSTEM AN/ASG-22								NO ADVANCED COURSE			
GSR: TO 1F-4D-2-33											
a. Optical display unit											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(2) Perform all applicable checks and alignments	2b	2b			3c				4d		
(3) Isolate malfunctions to the optical display unit	2b	2b			3c				4d		
(4) Correct malfunctions by re-placing the optical display unit	b	1b			3c				4d		
b. Lead computing amplifier											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(2) Perform all applicable checks and alignments	2b	2b			3c				4d		
(3) Isolate malfunctions to											
(a) Major components	2b	2b			3c				4d		
(b) Modules or pluggable com-ponents	2b	2b			3b				4d		
(c) Solderable components	a	1a			3b				4c		
(4) Correct malfunctions by replacing											
(a) Major components	b	2b			3c				4d		
(b) Modules or pluggable com-ponents	b	1b			3c				4d		
(c) Solderable components	a	1a			3b				4c		
c. Lead computing gyroscope											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(2) Perform all applicable checks	2b	2b			3c				4d		
(3) Isolate malfunctions to the gyro unit	2b	2b			3c				4d		
(4) Correct malfunctions by re-placing the gyro unit	b	1b			3c				4d		
d. Built-in test											
(1) Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
(2) Perform operational checks using built-in test procedures	2b	2b			3c				4d		
(3) Correct malfunctions by re-placing built-in test components	a	1a			3b				4c		

(A) GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION (B) Crs (3) Lvl	(C) AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(D) AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(E) Crs (7) Lvl	(F) AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
18. WEAPONS RELEASE COMPUTER SET AN/ASQ-91											
GSR: TO 1F-4D-2-33											
a. Analyzes circuit networks utilizing functional diagrams and schematics	B	B			B				C		
b. Perform all applicable checks and alignments	2b	2b			3c				4d		
c. Isolate malfunctions to											
(1) Major components	2b	2b			3c				4d		
(2) Modules or pluggable components	2b	2b			3b				4d		
(3) Solderable components	a	1a			3b				4c		
d. Correct malfunctions by replacing											
(1) Major components	b	2b			3c				4d		
(2) Modules or pluggable components	b	1b			3c				4d		
(3) Solderable components	a	1a			3b				4c		
19. PERFORM SYSTEM HARMONIZATION	-	2b			3c				4d		
GSR: TO 1F-4D-2-19 and TO 1F-4D-2-33											
20. PERFORM MAINTENANCE INSPECTION OF THE AIRCRAFT											
GSR: TO 00-20 series, TO 1F-4D-6, TO 1F-4D-2-19, TO 1F-4D-2-33											
a. Demonstrate proficiency in connecting and operating auxiliary aircraft power units	x	2b			3c			NO ADVANCED COURSE	4d		
b. Demonstrate an understanding of cockpit layout and procedures	x	2b			3c				4c		
c. Accomplish maintenance inspection of the AMCS	x	2b			3c				4d		
21. DEMONSTRATE PROPER TECHNIQUES IN THE CONNECTION, INITIAL SETTING AND USE OF THE FOLLOWING TEST EQUIPMENT OR ALTERNATES IN ACCORDANCE WITH APPROPRIATE TECHNICAL ORDERS											
a. Fire Control System Test Set (TS-1800)	-	1a			3b				4c		
GSR: TO 33D5-12-153-1											
b. Fire Control System Test Set (TS-1828A)	-	2b			3b				4c		
GSR: TO 33D5-12-168-2											

(A) GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	(B) Crs (3) Lvl	(C) AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(D) AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(E) Crs (7) Lvl	(F) AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
22. AN/APQ-100 RADAR											
GSR: TO 1F-4C-2-19, TO 1F-4C-2-20, TO 1F-4C-2-21, TO 12P2-2APQ100-2 series											
a. Analyzes the circuit networks peculiar to the AN/APQ-100 Radar utilizing functional diagrams and schematics	-	B			B				C		
b. Perform all applicable checks and alignments peculiar to the AN/APQ-100 Radar	-	2b			3c				4d		
c. Isolate malfunctions to											
(1) Major components	-	2b			3c				4d		
(2) Modules or pluggable components	-	2b			3b				4d		
(3) Solderable components	-	1a			3b				4c		
d. Correct AN/APQ-100 Radar malfunctions by replacing											
(1) Major components	-	2b			3c				4d		
(2) Modules or pluggable components	-	1b			3c				4d		
(3) Solderable components	-	1a			3b				4c		
23. AN/APA-157 RADAR SET GROUP											
GSR: TO 1F-4C-2-19, TO 1F-4C-2-20, TO 1F-4C-2-21, TO 12P2-2APA157-2											
a. Analyzes circuit networks peculiar to the AN/APA-157 utilizing functional diagrams and schematics	-	B			B				C		
b. Perform all applicable checks and alignments peculiar to the AN/APA-157 Radar Set Group	-	2b			3c				4d		
c. Isolate malfunctions to											
(1) Major components	-	2b			3c				4d		
(2) Modules or pluggable components	-	2b			3b				4d		
(3) Solderable components	-	1a			3b				4c		
d. Correct malfunctions by replacing											
(1) Major components	-	2b			3c				4d		
(2) Modules or pluggable components	-	1b			3c				4d		
(3) Solderable components	-	1a			3b				4c		
24. MISSILE FIRING CIRCUITS											
GSR: TO 1F-4C-2-19, TO 1F-4C-2-20, TO 1F-4C-2-21											
a. Analyzes firing circuit networks peculiar to AIM 9B and 9D missiles utilizing functional diagrams and schematics	-	B			B				C		
b. Perform all applicable checks and alignments peculiar to the AIM 9B and 9D missiles	-	2b			3c				4d		

(A) GENERAL TASKS, KNOWLEDGES AND STUDY REFERENCES	(B) Crs (3) Lvl	(C) AFSC (3) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(D) AFSC (5) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials	(E) Crs (7) Lvl	(F) AFSC (7) Lvl	Date OJT Started	Date Completed & Trainer's, Trainee's Initials
24c. Isolate AIM 9B and 9D missile firing circuit malfunctions to											
(1) Major components	-	2b			3c				4d		
(2) Modules or pluggable components	-	2b			3b				4d		
(3) Solderable components	-	1a			3b				4c		
d. Correct AIM 9B and 9D missile firing circuit malfunctions by replacing											
(1) Major components	-	2b			3c				4d		
(2) Modules or pluggable components	-	1b			3c				4d		
(3) Solderable components	-	1a			3b				4c		

Appendix III.

COURSE TRAINING STANDARD

COURSE TRAINING STANDARD
NUMBER LO52-AZR23270

HEADQUARTERS AIR TRAINING COMMAND
Randolph Air Force Base, Texas
13 July 1966

COLOR PHOTO PROCESSES

1. Purpose. This CTS, prepared IAW ATCR 52-17:

a. Sets forth the tasks, knowledges and extent of training to be provided by Course AZR23270, Color Photo Processes.

b. Provides the basis for the development of more detailed training materials and objectives, and training evaluation instruments for the course.

2. Course Description. The course covered by this standard is designed to provide training for Air Force photographic personnel who possess AFSC's 23250/70/90, 23450/70/90, 23352/72/92, 2331 and 2335 in the skills and knowledges necessary to perform as Color Photo Processes Technician. Scope of training includes principles of color photography, exposing and processing of reversal and negative color films, color copy, transparency and negative color duplication, reversal color printing with Ekta-Chrome materials, negative color printing and use of Panalure materials.

3. Qualitative Requirements. Attachment 1 contains the list of tasks, knowledges and extent of training referenced in paragraph 1.

4. Recommendations. Comments and recommendations are invited concerning quality of ATC training and graduates. Use this CTS as a reference and address correspondence to ATC (ATTDC), Randolph AFB, Texas.

OFFICIAL

SAM MADDUX, JR.
Lieutenant General, USAF
Commander

N. H. ROBERDEAU
Colonel, USAF
Director of Administrative Services

1 Attachment
Qualitative Requirements

This standard supersedes CTS 52-AZR23270, 18 December 1961
Lowry OPR: Department of Photographic Training
ATC OPR & Approval Date: ATTMS-I
DISTRIBUTION: (Continued on page 2)

QUALITATIVE REQUIREMENTS

PROFICIENCY CODE KEY

	SCALE VALUE	DEFINITION: The Individual
TASK PERFORMANCE LEVELS	1	Can do simple parts of the task. Needs to be told or shown how to do most of the task. (EXTREMELY LIMITED)
	2	Can do most parts of the task. Needs help only on hardest parts. May not meet local demands for speed or accuracy. (PARTIALLY PROFICIENT)
	3	Can do all parts of the task. Needs only a spot check of completed work. Meets minimum local demands for speed and accuracy. (COMPETENT)
	4	Can do the complete task quickly and accurately. Can tell or show others how to do the task. (HIGHLY PROFICIENT)
* TASK KNOWLEDGE LEVELS	a	Can name parts, tools, and simple facts about the task. (NOMENCLATURE)
	b	Can name the steps in doing the task and tell how each is done. (PROCEDURES)
	c	Can explain why and when the task must be done and why each step is needed. (OPERATING PRINCIPLES)
	d	Can predict, identify, and resolve problems about the task. (COMPLETE THEORY)
** SUBJECT KNOWLEDGE LEVELS	A	Can identify basic facts and terms about the subject. (FACTS)
	B	Can explain relationship of basic facts and state general principles about the subject. (PRINCIPLES)
	C	Can analyze facts and principles and draw conclusions about the subject. (ANALYSIS)
	D	Can evaluate conditions and make proper decisions about the subject. (EVALUATION)

– EXPLANATIONS –

* A task knowledge scale value is used alone or with a task performance scale value to define a level of knowledge for a specific task. (Examples: b and 1b)

** A subject knowledge scale value is used alone to define a level of knowledge for a subject not directly related to any specific task, or for a common subject related to several tasks.

\- This mark is used alone instead of a scale value to show that the individual needs no training in task performance, task knowledge, or subject knowledge at this skill level.

X This mark is used alone in ATC course columns to show that training is not given due to limitations in ATC resources.

DISTRIBUTION: X (Continued from page 1)
Hq USAF (AFPTR) 2; Hq ATC (ATTDC) 5; LTTC (TSOP) 25; LTTC (TSZ) 150.

KNOWLEDGE OR TASK AND EXTENT OF TRAINING	
1. PRINCIPLES OF COLOR PHOTOGRAPHY	
a. Electromagnetic spectrum	
(1) Photographable region	C
(2) Unphotographable region	C
b. Light and color formation	
(1) Additive color	C
(2) Subtractive color	C
c. Color formation utilizing dyes	
(1) Reversal systems	C
(2) Negative - positive systems	C
2. APPLY THE PRINCIPLES, TECHNIQUES AND PROCEDURES USED IN COLOR PHOTOGRAPHY	
a. Color film characteristics	
(1) Speed	3c
(2) Latitude	3c
(3) Reciprocity	3c
(4) Sensitivity	3c
(5) Color contrast	3c
(6) Latent image stability	3c
(7) Structure	3c
b. Exposure requirements for color photography	
(1) Meter techniques	3c
(2) Exposure testing	3c

KNOWLEDGE OR TASK AND EXTENT OF TRAINING	
(3) Filtration requirements	3c
(4) Lighting equipment	3c
(5) Lighting and lighting ratios	3c
c. Equipment requirements for color photography	
(1) Cameras	
(a) Lens types	3c
(b) Aberrations	3c
(c) Corrective adjustments	3c
3. APPLY THE PRINCIPLES, TECHNIQUES AND PROCEDURES FOR COLOR PRINTING	
a. Color paper characteristics	
(1) Structure	3c
(2) Speed	3c
(3) Latitude	3c
(4) Reciprocity	3c
(5) Sensitivity	3c
(6) Color Contrast	3c
(7) Latent image stability	3c
b. Color printing techniques	
(1) Projection methods	3c
(2) Contact methods	3c
(3) Cropping	3c
(4) Vignetting	3c

KNOWLEDGE OR TASK AND EXTENT OF TRAINING	
(5) Dodging	3c
(6) Filtration	3c
(7) Print finishing	3c
c. Equipment requirements for color printing	
(1) Printing devices	3c
(2) Timing devices	3c
(3) Filtering devices	3c
(4) Voltage controllers	3c
(5) Color analyzers	3c
4. APPLY THE PRINCIPLES, TECHNIQUES AND PROCEDURES FOR COLOR DUPLICATION	
a. Duplicating film characteristics	
(1) Structure	2b
(2) Speed	3b
(3) Latitude	3b
(4) Reciprocity	3b
(5) Sensitivity	2b
(6) Color contrast	3b
(7) Color saturation	3b
(8) Latent image stability	3b
b. Color duplicating techniques	
(1) Silver masking	3b
(2) Enlarging	3b

KNOWLEDGE OR TASK AND EXTENT OF TRAINING	
(3) Reducing	3b
(4) Cropping	3b
(5) Distortion control	3b
(6) Color saturation	3b
(7) Color contrast	3b
(8) Mounting and finishing	3b
c. Equipment requirements for color duplication	
(1) Cameras	3b
(2) Printers	3b
(3) Duplicators	3b
(4) Light sources	3b
(5) Filtration	3b
5. APPLY THE PRINCIPLES, TECHNIQUES AND PROCEDURES FOR COLOR PROCESSING	
a. Tank processing	3c
b. Tray processing	3c
c. Gaseous burst systems	3c
d. Processing chemistry	
(1) Developer	3c
(2) Short stop	3c
(3) Hardener	3c
(4) Bleach	3c

KNOWLEDGE OR TASK AND EXTENT OR TRAINING	
(5) Fixing bath	3c
(6) Clearing bath	3c
(7) Stabilizing bath	3c
6. APPLY THE PRINCIPLES, TECHNIQUES AND PROCEDURES FOR COLOR QUALITY CONTROL	
a. Mathematics for color quality control	
(1) Logarithms	2c
(2) Transmission	2c
(3) Opacity	2c
(4) Density	2c
b. Sensitometric exposure of control strips	
(1) Exposure standards	2c
(2) Equipment requirements	2c
c. Densitometric measurement of control strips	
(1) Visual densitometers	2c
(2) Photoelectric densitometers	2c
(3) Reading white light density	2c
(4) Reading color density	2c
d. Construction of color characteristic curves	
(1) D Log E	2b
(2) Density vs density	2b
e. Analysis of color characteristic curves	
(1) Color density	2b

KNOWLEDGE OF TASK AND EXTENT OF TRAINING	
(2) Color contrast	2b
(3) Highlight contrast	2b
(4) Control patch density	2b
f. Color processing quality control	
(1) Solution pH	2c
(2) Substitution testing	2c
(3) Time control	2c
(4) Temperature control	2c
(5) Agitation control	2c
(6) Replenishment	2c

Appendix IV.

COURSE CHART

COURSE CHART	NUMBER ABR32330G	DATE 13 October 1965 (R3)
OPR & APPROVAL DATE, ATC ATTAT-B 19 January 1965		SUPERSEDES COURSE CHART ABR32330G 25 May 1965 (R2)
OPR, CENTER Department of Avionics Training		

TABLE I – COURSE DATA

COURSE TITLE Defensive Fire Control Systems Mechanic (A-3A, MD-9, ASG-15 Turrets)	
ORGANIZATION Lowry Technical Training Center	
LOCATION OF COURSE Lowry AFB, Colorado	COURSE TYPE III - Airman Basic ATC Resident School Course
COURSE DURATION 39 Weeks Includes 1 week commander's time and 2 weeks mid-course leave	INSTRUCTIONAL HOURS Military: See Remarks — - Technical — 1080 TOTAL — 1080
COURSE SECURITY CLASSIFICATION CONFIDENTIAL	NON-ACADEMIC HOURS Commander's Time — 30 Mid-Course Leave — 60 TOTAL — 90
APPLICABLE TRAINING STANDARD JTS 32330G/50G/70G, 17 March 1965	

REMARKS

See ATCR 50-6, Airman Continuation Military Training

Classes conducted in CONTROLLED ACCESS area. Course materials include 18 weeks UNCL. and 18 weeks CONF.

TABLE II – MAJOR ITEMS OF EQUIPMENT

System Trainers: A-3A/MD-9/ASG-15 FCS.

Test Equipment: In-flight Evaluator Operator, In-flight Evaluator Armament. Standard electronic fundamentals training equipment is listed in Course Chart AQR32020.

ATC FORM 449 SEP 63 PREVIOUS EDITIONS OBSOLETE.

TABLE III - COURSE CONTENT - COURSE CHART ABR32330G

HOURS PER DAY / WEEKS	1	2	3	4	5	6
1	Non-Academic (Commander's Time)					
2 thru 19	Course Material - UNCLASSIFIED BLOCKS I-IX - Basic Electronics 540 Hours Students assigned to Course AQR32020, ATC Standardized Electronic Principles (ETV).					
20 21	Non-Academic (Mid-Course Leave)					
22 23 24	Course Material - CONFIDENTIAL BLOCK X - Normal Modes 90 Hours Orientation (3 hrs)(U); Air Force publications (6 hrs)(U); Maintenance management (6 hrs)(U); Air Force security (6 hrs)(U); Introduction to defensive fire control systems maintenance (9 hrs)(C); Warm-up mode (6 hrs)(C); On-mode (12 hrs)(C); Search mode (12 hrs)(C); Acquisition mode (12 hrs)(C); Radar track and second-target mode (12 hrs)(C); Measurement (6 hrs)(C). (Above titles are unclassified)					
25 26	Course Material - CONFIDENTIAL BLOCK XI - Alternate Modes 60 Hours Manual track radar range mode (3 hrs)(C); Manual track manual range mode (9 hrs)(C); Emergency modes (18 hrs)(C); Emergency search modes (15 hrs)(C); In-limits modes (9 hrs)(C); Measurement (6 hrs)(C). (Above titles are unclassified)					
27 28	Course Material - CONFIDENTIAL BLOCK XII - Computer Data Flow 60 Hours Introduction to computing system and gunnery problem (12 hrs)(C); Computer input servos (18 hrs)(C); Ballistics circuit and squaring servo (9 hrs)(C); Spherical correction circuit and prediction servo loop (9 hrs)(C); Turret drive and computer tie-in (6 hrs)(C); Measurement (6 hrs)(C). (Above titles are unclassified)					

ATC FORM 449A SEP 63 PREVIOUS EDITIONS OBSOLETE.

TABLE III – COURSE CONTENT – COURSE CHART ABR32330G

HOURS PER DAY / WEEKS	1 2 3 4 5 6
29 30	Course Material - CONFIDENTIAL BLOCK XIII - Search Radar Data Flow — 54 Hours Description of search radar (6 hrs)(C); Search transmitting loop (12 hrs)(C); Search receiving loop (13 hrs)(C); Search indicating loop (18 hrs)(C); Measurement (5 hrs)(C). (Above titles are unclassified)
30 31	Course Material - CONFIDENTIAL BLOCK XIV - Track Radar Data Flow — 36 Hours Description of track radar (3 hrs)(C); Track radar transmitting loop (3 hrs)(C); Track radar receiving and tracking loop (26 hrs)(C); Measurement (4 hrs)(C). (Above titles are unclassified)
32 33	Course Material - CONFIDENTIAL BLOCK XV - Evaluators — 60 Hours In-flight operator evaluator analysis (12 hrs)(U); In-flight operator evaluator tape reading (3 hrs)(U); In-flight operator evaluator operation (12 hrs)(C); In-flight armament evaluator analysis (12 hrs)(U); In-flight armament evaluator tape reading (3 hrs)(U); In-flight armament evaluator operation(12 hrs)(C); Measurement (6 hrs)(C). (Above titles are unclassified)
34 35	Course Material - CONFIDENTIAL BLOCK XVI - Tools, Test Equipment and System Tests and Adjustments — 36 Hours Tools and test equipment (4 hrs)(C); Operational check-out (10 hrs)(C); Turret servo amplifier and hydraulic valve test and adjustments (6 hrs)(C); Gyro zeroing (6 hrs)(C); Turret position limiting tests and adjustments (3 hrs)(C); Hydraulic system checks (3 hrs)(C); Measurement (4 hrs)(C). (Above titles are unclassified)

ATC FORM SEP 63 449A PREVIOUS EDITIONS OBSOLETE.

TABLE III – COURSE CONTENT – COURSE CHART ABR32330G

HOURS PER DAY / WEEKS	1 2 3 4 5 6
	Course Material - CONFIDENTIAL BLOCK XVII - Radar and Computer Tests and Adjustments — 54 Hours
35 36	Search radar tests and adjustments (21 hrs)(C); Track radar tests and adjustments (21 hrs)(C); Computer static problems (6 hrs)(C); Measurement (6 hrs)(C). (Above titles are unclassified)
	Course Material - CONFIDENTIAL BLOCK XVIII - Removal and Installation of Components — 36 Hours
37 38	Elevation hydraulic pump and drive motor (14 hrs)(C); Azimuth and elevation data units (12 hrs)(C); Plug-in units (3 hrs)(C); Gyros (3 hrs)(C); Measurement (4 hrs)(C). (Above titles are unclassified)
	Course Material - CONFIDENTIAL BLOCK XIX - Integration Tests and 50 Caliber Machine Guns — 54 Hours
38 39	Caliber 50 machine guns, removal, repair and installation (18 hrs)(C); Arming and dearming (6 hrs)(C); Component integration tests (18 hrs)(C); System harmonization (6 hrs)(C); Measurement (6 hrs)(C). (Above titles are unclassified)

ATC FORM SEP 63 449A PREVIOUS EDITIONS OBSOLETE.

Appendix V.

PLAN OF INSTRUCTION

PLAN OF INSTRUCTION

(Technical Training)

WEAPON CONTROL SYSTEMS MECHANIC (F4, AMCS)

LOWRY TECHNICAL TRAINING CENTER

9 March 1967

PLAN OF INSTRUCTION
NUMBER ABR32231P

3415TH TECHNICAL SCHOOL, USAF
LOWRY TECHNICAL TRAINING CENTER (ATC)
LOWRY AIR FORCE BASE, COLORADO
9 March 1967

FOREWORD

1. PURPOSE. This plan of instruction prescribes the qualitative requirements for Course ABR32231P, Weapon Control System Mechanic (F4, AMCS), in terms of specific learning objectives, listed in the preferred teaching sequence by units of instruction. It shows teaching level, time allocation, type of presentation, references, training standard correlation, major equipment and training aids used, and general guidance for the instructor.

2. COURSE DESCRIPTION. The course trains airmen to perform duties prescribed in AFM 39-1 for Weapon Control System Mechanic, semiskilled, AFSC 32231; to trace data flow and analyze and trace functional diagrams; troubleshoot, isolate and repair malfunctions; perform operational checks, alignments and replacement procedures; use associated test equipment; exercise safety precautions around electronic equipment, radioactive tubes, and high frequency radiation hazards; utilize technical publications and maintenance forms, F-4D AIRCRAFT.

3. COURSE STRUCTURE. Pages ii, iii, and iv identify blocks (major subject areas) of instruction, units of instruction and time allocation.

4. EQUIPMENT ALLOWANCE AND AUTHORIZATION. Training equipment authorizations for this course are listed in E-AID ABR32231P000. Training equipment authorizations for this course are based on Tables of Allowance as authorized by AFR 0-10/ATCSUP 1.

5. REFERENCES. This plan of instruction is based on JOB TRAINING STANDARD 32231P/51P/71P, 15 November 1966, and COURSE CHART, 9 March 1967. JTS items 9a through 9d are completed in Course AQR32020, and therefore are not shown in this plan of instruction.

APPROVED:

Edwin M Miller

EDWIN M. MILLER, Colonel, USAF
Chief
Operations Division

This replaces Plan of Instruction ABR32231P, 1 June 1966, Change, 21 November 1966, and Volume I of III, 1 February 1967.
OPR: Department of Avionics Training
DISTRIBUTION: As directed by ATCR 52-7 and related local directives.

TABLE III – COURSE CONTENT – COURSE CHART ABR32231P

HOURS PER DAY / WEEKS	1 2 3 4 5 6
1	Nonacademic (Commander's time)
2 thru 11	Course Material - UNCLASSIFIED BLOCK I - IV - Course Nr AQR32020, ATC Standardized Electronic Principles (ETV) 300 Hours
12 13	Nonacademic (Mid-course leave)
	BLOCKS V thru IX not used
14 15	Course Material - CONFIDENTIAL BLOCK X - Introduction to the Weapon Control System (WCS) 42 Hours Orientation (3 hrs)(U); System technical publications (3 hrs)(C); F4-WCS familiarization (18 hrs)(C); Component location and identification (14 hrs)(C); Weapon loads and configurations (1 hr)(C). Measurement (3 hrs)(C). (Above titles are unclassified)
15 16 17	Course Material - CONFIDENTIAL BLOCK XI - Theory of the AN/APQ-109 - Part I 60 Hours Introduction to the AN/APQ-109 (3 hrs)(C). Functional analysis of the: Low voltage DC power (3 hrs) (U); Transmitting system (21 hrs)(C); Electrical frequency control (18 hrs)(U); Receiving system (12 hrs)(C); Measurement (3 hrs)(C). (Above titles are unclassified)
17 18 19	Course Material - CONFIDENTIAL BLOCK XII - Theory of the AN/APQ-109 - Part II 60 Hours Functional analysis of the: Receiver gain control system (12 hrs)(C); Range track system (18 hrs)(C); Antenna (9 hrs)(C); Antenna stabilization (3 hrs)(C); Angle search (6 hrs)(C); Angle track (9 hrs)(C). Measurement (3 hrs)(C). (Above titles are unclassified)
19 20 21	Course Material - CONFIDENTIAL BLOCK XIII - Theory of the AN/APQ-109 - Part III 60 Hours Description of the display system (3 hrs)(C). Functional analysis of the: Indicators (12 hrs)(C); Indicator Control Unit (ICU) - "A" gun (15 hrs) (C); ICU - "B" gun (27 hrs)(C). Measurement (3 hrs)(C). (Above titles are unclassified)

ATC FORM 449A SEP 63 PREVIOUS EDITIONS OBSOLETE.

9 March 1967

TABLE III – COURSE CONTENT – COURSE CHART ABR32231P

HOURS PER DAY / WEEKS	1 2 3 4 5 6
  21 22	Course Material - CONFIDENTIAL BLOCK XIV - Theory of the AN/APA-165 48 Hours Introduction to the AN/APA-165 (3 hrs) (C). Functional analysis of the: Modulator (21 hrs)(C); Transmitter and waveguide (12 hrs)(C); Closing velocity and simulated doppler (6 hrs)(C); Tuning drive (3 hrs)(C). Measurement (3 hrs)(C). (Above titles are unclassified)
  23 24	Course Material - CONFIDENTIAL BLOCK XV - Theory of the AN/APA-165 and Missile Firing Circuits 48 Hours Functional analysis of the: Range computer (6 hrs)(C); Lead angle error (LAE) computer (6 hrs)(C); Allowable steering error (ASE) computer (6 hrs)(C); Head aim computer (6 hrs)(C); Missile firing circuits (21 hrs)(C). Measurement (3 hrs)(C). (Above titles are unclassified)
  24 25 26	Course Material - UNCLASSIFIED BLOCK XVI - Theory of the AN/ASG-22 and the AN/ASQ-91 48 Hours Introduction to the AN/ASG-22 Lead Computing Optical Sight System (LCOSS) (3 hrs). Description and operational characteristics of the: Optical sight and lead computing gyroscope (3 hrs). Functional analysis of the servo loops (6 hrs). Introduction to the AN/ASQ-91 Weapons Release Computer Set (WRCS) (3 hrs). Functional analysis of the following modes: Laydown (3 hrs); Dive laydown (3 hrs); Dive toss (6 hrs); Target find and offset bomb (9 hrs); Missile (9 hrs). Measurement (3 hrs).
  26	Course Material - CONFIDENTIAL BLOCK XVII - Theory of Built-In-Tests 24 Hours Functional analysis of the following built-in-tests: AN/APQ-109 and AN/APA-165 (15 hrs)(C); AN/ASG-22 and AN/ASQ-91 (6 hrs) (U). Measurement (3 hrs) (C). (Above titles are unclassified)
  27 28	Course Material - CONFIDENTIAL BLOCK XVIII - Maintenance Procedures - Part I 48 Hours Equipment orientation (3 hrs)(C). Checks, alignments and troubleshooting procedures of the AN/APQ-109: Low voltage power supply (LVPS)(3 hrs)(U); Modulator and transmitter (9 hrs)(C); Electrical frequency control (6 hrs)(C); Receiver control and noise loop (9 hrs)(C); Range track (12 hrs) (C). Measurement (6 hrs)(C). (Above titles are unclassified)

ATC FORM 449A SEP 63 PREVIOUS EDITIONS OBSOLETE.

TABLE III – COURSE CONTENT – COURSE CHART ABR32231P

HOURS PER DAY / WEEKS	1 2 3 4 5 6
	Course Material - CONFIDENTIAL BLOCK XIX - Maintenance Procedures - Part II 60 Hours
28 29 30	Checks, alignments and troubleshooting procedures of the AN/APQ-109: Angle search and track (12 hrs)(C); Indicators (15 hrs)(C); ICU - "A" gun (15 hrs)(C); ICU - "B" gun (12 hrs)(C). Measurement (6 hrs)(C). (Above titles are unclassified)
	Course Material - CONFIDENTIAL BLOCK XX - Maintenance Procedures - Part III 72 Hours
30 31 32	Checks, alignments and troubleshooting procedures of the AN/APA-165: Transmitter and modulator (6 hrs)(C); Target intercept computer (9 hrs) (C). Checks and troubleshooting procedures of the: Missile firing circuits (9 hrs)(C); AN/ASG-22 LCOSS and AN/ASQ-91 WRCS (9 hrs)(U). Maintenance management (12 hrs)(U). AF technical order system and course critique (3 hrs)(U). Built-in tests (12 hrs)(C). Measurement (6 hrs) (C). Inspection system and graduation (6 hrs)(U). (Above titles are unclassified)

ATC FORM 449 A SEP 63 PREVIOUS EDITIONS OBSOLETE.

9 March 1967

PLAN OF INSTRUCTION
(Technical Training)

COURSE TITLE: Weapon Control System Mechanic (F4, AMCS)

BLOCK TITLE: Introduction to the Weapon Control System (WCS)

STATEMENT OF LEARNING OBJECTIVES (A)	DURATION (HOURS) (B)	TRAINING STANDARD CORRELATION: STUDY REFERENCES: EQUIPMENT & TRAINING AIDS: INSTRUCTIONAL GUIDANCE (C)
1. Orientation a. Introduction (1) Technical school policies (2) Department policies (3) Branch policies (4) Airman classification system (5) Weapon control system ladder b. Identify all aspects of security as stated in the programmed security package (70% accuracy). (Outside study assignment to be completed prior to the end of the block) c. State safety procedures as defined in SSG/WB ABR32231P-1 around (1) Aircraft (2) Electronic equipment (3) Ground power equipment (4) Armed aircraft d. Prove an understanding of organizational policies, student responsibilities, security, safety, airman classification system, and weapon control system ladder by correctly completing the missions in SSG/WB ABR32231P-1 (75% accuracy) and correctly answering 70% of the applicable questions in the study question booklet and those posed by the instructor	3	TRAINING STANDARD CORRELATION JTS / CODE / JTS / CODE 1a, b / A / 3a / B 1c(1) / A / 3b / A 1c(2) / B / 3c / B 1c(3) (a), (b) / A / 3d(1) / b 1c(3) (c), (d) / B / 3d(2) / 2b 2 / 1a / 3d(3),(4) / b 6b(1) / A REFERENCES SSG/WB ABR32231P-1, Orientation SSG BT2, Orientation Programmed Security Package Study Question Booklet for Block X FR287/MP, TAC Evaluation of the F-110A Dual Channel Concept of Training Introduction to Measurement and Its Purpose INSTRUCTIONAL GUIDANCE Discussion (70%): Organizational policies and student responsibilities Demonstration (15%): Explain security procedures and explain how the students will accomplish the programmed security package. Show training film Performance (15%): Completion of training objectives using SSG/WB ABR32231P-1

PLAN OF INSTRUCTION (Continued)

NO.	STATEMENT OF LEARNING OBJECTIVES	DURATION (HOURS)	TRAINING STANDARD CORRELATION, STUDY REFERENCES, EQUIPMENT & TRAINING AIDS, INSTRUCTIONAL GUIDANCE
2.	System Technical Publications a. Identifies the technical orders (TOs) peculiar to the F4-WCS (80% accuracy) to include: (1) 1F-4D-2-19 (2) 1F-4D-2-33 (3) 12P2-2APQ109-2-1 (4) 12P2-2APQ109-2-2 (5) 12P2-2APQ109-2-3 (6) 12P2-2APQ109-2-4 (7) 12P2-2APQ109-2-5 (8) 12P2-2APQ109-2-6 (9) 12P2-2APQ109-2-7 (10) 12P2-2APQ109-2-8 (11) 12P2-2APA165-2 b. Correctly completes the missions in SSG/WB ABR32231P-2 (85% accuracy) and correctly answers 85% of the applicable questions in the study question booklet, and those posed by the instructor, to check his understanding of the system TOs	3	TRAINING STANDARD CORRELATION JTS — CODE 2 — 1a 4f(4), (5) — 2b 4i — 2b REFERENCES SSG/WB ABR32231P-2, System Technical Publications Study Question Booklet for Block X TO 1F-4D-2-19, Maintenance Instructions Fire Control System TO 1F-4D-2-33, Maintenance Instructions Weapons Release Computer and Optical Sight Systems TO 12P2-2APQ109-2-1, AN/APQ109 Radar Set, General Information TO 12P2-2APQ109-2-2, AN/APQ109 Radar Set, System Checkout or Analysis TO 12P2-2APQ109-2-3, AN/APQ109 Radar Set, Receiver-Transmitter TO 12P2-2APQ109-2-4, AN/APQ109 Radar Set, Electrical Synchronizer TO 12P2-2APQ109-2-5, AN/APQ109 Radar Set, Control Power Supply TO 12P2-2APQ109-2-6, AN/APQ109 Radar Set, Antenna TO 12P2-2APQ109-2-7, AN/APQ109 Radar Set, Indicator Control TO 12P2-2APQ109-2-8, AN/APQ109 Radar Set, AZ-EL Range Indicators, Radar Set Control Auxiliary Radar Set Control, Antenna Control, Auxiliary Equipment

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PLAN OF INSTRUCTION (Continued)

STATEMENT OF LEARNING OBJECTIVES	DURATION (HOURS)	TRAINING STANDARD CORRELATION/STUDY REFERENCES/EQUIPMENT & TRAINING AIDS/INSTRUCTIONAL GUIDANCE
		TO 12P2-2APA165-2, Radar Set Group AN/APA-165
		INSTRUCTIONAL GUIDANCE Discussion (60%: System TOs Demonstration (15%): How to use TOs Performance (25%): Completion of training objectives using SSG/WB ABR32231P-2
3. F4-WCS Familiarization	18	**TRAINING STANDARD CORRELATION**
a. Using AFM 101-8, orally describe the principles of radar	(6)	JTS — CODE 2 — 1a 3a — B 11y — 1a 12a — B 12b — a 13a,b,c,d,e,f,g — A
(1) Pulse radar system (a) Basic elements (b) Pulse characteristics (2) CW radar system		
b. Using TOs 1F-4D-2-19 and 1F-4D-2-33, orally describes the purpose and methods of operation of the WCS to include: (1) AN/APQ-109 Radar Set (2) AN/APQ-165 Radar Set Group (3) Missile firing circuits (4) AN/ASG-22 Lead Computing Optical Sight System (LCOSS) (5) AN/ASQ-91 Weapons Release Computer Set (WRCS)	(3)	**REFERENCES** SSG/WB ABR32231P-3, F4-WCS Familiarization TO 1F-4D-2-19, Maintenance Instructions, Fire Control System TO 1F-4D-2-33, Maintenance Instructions, Weapons Release Computer and Optical Sight Systems
c. Using TOs 1F-4D-2-19 and 1F-4D-2-33, identifies each unit of the WCS and orally describes its basic function and aircraft locations (1) AN/APQ-109 Radar Set (a) Antenna (b) Antenna mounting (c) Electrical Synchronizer (d) Control power supply	(3)	AFM 101-8, Fundamentals of Electronics Study Question Booklet for Block X **EQUIPMENT AND TRAINING AIDS** Transparencies for Block X TF 1-5383, Principles of Radar **INSTRUCTIONAL GUIDANCE** Discussion (60%): Principles of radar, purpose, method of operation, description of each WCS unit and test equipment

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PLAN OF INSTRUCTION (Continued)

(A) STATEMENT OF LEARNING OBJECTIVES	(B) DURATION (HOURS)	(C) TRAINING STANDARD CORRELATION: STUDY REFERENCES: EQUIPMENT & TRAINING AIDS: INSTRUCTIONAL GUIDANCE
(e) Receiver-transmitter (f) Azimuth-elevation-range indicator (pilots) (g) Azimuth-elevation-range indicator (radar pilots) (h) Antenna Control (i) Voltage monitor (j) Radar set control (k) Auxiliary radar set control (l) Indicator control (m) Desiccant dehydrator (n) Electrical equipment rack (o) Radar set group mounting (p) Special purpose electrical cable assembly (2) AN/APA-165 Radar Set Group (a) Transmitter (b) Modulator (c) Target intercept computer (d) Tuning Drive TG-75 (e) Waveguide components (3) Missile firing circuits (a) Armament control relay panel assembly (b) Missile control panel (c) Missile status panel (d) Trigger switch (e) Magnetic sequencing switch (f) Airborne missile control system subsystem (AMCSS) (g) Auxiliary armament control panel (4) AN/ASG-22 LCOSS (a) Optical display unit (b) Lead computing amplifier (c) Lead computing gyroscope (d) Gyroscope mount		Demonstration (20%): Describe aircraft location of WCS units and type of test equipment using aircraft TOs and transparencies, show training film Performance (20%): Completion of training objectives using SSG/WB ABR32231P-3

PLAN OF INSTRUCTION (Continued)

(A) STATEMENT OF LEARNING OBJECTIVES	(B) DURATION (HOURS)	(C) TRAINING STANDARD CORRELATION; STUDY REFERENCES; EQUIPMENT & TRAINING AIDS; INSTRUCTIONAL GUIDANCE
(5) AN/ASQ-91 WRCS (a) Ballistic computer (b) Computer-control (c) Computer-cursor control		
d. Identifies and orally describes the functions of the associated aircraft equipment applicable to the WCS as defined in SSG/WB ABR32231P-3 (1) Cooling air and pressurization (2) Electrical power system (3) Hydraulic system (4) Air data computer (ADC) (5) Inertial Navigation System, AN/ASN-63 (INS) (6) Attitude Reference and Bombing Computer Set, AN/AJB-7 (ARBCS)	(2)	
e. Orally explains the AN/AWM-26 Missile Control System (MCS) test set as described in SSG/WB ABR32231P-3 and TO 1F-4D-2-19 (60% accuracy) (1) Equipment (2) Aircraft connections	(1)	
f. Correctly completes the missions in SSG/WB ABR32231P-3 (95% accuracy) and correctly answers 90% of the applicable questions in the study question booklet and those posed by the instructor to confirm a familiarity of the F4-WCS	(3)	
4. <u>Component Location and Identification</u>	14	TRAINING STANDARD CORRELATION
a. Physically locates each major unit and subassembly on the WCS trainer (LT-36) and orally explains the function of each as stated in TOs 1F-4D-2-19 and 1F-4D-2-33	(4)	See table below

TRAINING STANDARD CORRELATION

JTS	CODE	JTS	CODE
2	1a	11x	2b
3a	B	11y	1a
3d(1)	b	11aa	2b
3d(2)	2b	11ab	2b
3d(3), (4)	b	11ac	2b

PLAN OF INSTRUCTION (Continued)

STATEMENT OF LEARNING OBJECTIVES (a)	DURATION (HOURS) (b)	TRAINING STANDARD CORRELATION: STUDY REFERENCES: EQUIPMENT & TRAINING AIDS: INSTRUCTIONAL GUIDANCE (c)
(1) AN/APQ-109 Radar Set (a) Antenna (b) Antenna mounting (c) Electrical synchronizer (d) Control power supply (e) Radar receiver-transmitter (f) Azimuth-elevation-range indicator (pilots) (g) Azimuth-elevation-range indicator (radar pilots) (h) Antenna control (i) Voltage monitor (j) Radar set control (k) Auxiliary radar set control (l) Indicator control (m) Desiccant dehydrator (n) Electrical equipment rack (o) Radar set group mounting (p) Special purpose electrical cable assembly (2) AN/APA-165, Radar Set Group (a) Transmitter (b) Modulator (c) Target intercept computer (d) Tuning Drive TG-75 (e) Waveguide components (3) Missile firing circuits (a) Missile control panel (b) Missile status panel (c) AMCSS (d) Magnetic sequencing switch (e) Armament control relay panel assembly (f) Auxiliary armament control panel		4f(4), (5) 2b 11ad a 11a 2b 11ae 1a 11d a 12a B 11e a 13a, b, c A 11f 2b 13g A 11k a 14j(2) 2b 11o, p 2b 15f(2) 2b 11r 2b 17d(2) 2b REFERENCES SSG/WB ABR32231P-4, Component Location and Identification TO 1F-4D-2-19, Maintenance Instructions Fire Control System TO 1F-4D-2-33, Maintenance Instructions Weapons Release Computer and Optical Sight Systems Study Question Booklet for Block X EQUIPMENT AND TRAINING AIDS WCS Trainer LT-36 (3) MCS Test Set, AN/AWM-26 (3) INSTRUCTIONAL GUIDANCE Discussion (10%): Identification of WCS units and test equipment Demonstration (30%): Trainer location of WCS units; AN/AWM-26 Test Set equipment location; System operating procedures Performance (60%): Completion of training objectives using SSG/WB ABR32231P-4

PLAN OF INSTRUCTION (Continued)

STATEMENT OF LEARNING OBJECTIVES (a)	DURATION (HOURS) (b)	TRAINING STANDARD CORRELATION: STUDY REFERENCES: EQUIPMENT & TRAINING AIDS: INSTRUCTIONAL GUIDANCE (c)
(4) AN/ASG-22 LCOSS (a) Optical sight unit (b) Lead computing amplifier (c) Lead computing gyroscope (d) Gyroscope mount (5) AN/ASQ-91 WRCS (a) Ballistic computer (b) Computer-control (c) Computer-cursor control (6) Associated aircraft equipment (a) LABS/WPR REL switch (b) Pedestal assembly (c) Angle of attack indexer lights (d) Attitude director indicator (e) Horizontal situation indicator (f) Bearing-distance-heading indicator (g) Mode selector control (h) BDHI mode select switch (i) Bomb release switch (j) Pull-up light		
b. Physically locates each unit on the AN/AWM-26 MCS and orally explains the function of each (60% accuracy) as stated in SSG/WB ABR32231P-3 and TO 1F-4D-2-19, and as explained by the instructor (1) Hydraulic pumping unit (2) Air Cooler (3) Compressor-dehydrator (4) Control Monitor, AWM-18A (5) Pallet coolers (6) RF power test set (7) Fire control test set (8) Radar modulator test set (9) Test set radar	(1.5)	

PLAN OF INSTRUCTION (Continued)

(A) STATEMENT OF LEARNING OBJECTIVES	(B) DURATION (HOURS)	(C) TRAINING STANDARD CORRELATION: STUDY REFERENCES: EQUIPMENT & TRAINING AIDS; INSTRUCTIONAL GUIDANCE
(10) Flight line analyzer (11) Missile interface test set (12) Boresight Telescope GPM-14 (13) Multimeter, PSM-6 (14) Electronic Multimeter, ME-6D/U (15) Cathode Ray Oscilloscope, AN/USM-105A (16) Antenna position simulator (17) Accessories kit c. Physically locates the switches and controls of the WCS trainer (LT-36) and explains the function of each (85% accuracy) as stated in TOs 1F-4D-2-19 and 1F-4D-2-33 (1) Radar set control unit (2) Auxiliary radar set control unit (3) Antenna control unit (4) Voltage monitor (5) Radar pilots indicator (6) Pilots indicator (7) Missile control panel (8) Missile status panel (9) Computer-control unit (10) Computer-cursor control unit (11) Pedestal assembly (12) Mode selector control unit (13) BDHI mode select switch (14) Auxiliary armament panel (15) Simulated aircraft switches (16) Pilots and radar pilots control sticks	(4)	

PLAN OF INSTRUCTION (Continued)

(A) STATEMENT OF LEARNING OBJECTIVES	(B) DURATION (HOURS)	(C) TRAINING STANDARD CORRELATION; STUDY REFERENCES; EQUIPMENT & TRAINING AIDS; INSTRUCTIONAL GUIDANCE
d. Observes trainer operation demonstrated by the instructor (1) Safety precautions (2) Extending nose package and lowering pallets (3) Search operation (4) Acquisition (5) Track (6) AN/ASG-22 operation (7) AN/ASQ-91 operation (8) Built-in-tests (BITS) (9) Trainer simulator operation (10) Using TOs 1F-4D-2-19 and 1F-4D-2-33, recognizes and explains indicator displays (75% accuracy)	(1.5)	
e. Correctly completes the missions in SSG/WB ABR32231P-4 (85% accuracy) and correctly answers 80% of the applicable questions in the study question booklet and those posed by the instructor to demonstrate a basic knowledge of the F4-WCS	(3)	
5. Weapon Loads and Configurations a. Recognizes the weapon loads and configurations peculiar to the F4-WCS as listed in SSG/WB ABR32231P-5 (1) AIM-7D/7E (2) AIM-4D (3) AGM-45 (4) Walleye (5) Bombs (6) Guns	1	TRAINING STANDARD CORRELATION JTS 2 – CODE 1a; JTS 11s – CODE b JTS 3a – CODE B; JTS 11t – CODE 2b JTS 3d(1) – CODE b; JTS 11ac – CODE 2b JTS 3d(2) – CODE 2b; JTS 11ad – CODE a JTS 3d(3), (4) – CODE b; JTS 13h – CODE A

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PLAN OF INSTRUCTION (Continued)

STATEMENT OF LEARNING OBJECTIVES (A)	DURATION (HOURS) (B)	TRAINING STANDARD CORRELATION: STUDY REFERENCES: EQUIPMENT & TRAINING AIDS; INSTRUCTIONAL GUIDANCE (C)
b. Describes the test equipment used for weapons peculiar to the WCS as defined in SSG/WB ABR32231P-5 (1) AN/AWM-19/20 test set (2) Missile interface test set (MITS) (3) Missile adapter tester (MAT) (4) AN/ASM-184, Weapon Control Test Set c. Correctly completes the missions in SSG/WB ABR32231P-5 (75% accuracy) and correctly answers 80% of the applicable questions in the study questions booklet and those posed by the instructor to show an understanding of the weapon loads and configurations peculiar to the F4-WCS		<u>REFERENCES</u> SSG/WB ABR32231P-5, Weapon Loads and Configurations Study Question Booklet for Block X <u>INSTRUCTIONAL GUIDANCE</u> Discussion (70%): Weapon loads and configurations and test equipment Performance (30%): Completion of the training objectives using SSG/WB ABR32231P-5
6. <u>Measurement</u>	3	
a. Performance test	(2)	
b. Test critique	(1)	

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PLAN OF INSTRUCTION
(Technical Training)

COURSE TITLE: Weapon Control System Mechanic (F4, AMCS)

BLOCK TITLE: Theory of the AN/APQ-109 - Part I

STATEMENT OF LEARNING OBJECTIVES (A)	DURATION (HOURS) (B)	TRAINING STANDARD CORRELATION: STUDY REFERENCES: EQUIPMENT & TRAINING AIDS: INSTRUCTIONAL GUIDANCE (C)
1. Introduction to the AN/APQ-109 a. Describes the AN/APQ-109 prinicples of operation as defined in TO 12P? -2APQ109-2-1 (1) Air-to-air (2) Air-to-ground b. Orally describes the AN/APQ-109 Radar functional loops (80% accuracy) as specified in TO 12P2-2APQ109-2-1 (1) Transmitting system (2) Receiving system (3) Electrical frequency control (EFC) (4) Automatic gain control (AGC) (5) Range track system (6) Antenna servo loop (7) Display system (8) Power supplies (9) BITs c. Explains the purpose of each of the functional loop signals (80% accuracy) while analyzing the AN/APQ-109 block diagram in TO 12P2-2APQ109-2-1 (1) Transmitter (2) Receiver (3) EFC (4) AGC (5) Range Track (6) Display (7) Control Circuits (8) Antenna servo (9) Stabilization	3	TRAINING STANDARD CORRELATION JTS — CODE 2 — 1a 3a — B 41 — 2b 12a — B REFERENCES SSG/WB ABR32231P-6, Introduction to the AN/APQ-109 TO 12P2-2APQ109-2-1, AN/APQ-109 Radar Set, General Information Study question Booklet for Block XI EQUIPMENT AND TRAINING AIDS Transparencies for Block XI INSTRUCTIONAL GUIDANCE Discussion (60%): Principles of operation; Functional loops and signals Demonstration (20%): Analysis of functional loops using applicable diagrams Performance (20%): Completion of training objectives using SSG/WB ABR32231P-6

PLAN OF INSTRUCTION (Continued)

STATEMENT OF LEARNING OBJECTIVES (A)	DURATION (HOURS) (B)	TRAINING STANDARD CORRELATION: STUDY REFERENCES: EQUIPMENT & TRAINING AIDS; INSTRUCTIONAL GUIDANCE (C)
d. Correctly completes the missions in SSG/WB ABR32231P-6 (85% accuracy) and correctly answers 85% of the applicable questions in the study question booklet and those posed by the instructor to prove an understanding of the AN/APQ-109		
2. Low Voltage DC Power a. Describes the low voltage power supply (LVPS) (85% accuracy) as specified in TO 12P2-2APQ109-2-1 (1) Voltage outputs (2) Reference voltage (3) Time delay circuit (4) Loss protection circuits (5) B-volts switch b. Traces and analyzes the LVPS circuit networks on the DC power distribution diagram (90% accuracy) in TO 1F-4D-2-19 and the circuit networks of the power supply schematic (95% accuracy) in the AN/APQ-109 schematic booklet (1) DC power application (2) AC power application (3) Relay circuits (4) Voltage regulators (5) DC power to major units c. Correctly completes the missions in SSG/WB ABR32231P-7 (85% accuracy) and correctly answers 85% of the applicable questions in the study question booklet, and those posed by the instructor, to check his under standing of the low voltage DC power	3	TRAINING STANDARD CORRELATION JTS — CODE 2 — 1a 3a — B 4f(4) — 2b 4i — 2b 12a — B 13a — A 14a(1) — B REFERENCES SSG/WB ABR32231P-7, Low Voltage DC Power TO 1F-4D-2-19, Maintenance Instructions Fire Control System TO 12P2-2APQ109-2-1, AN/APQ-109 Radar Set, General Information AN/APQ-109, Schematic Diagram Booklet Study question Booklet for Block XI EQUIPMENT AND TRAINING AIDS Transparencies for Block XI

PLAN OF INSTRUCTION (Continued)

(A) STATEMENT OF LEARNING OBJECTIVES	(B) DURATION (HOURS)	(C) TRAINING STANDARD CORRELATION: STUDY REFERENCES: EQUIPMENT & TRAINING AIDS; INSTRUCTIONAL GUIDANCE
		INSTRUCTIONAL GUIDANCE Discussion (70%): Operational characteristics of the power supplies; Trace and analyze circuit network of DC power supply Demonstration (15%): Trace and analyze relay operation and regulator operation using applicable diagrams Performance (15%): Completion of training objectives using SSG/WB ABR32231P-7
3. Transmitting System	21	**TRAINING STANDARD CORRELATION**
a. Using SSG/WB ABR32231P-8 and the AN/APQ-109 schematic diagram booklet, identifies the electronic fundamental circuits peculiar to the transmitting system to include (1) Astable plate-coupled multivibrator (2) Waveshaping circuits (a) Integrating (b) Differentiating (c) Diode limiting (3) Blocking oscillator (4) Artificial transmission lines (pulse forming network - PFN) (5) Magnetron oscillator (a) Tunable magnetrons (b) Pulse modulation of magnetrons (6) Magnetic amplifier and saturable reactors (7) Waveguides	(12)	JTS / CODE / JTS / CODE 2 / 1a / 9h,i / B 3a / B / 12a / B 4f(4) / 2b / 13a / A 4i / 2b / 14b(1) / B 9e, f / B / 14j(1) / B **REFERENCES** SSG/WB ABR32231P-8, Transmitting System TO 1F-4D-2-19, Maintenance Instructions, Fire Control System TO 12P2-2APQ109-2-1, AN/APQ-109 Radar Set, General Information AN/APQ-109, Schematic Diagram Booklet Study Question Booklet for Block XI

PLAN OF INSTRUCTION (Continued)

STATEMENT OF LEARNING OBJECTIVES (A)	DURATION (HOURS) (B)	TRAINING STANDARD CORRELATION: STUDY REFERENCES: EQUIPMENT & TRAINING AIDS; INSTRUCTIONAL GUIDANCE (C)
(a) Advantages (b) Cut-off frequency (c) Boundary conditions (d) Modes (e) Fields (f) Bends (g) Joints (h) Matching devices (i) Termination (j) Pressurized (k) Linearly and circularly polarized waves (l) Directional couplers (m) Duplexers (n) H-plane resonance ferrite isolators		**EQUIPMENT AND TRAINING AIDS** Transparencies for Block XI **INSTRUCTIONAL GUIDANCE** Discussion (70%): Electronic fundamentals; Functional analysis of the transmitting system Demonstration (15%): Identifying electronic fundamental circuits; Trace and analyze transmitting system circuits on diagrams Performance (15%): Completion of the training objectives using SSG/WB ABR 32231P-8
b. By following the general description in TO 12P2-2APQ 109-2-1, orally states the purpose of the transmitting system (85% accuracy) (1) Magnetron (2) Modulator (3) Radar trigger (4) BITs (5) EFC (6) Protective devices	(1)	
c. Traces and analyzes (90% accuracy) the networks of the transmitter system functional block diagram in TO 12P2-2APQ109-2-1 and the circuit networks of the transmitting functional diagram in TO 1F-4D-2-19 (1) Power control circuits (a) Standby	(5)	

PLAN OF INSTRUCTION (Continued)

STATEMENT OF LEARNING OBJECTIVES (A)	DURATION (HOURS) (B)	TRAINING STANDARD CORRELATION: STUDY REFERENCES: EQUIPMENT & TRAINING AIDS; INSTRUCTIONAL GUIDANCE (C)
1 Relaxation oscillator 2 PRF generator 3 Trigger thyratron 4 Synchronizing trigger (b) Operate 1 Pulse forming network (PFN) 2 Magnetron (2) Waveguide (a) Ferrite isolator (b) Couplers (c) CW filter (d) Waveguide switch (e) Feedhorn (3) Protective circuits		
d. Correctly completes the missions in SSG/WB ABR32231P-8 (85% accuracy) and correctly answers 85% of the applicable questions in the study question booklet, and those posed by the instructor, to determine his understanding of the transmitting system	(3)	
4. <u>Electrical Frequency Control</u>	18	<u>TRAINING STANDARD CORRELATION</u>
a. Using SSG/WB ABR32231P-9 and the AN/APQ-109 schematic diagram booklet, identifies the electronic fundamental circuits peculiar to the EFC to include (1) Reflex klystron (2) Magic-T (3) Crystal detector (4) Resonance circuits (5) If and RF amplifiers	(11)	<u>JTS</u> / <u>CODE</u> / <u>JTS</u> / <u>CODE</u> 2 / 1a / 9i / B 3a / B / 12a / B 4f(4) / 2b / 14b(1) / B 4i / 2b / 14d(1) / B 9e / B

PLAN OF INSTRUCTION (Continued)

STATEMENT OF LEARNING OBJECTIVES (A)	DURATION (HOURS) (B)	TRAINING STANDARD CORRELATION: STUDY REFERENCES: EQUIPMENT & TRAINING AIDS; INSTRUCTIONAL GUIDANCE (C)
(6) Discriminators (7) Pulse stretchers (8) Synchronous vibrators (mechanical chopper) b. Orally describes the purpose of the EFC by explaining the following as defined in TO 12P2-2APQ109-2-1 (1) Automatic frequency control (2) Manual frequency control c. Traces and analyzes the circuit networks on the EFC functional diagram (85% accuracy) in TO 1F-4D-2-19 (1) Intermediate frequency (IF) amplifier (2) Discriminator (3) Video amplifier and pulse stretcher (4) Integrating amplifier and chopper circuits (5) Sweep stop circuit (6) Local oscillator d. Correctly completes the missions in SSG/WB ABR32231P-9 (85% accuracy) and correctly answers 90% of the applicable questions in the study question booklet, and those posed by the instructor, to check his comprehension of the EFC	(1) (4) (2)	REFERENCES SSG/WB ABR32231P-9, Electrical Frequency Control TO 1F-4D-2-19, Maintenance Instructions, Fire Control System TO 12P2-2APQ109-2-1, AN/APQ-109 Radar Set, General Information AN/APQ-109, Schematic Diagram Booklet Study Question Booklet for Block XI EQUIPMENT AND TRAINING AIDS Transparencies for Block XI INSTRUCTIONAL GUIDANCE Discussion (70%): Electronic fundamentals, Functional analysis of the EFC circuits Demonstration (15%): Identifying electrical fundamental circuits; Trace and analyze EFC circuits on diagrams Performance (15%): Completion of the training objectives using SSG/WB ABR 32231P-9

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PLAN OF INSTRUCTION (Continued)

(A) STATEMENT OF LEARNING OBJECTIVES	(B) DURATION (HOURS)	(C) TRAINING STANDARD CORRELATION: STUDY REFERENCES: EQUIPMENT & TRAINING AIDS; INSTRUCTIONAL GUIDANCE
5. <u>Receiving System</u>	12	<u>TRAINING STANDARD CORRELATION</u>
a. Using SSG/WBs ABR32231P-8, 9 and 10 and AN/APQ-109 schematic diagram booklet, identifies the electronic fundamental circuits peculiar to the receiving system to include (1) Waveguide (2) Crystal mixers (3) IF amplifier (a) Cascade staging (b) Cascoded coupling (4) Ultrasonic delay lines	(5)	<u>JTS</u> <u>CODE</u> <u>JTS</u> <u>CODE</u> 2 1a 12a B 3a B 14c(1) B 4f(4) 2b 14d(1) B 4i 2b 14e(1) B 9e B 14j(1) B 9i B <u>REFERENCES</u> SSG/WBs ABR32231P-8, 9 and 10, Transmitting System, Electrical Frequency Control, Receiving System
b. Traces and analyzes the networks of the receiving system (80% accuracy) functional block diagram in TO 12P2-2APQ109-2-1 (1) Waveguide system (2) Crystal mixers (3) Preamplifier (4) Postamplifier (5) Narrow band (NB) IF amplifier (6) Back bias (BB) IF amplifier	(2.5)	TO 1F-4D-2-19, Maintenance Instructions, Fire Control System TO 12P2-2APQ109-2-1, AN/APQ-109 Radar Set, General Information AN/APQ-109 Schematic Diagram Booklet Study Question Booklet for Block XI <u>INSTRUCTIONAL GUIDANCE</u> Discussion (70%): Electronic fundamentals, Functional analysis of receiving system
c. Trace and analyze the circuit networks of the receiving system (85% accuracy) functional diagram in TO 1F-4D 2-19 (1) Signal reception and detection (2) I-F preamplifier (3) I-F postamplifier (4) NBIF amplifier (5) BBIF amplifier (6) Signal mixing circuits	(3)	Demonstration (15%): Identifying electronic fundamentals; Trace and analyze receiving system circuits on diagrams Performance (15%): Completion of training objectives using SSG/WB ABR32231P-10

PLAN OF INSTRUCTION (Continued)

(A) STATEMENT OF LEARNING OBJECTIVES	(B) DURATION (HOURS)	(C) TRAINING STANDARD CORRELATION: STUDY REFERENCES: EQUIPMENT & TRAINING AIDS; INSTRUCTIONAL GUIDANCE
d. Correctly completes the missions in SSG/WB ABR32231P-10 (85% accuracy) and correctly answers 85% of the applicable questions in the study question booklet, and those posed by the instructor, to check his knowledge of the receiving system	(1.5)	
6. <u>Measurement</u>	3	
a. Performance test	(2.5)	
b. Test critique	(.5)	

Appendix VI.

GRADUATE EVALUATION QUESTIONNAIRE

GRADUATE EVALUATION QUESTIONNAIRE

TO: The immediate supervisor of ______________________________
a graduate of Course Nr. ABR32231N, Weapons Control Systems Mechanic
(F-105 D/F, ASG-19 Systems)

1. Your assistance is requested in performing a field evaluation of the above graduate assigned your organization. In completing the questionnaire, the following steps should be observed:

a. Read the training standard item.

b. Place a check mark (✓) in column "NP" if the graduate has not performed the task in his current assignment.

c. Place a check mark (✓) in column "NR" if the graduate is not required to perform the task.

d. If columns "NP" or "NR" have not been checked indicate your evaluation of the graduate's ability to perform the task by placing a check mark (✓) in the appropriate column ("1", "2", "3", or "4"). If you have not actually observed his performance of the task, do not enter a check mark.

2. We plan to tabulate the results obtained from this and other questionnaires on ______________________: request return of this questionnaire to the following address by that date:

Tech Tng Cen (TSE)
Lowry AFB Co 80230

3. Please insert on the lines below the required information pertaining to the graduate:

a. Control AFSC ____________________

b. Duty AFSC ______________________ Position title ______________

c. How long has he been under your immediate supervision since graduation ______________________ weeks.

4. Please insert on the lines below the required information pertaining to yourself:

a. Duty AFSC ________________ Position title __________________

b. Graduate of Course Yes ___ No ___

c. This questionnaire completed: ______________________________
(Date)

d. Total experience in 322XXN AFSC: ____________________ months

e. Your name ______________________ ______________________
(Print) (Rank or Grade)

f. Location ____
(Air Force Base)

g. Major Command ____

Auth: AFR 50-10, Field Evaluation
of ATC Graduates

GRADUATE EVALUATION QUESTIONNAIRE

PERFORMANCE SCALE VALUE	DEFINITION	
4	Can do the complete task quickly and accurately. Can tell or show others how to do the task	HIGHLY PROFICIENT
3	Can do all parts of the task. Needs only a spot check of completed work. Meets minimum local demands for speed and accuracy.	COMPETENT
2	Can do most parts of the task. Needs help only on hardest parts. May not meet local demands for speed or accuracy.	PARTIALLY PROFICIENT
1	Can do simple parts of the task. Needs to be told or shown how to do most of the task.	EXTREMELY LIMITED
NP	Graduate has not performed task in current assignment.	
NR	Task not required in graduate's specific assignment.	

TRAINING STANDARD ITEMS	NR	NP	1	2	3	4
3d(2). Applying precautions during job performance around electronic equipment						
4f. Using 1-category technical publications: (1). TO 1F-105D-2-11						
(2). TO 1F-105D-2-13-1						
4g. Using 11-category technical publications						
8. Maintenance and inspection system and forms: b. Using manhour reporting forms						
c. Using maintenance data collecting forms						
9. Using hand and special tools						
15. Aligning and calibrating the R-14A/G radar subsystem: a. Transmitter						
b. Receiver section (1) Range channel						
(3) Azimuth channel						
c. Automatic electrical frequency control						
d. Antenna						
e. RF plumbing						
f. Electronic control amplifier						

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LOWRY TC Office FORM 171 APR 67

ATC - LOWRY AFB. COLORADO

GRADUATE EVALUATION QUESTIONNAIRE

PERFORMANCE SCALE VALUE	DEFINITION	
4	Can do the complete task quickly and accurately. Can tell or show others how to do the task	HIGHLY PROFICIENT
3	Can do all parts of the task. Needs only a spot check of completed work. Meets minimum local demands for speed and accuracy.	COMPETENT
2	Can do most parts of the task. Needs help only on hardest parts. May not meet local demands for speed or accuracy.	PARTIALLY PROFICIENT
1	Can do simple parts of the task. Needs to be told or shown how to do most of the task.	EXTREMELY LIMITED
NP	Graduate has not performed task in current assignment.	
NR	Task not required in graduate's specific assignment.	

TRAINING STANDARD ITEMS	NR	NP	1	2	3	4
g. Electrical synchronizer:						
(1) Search attack						
(a) Search						
(c) Visual acquisition						
(e) Air to ground						
(3) Contour mapping						
(4) Ground mapping						
h. Flight indicator						
i. Clearance plane indicator						
j. Radar calibration control						
k. Power supply						
19. Aligning and calibrating the attack and display subsystem:						
a. Sight head						
c. Gyro lead computer						
d. Display tube amplifier						
f. Missile launch computer						
23. Aligning and calibrating the bomb tossing computer:						
a. Power supply						

GRADUATE EVALUATION QUESTIONNAIRE

	SCALE VALUE	DEFINITION	
PERFORMANCE	4	Can do the complete task quickly and accurately. Can tell or show others how to do the task	HIGHLY PROFICIENT
	3	Can do all parts of the task. Needs only a spot check of completed work. Meets minimum local demands for speed and accuracy.	COMPETENT
	2	Can do most parts of the task. Needs help only on hardest parts. May not meet local demands for speed or accuracy.	PARTIALLY PROFICIENT
	1	Can do simple parts of the task. Needs to be told or shown how to do most of the task.	EXTREMELY LIMITED
	NP	Graduate has not performed task in current assignment.	
	NR	Task not required in graduate's specific assignment.	

TRAINING STANDARD ITEMS	NR	NP	1	2	3	4
b. Amplifier assembly						
d. Angle position drive assembly						
f. Time and range drive assembly						
g(1). OIP computer angle A assembly						
h. Drift angle and range wind assembly						
24 a. Determining existance of proper signal data using applicable equipment and technical material to isolate malfunctions to major components.						
25. Demonstrating proper technique in the connection, initial settings and use of the following test equipment						
a. Oscilloscope						
b. Tube tester						
c. Electronic multimeter						
d. Multimeter (PSM-6)						
e. Differential voltmeter						
g. Crystal rectifier test set						
i. Spectrum analyzer						
k. Audio oscillator						
l. X-band signal generator						
m. Radar test set						

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GRADUATE EVALUATION QUESTIONNAIRE

PERFORMANCE SCALE VALUE	DEFINITION	
4	Can do the complete task quickly and accurately. Can tell or show others how to do the task	HIGHLY PROFICIENT
3	Can do all parts of the task. Needs only a spot check of completed work. Meets minimum local demands for speed and accuracy.	COMPETENT
2	Can do most parts of the task. Needs help only on hardest parts. May not meet local demands for speed or accuracy.	PARTIALLY PROFICIENT
1	Can do simple parts of the task. Needs to be told or shown how to do most of the task.	EXTREMELY LIMITED
NP	Graduate has not performed task in current assignment.	
NR	Task not required in graduate's specific assignment.	

TRAINING STANDARD ITEMS	NR	NP	1	2	3	4
p. Magnet current ammeter						
s. Radar Analyzer						
t. Radar plug-in-test set						
y. Gyro-computer test set						
aa. Missile launch computer test set						
cc. Display and missile launch computer test set						

(JTS 32231N/51N/71N, 24 Sep 1965/03057)

LOWRY TC Office FORM 171 APR 67

ATC - LOWRY AFB, COLORADO

1. If the school training did not bring this graduate up to the level of a 3 level apprentice as indicated in Column B of the 24 Sept 1965 training standard, list below any additional training your organization had to give him. (If you do not have access to the above training standard, state this fact in the comment section below, but list those subjects you feel the graduate is weak in or should have known, and the training time given per subject.)

Subjects Trained In: (This is not Upgrade OJT)	Training Time Per Subject, Given in Hours:
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________

2. Please list any comments or suggestions you have concerning the training program:

ADJECTIVE RATING

3. Please check the following adjective rating which, in your opinion, most nearly represents the graduate's overall ability to perform his assigned duties:

__________ OUTSTANDING __________ SATISFACTORY __________ UNSATISFACTORY

If you rated this graduate UNSATISFACTORY give your opinion as to the underlying cause (lack of aptitude, insufficient training, lack of interest.)

____

____

____

Appendix VII.

GRADUATE'S EVALUATION OF TRAINING

GRADUATE'S EVALUATION OF TRAINING	COURSE NUMBER AND TITLE ALR32271, F-111 Radar and Controls Test Station Technician
TO (Graduate's Full Name and Address)	FROM Training Evaluation Division (TSE) Lowry Technical Training Center (ATC) Lowry Air Force Base, Colorado 80230

This center is currently making a study of the effectiveness of the training offered in above referenced course. One phase in this study consists of contacting a representative sampling of previous graduates to determine what they have been doing since graduation, how well their training prepared them to perform their job, and what suggestion they may have for making our training more objective.

As a graduate of this course, your cooperation in supplying the information requested in this evaluation will assist us materially in improving our training program and thus improve the overall effectiveness of the Air Force. Your replies, in so far as you as an individual are concerned, will be kept confidential and will be used for the sole purpose of evaluation of training.

Your early completion ahd return of this questionnaire will enable us to give more immediate attention to improvements needed in our present training program.

YOUR PRESENT JOB TITLE	PRESENT DUTY AFSC

HAVE YOU BEEN ASSIGNED TO OTHER POSITIONS SINCE GRADUATION	If "Yes," list position(s)
☐ YES ☐ NO	

Following is a detailed listing of the knowledge and performance items on which you were trained in the course. Please indicate your opinion of the adequacy of training on each item by placing an "X" in the appropriate columns. Base your evaluation on the requirements of your present position. Items not required in your present position should be marked in the "N" column only.

CODE	DESCRIPTION
I	TRAINING WAS INADEQUATE FOR REQUIREMENTS OF MY PRESENT POSITION.
A	TRAINING WAS ADEQUATE FOR REQUIREMENTS OF MY PRESENT POSITION.
N	TASK NOT REQUIRED IN MY PRESENT POSITION.

REMARKS

1. If you feel that training was *inadequate* (I) on an item, please explain. This will help us correct the situation. We need your honest opinion.
2. As the course may have changed since your graduation, the list may contain some items that were not included in the course while you were a student. A remark on the importance of these items would be helpful.
3. Please feel free to make any comment or suggestion you believe would improve the training program.

TRAINING STANDARD TASKS	N	A	I	REMARKS
2. SOLID STATE DEVICES, BINARY NUMBER SYSTEM, BOOLEAN ALGEBRA AND LOGIC CIRCUITS: d. Identify standard logic symbols				
e. Understand and trace logic circuits				
3. AN/GJQ-9 PROGRAMMER COMPARATOR AND INTERFACE ADAPTER: d. Describe and explain programming codes				
e. Identify and locate each unit of AN/GJQ-9				
i. Connect cables between Interface Adapter and AN/GJQ-9				
j. Identify and locate each unit of the Interface Adapter				

Continued on reverse.

TRAINING STANDARD TASKS	N	A	I	REMARKS
l. List the general and electrical characteristics of the AN/GJQ-9 and Interface Adapter				
m. Perform AN/GJQ-9 turn-on procedures				
n. Operate AN/GJQ-9 in automatic mode using confidence tape				
o. Program and operate AN/GJQ-9 in manual mode using applicable publications				
p. Trace logic analysis of AN/GJQ-9				
q. Trace logic analysis of interface adapter				
4. RECEIVER-TRANSMITTER-MODULATOR TEST STATION, AGERD 6802 (AEROSPACE GROUND EQUIPMENT RECOMMENDATION DATA): c. Locate and name each tester replaceable unit (TRU) within AGERD 6802				
e. Trace and analyze block diagram of each TRU of AGERD 6802				
f. Trace input and output signals of each TRU of AGERD 6802				
g. Trace and analyze circuits of applicable TRUs of AGERD 6802				
i. Trace data flow through entire AGERD 6802				
k. Perform in-station verification of applicable AGERD 6802 TRUs using proper standards				
l. Perform maintenance and calibration on Category II TRUs of AGERD 6802				
m. Trace and analyze circuits of each line replaceable unit (LRU) assigned to AGERD 6802				
n. Select and install proper cabling and router for each LRU assigned to AGERD 6802				

TRAINING STANDARD TASKS	N	A	I	REMARKS
o. Operate AGERD 6802 to perform maintenance on assigned LRUs				
p. Isolate malfunctions in AGERD 6802 and assigned LRUs				
q. Remove and install TRUs of AGERD 6802				
5. TERRAIN FOLLOWING RADAR SYSTEM (TFR): b. System analysis: (1) Identify major components				
(2) List general and electrical characteristics				
(3) Trace data flow throughout system using block diagrams				
(4) Perform circuit analysis of system LRUs				
(5) Identify and describe controls used with the TFR				
(7) Tie-in of TFR to associated systems				
6. ATTACK RADAR SYSTEM (ARS): b. System analysis: (1) Identify major components				
(2) List general and electrical characteristics				
(3) Trace data flow throughout system using block diagrams				
(4) Perform circuit analysis of system				
(5) Identify and describe controls for ARS				
(6) Tie-in of ARS to associated systems				
7. VIDEO TEST STATION, AGERD 6815: c. Locate and name each TRU within AGERD 6815				

TRAINING STANDARD TASKS	N	A	I	REMARKS
e. Trace and analyze block diagram of each TRU of AGERD 6815				
f. Trace input and output signals of each TRU of AGERD 6815				
g. Trace and analyze circuits of applicable TRUs of AGERD 6815				
i. Trace data flow through entire AGERD 6815				
k. Perform in-station verification of applicable AGERD 6815 TRUs using proper standards				
l. Perform maintenance and calibration on Category II TRUs of AGERD 6815				
m. Trace and analyze circuits of each LRU assigned to AGERD 6815				
n. Select and install proper cabling and router for each LRU assigned to AGERD 6815				
o. Operate AGERD 6815 to perform maintenance on assigned LRUs				
p. Isolate malfunctions in AGERD 6815 and assigned LRUs				
q. Remove and install TRUs of AGERD 6815				
8. COUNTERMEASURES RECEIVER SYSTEM (CMRS) AND COUNTERMEASURES DISPENSING SYSTEM (CMDS): b. System analysis: (1) Identify major components				
(2) List general and electrical characteristics				
(3) Trace data flow through CMRS and CMDS				
(4) Identify and describe controls for CMRS and CMDS				
9. LOW ALTITUDE RADAR ALTIMETER (LARA): b. System analysis:				

TRAINING STANDARD TASKS	N	A	I	REMARKS
(1) Identify major components				
(2) List general and electrical characteristics				
(3) Trace data flow through LARA using block diagrams				
(4) Identify and describe controls for LARA				
(5) Perform circuit analysis of system LRUs				
(7) Tie-in of LARA to associated systems				
10. LEAD COMPUTING OPTICAL SIGHT (LCOS): b. System Analysis: (1) Identify major components				
(2) List general and electrical characteristics				
(3) Trace data flow through LCOS using block diagrams				
(4) Perform circuit analysis of system LRUs				
(5) Identify and describe controls of LCOS				
(7) Tie-in of LCOS to associated equipment				
11. SERVO AND INDICATORS TEST STATION, AGERD 6825: c. Locate and name each TRU within AGERD 6825				
e. Trace and analyze block diagram of each TRU of AGERD 6825				
f. Trace input and output signals of each TRU of AGERD 6825				
g. Trace and analyze circuits of applicable TRUs of AGERD 6825				
i. Trace data flow through entire AGERD 6825				
k. Perform in-station verification of applicable AGERD 6825 TRUs using proper standards				

TRAINING STANDARD TASKS	N	A	I	REMARKS
l. Perform maintenance and calibration of Category II TRUs of AGERD 6825				
m. Select and install proper cabling to allow for maintenance of AGERD 6825 and associated LRUs				
n. Trace and analyze circuits of each LRU assigned to AGERD 6825				
o. Operate AGERD 6825 to perform maintenance on assigned LRUs				
p. Isolate malfunctions in AGERD 6825 and assigned LRUs				
q. Remove and install TRUs of AGERD 6825				
12. USE APPLICABLE AUXILIARY TEST EQUIPMENT				
13. INSPECTIONS: a. Perform confidence checks on AGERD 6802, AGERD 6815 and AGERD 6825				
b. Perform daily inspection on AGERD 6802, AGERD 6815 and AGERD 6825				
c. Perform periodic inspections on AGERD 6802, AGERD 6815 and AGERD 6825				
28026				

LIST BELOW, ANY JOB ELEMENT(S) NOT INCLUDED IN THIS QUESTIONNAIRE WHICH ARE REQUIRED IN THE SUCCESSFUL ACCOMPLISHMENT OF YOUR ASSIGNED DUTIES.	EXPLAIN THE NEED FOR EACH ITEM LISTED.

LIST BELOW, ANY TRAINING STANDARD TASKS YOU FEEL TRAINING WAS MORE THAN ADEQUATE FOR THE REQUIREMENTS OF YOUR PRESENT POSITION.

Upon completion of this questionnaire, please place the forms in the attached self-addressed envelope and return it directly to us. This direct correspondence is requested in accordance with the requirements of Air Force Regulation 50-10 and ATC Regulation 52-1.

DATE THIS EVALUATION WAS COMPLETED	GRADUATE'S SIGNATURE	GRADE	AFSN

ORGANIZATION	POSITION TITLE

Appendix VIII.

AIR FORCE FORM 623
CONSOLIDATED TRAINING RECORD

CONSOLIDATED TRAINING RECORD

SECTION I PART A		ON-THE-JOB UPGRADE TRAINING
Step 1	Unit Commander *(Grade and Name)*	Insures that your assignment is in accord with your classification and specific skills background.
Step 2	Unit Training Officer *(Grade and Name)*	Interviews and counsels you regarding: a. Overall squadron training program and how you will fit into it. b. Completeness of your incoming training records. c. Career development and importance of your own initiative. Introduces your Unit Training NCO.
Step 3	Unit Training NCO *(Grade and Name)*	Prepares consolidated training record and delivers it to section supervisor. Introduces your Section Supervisor.
Step 4	Section Supervisor *(Grade and Name)*	Briefs you on section training program and explains the following items: a. Specific AFS description. b. Training requirements. c. Explanation of training folder with emphasis on Air Force Job Training Standard. d. Personal gain from your own initiative. e. Enrollment in career development courses. f. ECI and USAFI courses. g. Upgrading to promotion. h. Specialty Knowledge Test (SKT) procedures. i. Proficiency testing. j. Use of DAF OJT Packages, CDCs and Job Proficiency Guides.

SECTION I PART B

POSITION FOR WHICH YOU ARE TRAINING	TRAINEE SIGNATURE	REFERRAL TO TRAINING OFFICER FOR CAREER DEVELOPMENT ☐ YES ☐ NO

TRAINING OBJECTIVE	DATE ENTERED TRAINING AND AUTHORITY	ESTIMATED COMPLETION DATE	AFSC AWARDED	DATE OF AND AUTHORITY FOR AWARD	DATE OF BOARD ACTION	ACTION
3 SKILL LEVEL						
5 SKILL LEVEL						
7 SKILL LEVEL						

SECTION I PART C UPGRADE KNOWLEDGE TRAINING

VOL	CAREER DEVELOPMENT COURSE TITLE AND NUMBER	DATE STARTED	ESTIMATED DATE OF COMPLETION	DATE OF SATISFACTORY COMPLETION	END OF VOL SCORE	UNIT TRAINING OFFICER SIGNATURE

SKT	SCORE	AUTHORITY

SECTION I PART D UPGRADE PROFICIENCY TRAINING

AIR FORCE JOB TRAINING STANDARD PHASE OF TRAINING AND/OR JOB PROFICIENCY GUIDE	DATE STARTED	DATE SAFTY CMPL	TYPE TEST *	RESULT	SECTION SUPERVISOR SIGNATURE	TRAINEE INITIAL

* "O"—ORAL, "W"—WRITTEN, "P"—PRACTICAL

SECTION II PART A				ACT/ACB/AQE TEST RESULTS		
MECHANICAL	ADMIN	GENERAL	RADIO	ELECTRONICS	EDUCATION LEVEL—YEARS	REFERRAL TO EDUCATION OFFICER ☐ YES ☐ NO

SECTION II PART B USAFI, ECI, ETC. PARTICIPATION

CRS NR	NR OF VOL	DATE STARTED	DATE SAFTY CMPL	UNIT TNG OFFICER SIGNATURE	REMARKS (*USAFI, ECI Test Results, etc.*)

SECTION II PART C TECHNICAL TRAINING

COURSE TITLE AND NUMBER	COURSE DURATION	LOCATION	COMPLETION DATE	CERTIFICATION

SECTION II PART D SUPERVISORY TRAINING

COURSE TITLE	LOCATION	DATE SAFTY CMPL
Base Level Management Course		
NCO Academy		
ECI Course Number 6		
OJT Administrative Supervisor		

SECTION III PART A SPECIAL QUALIFICATIONS IN ADDITION TO UPGRADE TRAINING (*Maintenance Training, Licenses to Operate, Inspector, etc.*)

GRADE	NAME (LAST)	(FIRST)	(MI)
SERVICE NUMBER			

CAFSC	DAFSC	FAFSC

JOB TITLE

MAXIMUM TNG DATE	DATE FOR CLASN BD REV.	DATE FOR SUPV EVAL

* GPO : 1966 OF—797-684

SECTION III PART B	**JOB PERFORMANCE EVALUATION**	
DATE	JOB TITLE	RESULTS

SECTION III PART C **REMARKS** *(Leave Time, Interruptions to Training, etc.)*	DATE

SECTION IV	**DATE TOTAL TRAINING COMPLETED**	GRADE AND SIGNATURE OF SECTION OIC
3 LEVEL		
5 LEVEL		
7 LEVEL		

Appendix IX.

EXPLANATION OF TERMS

EXPLANATION OF TERMS

Aerospace	The aerospace is an operationally indivisible medium consisting of the total expanse beyond the earth's surface.
Airman Qualifying Examination (AQE)	This examination is administered to all Air Force recruits. The examination yields four aptitude indices: (1) General; (2) Administrative; (3) Mechanical; and (4) Electronics. The obtained scores are used for classification purposes.
Air Force Specialty (AFS)	The basic occupational unit of the Air Force personnel classification system. It consists of a broad grouping of duties and tasks into positions requiring common qualifications -- skills, knowledges, and responsibilities.
Air Force Specialty Code (AFSC)	A combination of digits or of digits and letters identifying a given Air Force Specialty.
"Black Box"	A group of electrical or electronic parts that can be plugged in or unplugged from equipment as a single functional unit. The same as Line Replaceable Unit (LRU).
Career Field	A group of related Air Force Specialties (AFS's) involving basically similar knowledges and skills.
Category I	SUBSYSTEM DEVELOPMENT TEST AND EVALUATION -- This category consists of development testing of the components and subsystems of a system.

Category II	SYSTEM DEVELOPMENT TEST AND EVALUATION - This category consists of development testing and evaluation of integrated subsystems.
Category III	SYSTEM OPERATIONAL TEST AND EVALUATION - This category consists of user tests and evaluations, under operational conditions, of operationally configured systems with all components, support items and personnel skills.
Checkout	A sequence of operational calibrational tests needed to determine the condition and status of a weapon system.
Directed Duty Assignee (DDA)	An airman assigned directly from basic military training to an operational unit without attending a formal resident training course.
Depot Maintenance	Depot maintenance is that level of maintenance which is beyond the responsibility or the capability of the using command. It involves work performed on materiel requiring a major overhaul or a rebuilding of components. Depot level maintenance is normally accomplished at Air Force Logistics Command facilities or commercial maintenance shops, but may be performed in the field by depot maintenance teams.
Duty	A series of tasks comprising a major requirement within a specific position for maintaining or operating the equipment system.
Equipment	A major functional part of a system or subsystem, usually consisting of several components which are essential to operational completeness of the system or subsystem (e.g., radio compass, radio command set, electrical power supply).

Field Maintenance — Field maintenance consists of the bench check of components; repair of unserviceable parts, accomplishing Technical Order compliances and calendar inspections; performing functional acceptance checks on equipment initially received from supply sources and testing, calibration, and reclamation as authorized. Field Maintenance is normally performed in the assembly or maintenance shop located at the support base. However, it may be necessary to perform field maintenance at the launch site or flight line on certain items that are difficult or impossible to remove because of size or method of installation.

Ground Environment — (1) The environment that surrounds and effects a system on the ground. (2) That system or part of a system, such as a guidance system, that functions on the ground; the aggregate of equipment, conditions, facilities, and personnel that go to make up a system, or part of a system, functioning on the ground.

Job — Equivalent to Position, but the term "job" does not mean "task."

Line Replaceable Unit (LRU) — "Black Box" - A group of electrical or electronic parts that can be plugged in or unplugged from equipment as a single functional unit.

Mockup — A three-dimensional, full-scale model of an operational article. So far as is practicable, it represents the configuration of the operational article with particular emphasis on the general arrangement of all components.

Operational Readiness — The condition or state of a person's or unit's being ready, in terms of the concept or plan of a particular operation, to carry out the operation, required by the mission of the person or unit, either combat or noncombat. Also, the condition or state of a piece of an equipment that makes it ready and available for use.

Organizational Maintenance — Organizational maintenance is normally performed on air or aerospace vehicles and applicable ground equipment at the launch site or flight line. It consists of troubleshooting functions; necessary alignment, calibration, and performance test; prelaunch, preflight, daily, and periodic inspections; preventive maintenance; and removing and replacing components.

Personnel Subsystem (PSS) — A composite of the trained military personnel and employment techniques required to operate, control, and maintain the integrated hardware subsystem of a weapon system.

Position — A position is the total set of activities and responsibilities assigned to one man in an expected operational situation. See "Job."

Shredout — (Personnel) A subdivision of an Air Force Specialty set up to indicate qualification in specific equipment, functions, or positions covered by a given Air Force Specialty. It is identified by means of a title and alphabetical suffix to the Air Force Specialty Code.

Simulator — A relatively complex item of equipment utilizing primarily electronic and mechanical means to functionally reproduce operational conditions to the extent necessary to accomplish the operational mission of an individual or crew. Simulators reflect a physical duplicate of the visual operational equipment and a functional duplicate of all subsystems and systems required to accomplish the stated training requirements. Typical examples are: aircrew simulator, missile launch simulator, and aircraft flight simulator.

Specialty Knowledge Test (SKT) — Measures job knowledge in the various Air Force career fields. An SKT is normally available for each position. The test results are used for skill upgrading purposes.

Task	A task is a group of human operations occurring about the same time or in close sequence, having some common purpose, and usually directed toward some specific machine or human output(s) which they have in common.
Training Media	A general plural term which includes all devices used in instruction such as training aids, teaching machines, trainers, and simulators. Singular: Training medium.
Troubleshooting	Locating a malfunction by symptoms or by making a series of checks.
Subsystem	A major functional part of a system, usually consisting of several equipments or components which are essential to operational completeness of the system (e.g., airframe, navigation, communication).
System	A composite of equipment, skills, and techniques which when combined forms a self-sufficient entity capable of performing a clearly defined function in support of an Air Force mission.

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13. ABSTRACT

This report describes the proposed development and evaluation of a Learner-Centered (LCI) systems approach to electronics maintenance training. An electronics course, appropriate for airmen of various aptitudes, will be prepared to develop proficiency in the specific duties required of the Weapon Control Systems Mechanic/Technician (AFSC 322XIR) in the F-111A weapon system. The course will be developed within the environment of the weapon system development cycle, using data available during the time period and meeting the demanding time schedules. The course will be highly job-relevant and will include multimedia, self-instructional, apprentice-like experiences. Personnel of various levels of aptitude in electronics, including levels lower than those currently used, will take the course. Their on-the-job performance will be carefully and systematically evaluated and compared with the performance of personnel from the parallel course. The total program will focus and demonstrate the technology for developing job specific, apprentice-like technical courses as an integral part of the weapon system development cycle. Also, the weapon control system equipment and Air Force training and course development procedures are described.

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Security Classification

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
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