

Research Note 82-22

DEVELOPMENT AND EVALUATION OF A GENERALIZABLE
JOB PROFICIENCY MATRIX

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TRAINING RESEARCH LABORATORY



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This project explored the feasibility of constructing task-by-element matrices for three avionics MOSs--35L, 35M, and 35R. Matrix rows define critical tasks, and columns specify behavioral elements (soldier perceptions, decisions, and actions) required for successful task performance. The GJPM identifies commonalities among tasks within and across MOSs based on behavioral content. Concurrent with this analysis, a generalizable avionics troubleshooting guide was developed. The GJPM was used to develop prioritized task lists,		

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identify performance measures for critical tasks, and identify behavioral elements common across tasks in one or more MOSs. SQT written components were developed for the three MOSs. The GJPM facilitated MOS content coverage while reducing unnecessary redundancy.

Interviews were conducted upon completion of the SQTs to evaluate the usefulness of the GJPM for SQT development, training design, training media evaluation, and MOS management, and to discuss appropriate levels of matrix task and element specificity.

The project demonstrated that the GJPM facilitates SQT development. Interviews suggest that the GJPM will be useful for training, training device design, and test design and development. The GJPM is a systematic approach that can point out areas of commonality not previously apparent, and can identify areas of differences where commonality had been assumed.



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PREFACE

The generalizable job proficiency matrix (GJPM) concept was developed to provide training developers with a formal and systematic method for the analysis of the behavioral and cognitive elements of job performance that is applicable to a wide range of training related areas. GJPMs were developed for three avionics maintenance military occupational specialities (MOS) and applied during the construction of three skill qualification tests (SQT). The favorable evaluation by Army personnel of these SQTs relative to existing SQTs points to the usefulness of the GJPM concept in the development of SQTs suggests the utility of further refinement and application of the concept to other areas of training design, evaluation and MOS management.

We wish to acknowledge the contributions of various organizations to this effort. Honeywell's Systems and Research Center performed this effort as a subcontractor to Personnel Decisions Research Institute (PDRI), and we would like to thank PDRI for their timely delivery of technical documentation. We want to make special mention of the contribution provided by Honeywell's Avionics Technical Training Group. Paul Santori, Kevin Austin, Robert Dawson, and Charles Biakowski prepared the generalized trouble-shooting guide, assisted us in matrix and test development, and provided subject matter expertise during in depth internal reviews. We finally want to express our gratitude to the Signal School. The support we received was outstanding during all stages of the contract; initial data gathering, matrix development, commonality analyses, SQT construction, and the interview phase. We would in particular like to thank Harold Knippenberg, John Rogers, and Sgts. Barce, Jordan, and Riley for their analysis and comments throughout the contract. We believe the GJPM will facilitate the performance of their critical job and result in improved training analyses and products.

DEVELOPMENT OF A GENERALIZABLE JOB PROFICIENCY MATRIX

BRIEF

Requirement:

To develop a new taxonomic system approach, called the generalizable job proficiency matrix (GJPM), to be used in the analysis of three avionics maintenance military occupational specialties (MOS); to apply the GJPM during the development of written components for three avionics maintenance Skill Qualification Tests (SQT); and to develop a generalizable troubleshooting guide for maintaining avionics equipment.

Procedure:

This research effort resulted in the construction of task by element matrices for the tasks in three avionics MOSs--35L, 35M, and 35R. The matrices are characterized by rows defining the critical tasks in each MOS and columns specifying the behavioral elements involved in task performance. These matrices provide users with a systematic method for identifying commonalities among tasks within and across MOSs based on behavioral content. Concurrent with this analysis, a generalizable troubleshooting guide was prepared for the Signal School.

The key ingredients in the GJPM are the behavioral elements (i.e., the perceptions, decisions, and actions) required of the soldier for successful task performance. A behavioral element must be defined sufficiently broadly to allow generalization beyond its immediate application, yet precise enough in its terminology and behavioral descriptions to be interpretable by the training developer. Such a set of elements was developed during the contract.

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2. The process of constructing the GJPM necessitated judgements for the MOSs on the equipment, actions, and knowledge commonalities and differences that led to greater understanding by the developers and by signal school personnel of the skills and responsibilities of each MOS.
3. The level of the behavioral component specificity of the task analysis in the GJPM was appropriate for SQT development, but should be tailored to a greater or lesser degree of specificity to the objectives associated with its particular application.

Utilization of Findings:

The present contract demonstrated that the GJPM can facilitate the development of improved, more generic SQTs. The GJPM can be applied to other MOSs for further SQT development or for use as a general analysis tool. The use of the GJPM allows determination of commonalities that may be useful in training, training device, and test design and development. It can also be used to support MOS management decisions. The GJPM concept is a systematic approach that can point out areas of commonalities not previously apparent and, conversely, can identify areas of differences where commonalities were once assumed.

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SECTION I

INTRODUCTION

Background

Today's Army must operate in an environment characterized by advanced technology, complex, sophisticated weapons and operational systems, increased emphasis on combat support elements, and high dependency on automation. These changes have had a profound effect on how training requirements are defined, analyzed, and implemented.

Army training experienced a major revolution during the late 1960s and early 1970s. Performance-based training and testing, based on critical job tasks and criterion-referenced standards of performance, were being implemented in entry-level training courses. As early as 1973, the Army was engaged in defining a proceduralized model for instructional systems development (Branson, 1978). These efforts by the U.S. Army Combat Arms Training Board (CATB) at Ft. Benning, Georgia, led eventually to the Interservice Procedures for Instructional Systems Development (IPISD). The IPISD is now the standard document for development of military instruction.

One of the major requirements of an instructional model is the classification of behavior. It must be classified in a manner sufficiently broad to allow generalization beyond its immediate application, yet precise enough in its terminology and behavioral descriptors to be interpretable by the training developer. The present research effort developed such a method

and applied it to the development of Skill Qualification Test (SQT) written components for three avionics maintenance military occupational specialties (MOS).

Taxonomies

Ever since Bloom (1956) published his Taxonomy of Educational Objectives, research has been directed at defining methods for classifying human behavior into discrete categories. Taxonomies of behavior tend to be situationally specific (e.g., Miller, 1969), or directed toward a restricted domain, like psychomotor (e.g., West, 1957), or cognitive (e.g., Bloom, 1956).

Bownas and Cooper (1978) conducted a review of the behavioral taxonomy literature. This review was the first task in the Generalizable Job Proficiency Matrix (GJPM) contract and explored a wide range of taxonomic approaches and their application. The following several paragraphs are taken from the Bownas and Cooper review.

A taxonomy, or more precisely, a taxonomic system, is a set of rules for classifying elements into an organized structure of categories. The taxonomic structure is designed to have properties useful either for explaining variations among the attributes of the elements, or for relating characteristics of the elements to phenomena external to the system.

The nature of a taxonomy depends upon its intended use. The types of elements and the types of important relationships sought among elements determine the rules of classification which, in turn, determine the taxonomic structure. Ultimately,

it is the researcher interested in categorizing observations who is responsible for selecting the optimal set of classificatory rules.

Taxonomies reviewed by Bownas and Cooper varied greatly depending on whether they were developed for employee selection (Theologus, Romashko, & Fleishman, 1970), for training design (Powers, 1977), for purely scientific research into the nature of human attributes (Guilford and Hoepfner, 1971), or solely to examine methods of developing taxonomies (Austin, 1974). The types of elements to be categorized varied according to these orientations as well, with some researchers focusing on basic cognitive abilities, some on physical or psychomotor functions, and some on non-ability constructs. Most researchers dealt with combinations of these factors.

Taxonomies are typically developed in one of two ways. Some researchers attempt to describe the entire range of human abilities, and seek to connect these abilities with job performance only after the relationships underlying the ability domain have been thoroughly explicated, typically by factor analytic procedures. Two research programs exemplify a further dichotomy within this latter approach. Fleishman's research on human abilities at the American Institutes for Research (Theologus, Romashko, & Fleishman, 1970) focused primarily on psychomotor abilities which had been shown or were hypothesized to determine or affect work behavior. Researchers at the Educational Testing Service (ETS) on the other hand (French, 1973; Ekstrom, French, & Harman, 1975) focused exclusively on paper and pencil tests of cognitive ability that have not been directly linked to proficiency in a variety of jobs.

Other researchers focus on the tasks of a specific job and attempt to define major performance or behavioral element dimensions rationally (e.g., McCormick, Jeanneret, & Mecham, 1969; Powers, 1977; Cunningham, 1972). Their taxonomic elements are usually expressed in terms readily applicable to a variety of job settings and their taxonomic classes are task-oriented. The research effort described in this report is an example of the task-oriented taxonomic approach.

Avionics Maintenance

The domain of interest in the present program was avionics maintenance. Keeping today's inventory of aviation electronic equipment in operational condition requires a highly trained group of maintenance personnel. Personnel are trained to diagnose and repair faults on a subset of equipment within a major functional area such as communications or navigation.

Students are trained in basic electronics and MOS specific tasks to include familiarization with the operation, maintenance philosophy, and the technical manual troubleshooting and repair procedures for each piece of equipment within their MOS.

This approach to training places school trained technicians in the field in a minimum of time. However, with the inventory of avionics increasing so rapidly, technicians in the field are often required to repair equipment unfamiliar to them. Furthermore, technicians often encounter symptoms of faults not specially covered in technical manuals. Many technicians do not adequately understand the rules and superstructure required to be adaptive to the work environment outside the classroom.

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More emphasis is needed on teaching the basic elements common across electronics maintenance tasks. Examples include operation and use of basic test equipment to perform basic electrical measurements, selection and use of hand tools, standard shop procedures, and safety precautions. Additional instruction related to basic component and circuit behavior would enable the student to develop a core set of basic skills and knowledges common to all electronics maintenance.

Generalizable Job Proficiency Matrix Concept

The generalizable job proficiency matrix (GJPM) concept defined by the Army Research Institute was developed to address generic job requirements. A job proficiency matrix is a matrix representation of the tasks performed in an MOS and the behavioral skill elements required to perform these tasks. Matrix cell values represent the contributions each behavioral element makes to performing each task.

The matrix enables identification of elements common to sets of tasks in an MOS. It provides a basis for relating proficiencies on separate tasks and distinct systems by first identifying and then analyzing the behavioral elements they share. Therefore, an evaluation of job proficiency can be more than a sum of discrete, independent task proficiency assessments. Development of the job proficiency matrix concept allows for a more complete evaluation of job proficiency.

A job proficiency matrix may be also useful for developing criterion referenced, performance oriented tests of tasks, and for drawing both task and job related inferences of soldier proficiency. The potential utility of such a matrix

and its desired properties became apparent during the initial Skill Qualification Test (SQT) construction and validation efforts of the U.S. Army. SQTs are job relevant evaluations of a soldier's ability to perform in his MOS. SQTs test soldiers on their ability to perform critical job tasks, and are also used to infer soldiers' overall job proficiencies.

The orientation of the SQT program is that of a domain and criterion referenced testing system (Maier and Hirshfeld, 1978). A fundamental concern of such a system is the validity and generalizability of the information gained through testing. This involves a careful definition of the content domain, the specification of what is to be included in the test of that domain, and the desire to draw reasonable inferences about a soldier's ability on the specific tasks included in the test, as well as being able to generalize from the test to the overall job proficiency of that soldier.

A job proficiency matrix can be developed that focuses on the skills required for successful performance of a task. Identifying skills underlying successful task performance, however, is a difficult requirement. It is unlikely that subject matter experts can agree on the definition of a skill and on which skills underlie performance of particular tasks. Without sufficient confidence in one's ability to identify skills, the validity and reliability of measurement of individual task by skill cells is questionable.

Attention, therefore, was directed at more behaviorally defined elements required for successful task performance. Behaviors such as measure, adjust, connect, etc. can be viewed as actions that are applicable across specific tasks. Consensus among experts should be high as to which actions are

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applicable for each task step. Therefore, identifying behavioral elements is more direct than identifying skills underlying task performance. For this reason this initial empirical examination of a job proficiency matrix concept concentrated on behavioral elements rather than skills. The research effort focuses on three avionics maintenance MOSs:

- 35L Avionics Communication Equipment Repairer
- 35M Avionics Navigation and Flight Control Equipment Repairer
- 35R Avionics Special Equipment Repairer.

Products of this contract include:

- Generalizable troubleshooting guide
- Task by behavioral element matrices for each MOS
- Skill Qualification Test (SQT) written components for each MOS.

The following section describes the input data, the technical requirements, and the technical approach used by Honeywell in developing the above products.

SECTION II

TECHNICAL APPROACH

The contract work performed by Honeywell was done as a subcontractor to Personnel Decisions Research Institute (PDRI). The Honeywell effort consisted of four major tasks.

- Task 1 - Develop task by element matrices
- Task 2 - Develop selection criteria and select tasks and elements for testing
- Task 3 - Develop SQTs
- Task 4 - Evaluate required specificity of task analysis documentation

In order to perform the specified contract requirements, Honeywell obtained the following data prior to conducting the developmental tasks.

1. Soldier's Manuals for skill levels 1 and 2 of MOSs 35L, 35M, and 35R.
2. All technical manuals referenced in the Soldier's Manuals including manuals describing test equipment set-up and use, standard shop practices, and prime equipment technical manuals.
3. Lists of equipment that will not be referenced in next generation Soldier's Manuals.
4. Any available task analyses for skill levels 1 and 2 of MOSs 35L, 35M, and 35R.

Task 1 - Develop Task by Element Matrices

The objective of Task 1 was to construct task-by-element matrices for the tasks in three Army avionics MOSs--35L, 35M, and 35R. The matrices are characterized by rows defining the critical tasks in each MOS and columns specifying the behavioral elements involved in task performance. Once completed, these task-by-element matrices can provide users with a systematic method for identifying commonalities among tasks within and across MOSs based on behavioral content. Concurrent with the analysis activity, a generalizable troubleshooting guide was prepared for the Signal School. The guide provides an overview of the troubleshooting process. A copy of the guide is included in Appendix A.

The process followed in developing task-by-element matrices involved the following four major activities, each of which is described in more detail below.

- Review task data in Soldier's Manuals and technical manuals.
- Define behavioral elements.
- Enter task and element data in matrix format.
- Revise matrices--reanalyze and collapse elements into the most economical set of descriptors.

Review task data--Honeywell reviewed the Soldier's Manuals (SM) for each MOS. A Soldier's Manual contains the task title, conditions, standards, and a list of performance measures which outline the activities involved in task performance. Each performance measure references a technical manual which provides the soldier with detailed, step-by-step procedures for executing

each performance measure. Every SM and technical manual in our data base was reviewed to gain a better understanding of the equipments maintained by each MOS, the tasks to be performed on each piece of equipment, the level of maintenance to be performed by skill level 1 and 2 technicians, and the test equipment required to perform the tasks.

Define behavioral elements--During the review process, each performance measure in the SM was reviewed in detail using the appropriate technical manual. Worksheets were prepared summarizing the behaviors in each performance measure. Each summary was reviewed by other team members in order to insure consistency in the analysis. Discrepancies were worked out in team discussions. The procedures used during these analyses were consistent with the basic guidelines for job and task analysis contained in TRADOC Circular 351-4.

Behavioral elements are the subtasks or steps (i.e., perceptions, decisions, or actions) that are required of the soldier for him to perform each task in the Soldier's Manual successfully. The behavioral elements, in this context, are equivalent to the behavioral competencies for mastering a behavioral objective (i.e., a critical task). The major thrust of the analysis process was concerned with the definition, identification, and characterization of these behavioral elements.

The behavioral elements had to be defined at a level of specificity interpretable and implementable by a training material or test developer. A behavioral element required the following basic properties:

- The element must convey enough information to the user that the key requirements of successful task performance are specifiable.

- The element must enable the user to identify common behaviors both within and across MOSs.

The elements defined during the analysis process were characterized as belonging to either one of two groups, equipment elements or behavioral elements.

Equipment elements are discussed first. Test equipment used in the maintenance of avionics systems provides capabilities defined by system function. It was viewed as more important to identify the functions and knowledges pertinent to classes of equipment than it was to identify specific locations of controls on the individual equipment items. Equipment requirements for testing avionics systems were found to be one means of measuring task and MOS commonality.

Set-up, connect, and operate voltmeter, for example, implies the maintenance person is responsible for identifying the controls and displays of that piece of equipment, how it should be connected to a unit under test (UUT), what information it will provide him, and the sequence of actions he must follow to utilize the equipment's capabilities. The element also implies knowledge of safe operating procedures. Therefore, elements such as "set-up, connect, and operate voltmeter" were included as common elements in the matrices. They were separated from the larger group of behavioral elements only because of their equipment orientation. However, these elements were treated the same as other behavioral elements during all subsequent analyses.

Behavioral elements generally consist of more than one discrete perception or action. While this makes them larger than truly unique "elements," a lower level of definition would not provide

a useful basis for determining commonality. The key factor in determining how many distinct similar elements are required is whether the analysis process indicated some unique aspect of job performance associated with one candidate element that cannot be accounted for in the already identified element. The following is an example of such a distinction. Elements such as "adjust resistance with a multimeter" and "adjust resistance with an oscilloscope" were listed distinctly for reasons of differences in determination of the value; one requiring reading a meter dial, the other analysis of a waveform. These two requirements point out behavioral differences which would not be recognized had the performance element been listed as "adjust resistance." Table 2-1 is a list of the derived set of all behavioral elements.

Behavioral elements preceded by "measure" imply the use of proper techniques, equipment, and the knowledges associated with the parameter which makes the element distinct. "Adjust" elements are generally distinct in two ways, a parameter and a facility for measuring it. The elements "Identify symptom," "Identify faulty section, faulty stage, or faulty part" are indicators of the level of system theory knowledge required of a technician for performance of a given fault isolation task. Symptom identification implies "top level" working knowledge of a system while faulty part identification implies the technician has the knowledge to identify symptoms, faulty sections, stages within sections, and finally to troubleshoot the system to the component level. This type of troubleshooting requires a much deeper level of system theory understanding than determining if the system is working correctly or not. Elements preceded by "Interpret," "Calculate," "Select," "Review," and "Verify" indicate a requirement for the correct use of technical documentation, the ability to comprehend written fault isolation

TABLE 2-1. BEHAVIORAL ELEMENTS

Set up, connect & operate

Voltmeter/multimeter
Oscilloscope
Signal generator
Wattmeter
Frequency counter/meter
Frequency converter
Power supply
Pulse generator
Frequency comparator
Time mark generator
Standing wave ratio indicator
Transfer oscillator
Square law detector
Echo box
Variable attenuator
Variable transformer
Recorder w/preamps
Tape reader
Decade synchro bridge
Headset/microphone
Modulation meter
Decade resistor
Spectrum analyzer
Dummy load
Attenuator

150 ohm resistor
10 K ohm resistor
Audio oscillator
(TS 382/U)
Simulator, antenna coupler
Fuseholder
Audio Generator
Modulator
Millival meter
Demodulator
Navigational coupler
Navigation set mount
Test facilities/main-tenance kit
Radio test set
Module tester
(AN/ARM-87)
Radio interference measuring set
Test set (AN/URM-120)
Test set (TS-1967)
VOR test set
SCAS test set
Pilot static system tester

Pulse Power T.S.
R.F. Power T.S.
Inertial Navigation T.S.
Gyro Stabilize Platform T.S.
Subassembly T.S.
Bench T.S.
T.S. Subassembly
Gyro T.S.
Electron Tube T.S.
Attitude Reference Control T.S.
Gyro & Compass Signal Simulator
Gyro Instrument/Tilt Table
Precise Angle/Angle Position Ind.
Decade Capacitor
Gyro Stabilized Platform Test Stand
Computer Mount
Purge & Fill Unit
Stop Watch
Test Tapes
Thermistor Mount
Antenna Mounting Fixture
Carriages
Slotted Section
Probe
Battery
Test Facilities Kit
Pulse Power Calibrator Meter
RF Power Meter
Differential Voltmeter
Horizontal Situation Indicator (HSI)
Digital Voltmeter
Transistor T.S.
Amplifier T.S.
Direction finder T.S.
Stabilization equipment T.S.
Rotary actuator T.S.
Attitude heading Reference T.S.
Accelerometer T.S.
Reference control tester
Gyro-magnetic T.S.
Electron tube T.S.
Radar altimeter T.S.
TACAN T.S.
Radar T.S.
Transponder T.S.
Simulator T.S.

TABLE 2-1 (Cont)

Measure:

Suppression Count
 Degrees w/syncro bridge
 Angular speed ($^{\circ}$ /sec)
 Time
 Voltage
 Resistance
 Current
 Power
 Frequency
 Continuity
 Waveform Characteristics
 Distortion
 Frequency Deviation
 Mechanical/angular position
 Vacuum Tube Characteristics
 Leakage (Rate)
 State gain
 Capacitance
 Output

Identify:

Symptom
 Faulty Section
 Faulty Stage
 Faulty Part/Component

Interpret:

Fault Isolation Tables/Charts
 Schematics/Wiring/Test
 Point Diagrams

 F.I. Charts/Tables
 Mechanical Diagrams

Calculate:

Radio set distortion
 S/N - S+N/N Ratios
 Difference Frequency
 Percent Modulation
 Bandwidth
 Slaving Rate
 Static Settling Points
 Settling Point Difference
 R'S Scale Error
 Heading Change
 Latitude Drift Rate
 Change (Δ) Heading Limits
 Attitude Change
 Pitch/Roll Excursion
 Stage Gain
 Total Loop Attenuation
 Cable Length
 Average Power Out
 Difference Voltage
 Peak Power
 Receiver Sensitivity
 Sideband W/Cal. Curves
 Center Frequencies
 Power W/Calibration Curves
 (Signal + Noise) / Noise
 Drift Rate (in A R C Minutes)
 Signal/Noise Ratio
 Required Adjustment

TABLE 2-1 (Cont)

Remove/Replace:

Covers, Panels, Housing
 Lamps
 Trays
 Gears/Gear Train
 Subassembly/Module
 Circuit Board/Card
 Component
 Cables - Wiring
 Screws
 Fasteners
 Washer
 Pin
 Nuts/Bolts
 Filter
 Connectors
 Worn Parts
 Memory Drum Pins
 Knobs
 Coaxial Cables
 Soldered Leads/Harness
 Electron Tubes
 Cams
 Ball Bearings

 Panel Lights
 Meters
 Soldered Components
 Soldered Semi- conductors
 Soldered Covers
 Retaining Ring
 Gaskets
 Soldered Leads/Harness
 Pad, Filter
 Load
 Stable Element
 Clamps
 Handling Fixture
 Safety Block

Monitor:

Audio Signal on Headset
 Test Set Displays/Indicators
 UUT Displays/Indicators
 Signal Generator
 Standing Wave Indicator
 Recorder Waveform
 Multimeter

Adjust:

Resistor
 Resistance W/Oscilloscope
 Resistance W/Meter
 Resistor W/Test Set Displays
 Resistor W/UUT Display
 Resistance W/Multimeter
 Resistance W/Headset
 Resistance W/Angular Speed
 Variable Resistors
 Inductor W/Tuning Wand
 Inductor W/Oscilloscope
 Inductor W/Wand and Meter
 Inductor W/Multimeter
 Inductor W/Frequency Meter
 Inductor W/ Headset
 Transformer W/Wand and Scope
 Transformer W/Meter
 Transformer W/Oscilloscope
 Capacitor(s)
 Capacitance W/Frequency Meter
 Capacitance W/Voltmeter
 Capacitance W/Oscilloscope
 Capacitance W/Meter
 Capacitance W/Headset
 Capacitor W/Test Set Displays
 Testset Controls W/Multimeter
 Testset Controls W/Oscilloscope
 Testset Controls W/Headset
 Testset Controls W/UUT Display
 Connector Body W/Meter

TABLE 2-1 (Cont)

Adjust: (cont.)

Output W/Testset Display
Tuning Screw W/Oscilloscope
Gear W/Meter
Crystal Drums W/Meter
Pressure W/Gauge
Drift Bias
Antenna Position
Resolver
UUT Controls
Tuner Transformers
Mechanical Alignment
Cams/Slipclutch
Thermal Delay Relay

Connect/Disconnect:

Cables
Electrical Connectors
Coaxial Connectors
Pressure Line
Electric Components

Apply:

Sealing Compound
Heat Conducting Compound
Lubricant
Review Symptom List
Repair Wiring
Assemble/Disassemble UUT
Record Test Results in Digital
Format
Perform UUT Adjustments
Solder/Desolder Components/Wiring
Perform Signal Substitution
Select Component
Check Part Value & Operation
Check Mechanical Operation
Disconnect/Connect Mechanical
Linkage

Test Transistor W/Tester
Test Tube W/Test Set
Verify Correct Performance Param.
Align Synchro
Load and Run Tapes
Fabricate Cables
Open/Close Valves
Perform Leak Test
Check Blower Operation
Check Diodes
Check Circuitry
Tag the Leads/Wires
Insert Switch Shaft
Dismount Heat Sinks
Apply Lubricant
Break/Apply Cement
Wrap the New Part
Clean Circuit Board
Apply Varnish
Inspect

Select Components/Valves
Fabricate Test Circuit (Diode)
Solder/Desolder Parts/Components
Test Transistor W/Tester
Select Components/Valves
Test Tube W/Test Set
Visual Inspection
Drill Hole in Cam & Shaft
Fabricate & Install Shims
Safety Wire Components
Identify Resistance by Color Code
Stripwire W/Thermal Stripper
Verify Blower Operation
Check Continuity

TABLE 2-1 (Cont)

Apply: (cont.)

Remove & Apply Circuit Card
Protective Coating

Mix Lubricant

Torque Fasteners

Clean Gasket & Mate Surface

Store Assembly on Foam Pad

Pressurize Unit

Check sweep sync

Check rf Source Marker

Check IF Output

Loosen/Tighten: Screws,Nuts

Scrape RTV/Coat with RTV

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procedures and instructions, and the use of computations for fault isolation. While these behaviors are common to maintenance of dissimilar systems, and may not provide a basis for determining different levels of commonality between similar systems, they do identify important requirements for measuring performance capability. The remaining elements are generally manipulative in nature; "Remove and replace," "Repair," "Apply," "Assemble/Disassemble," etc., and are included for task comparison on the basis of the knowledges required for their correct performance.

Enter task and element data--The concept of a generalizable job proficiency matrix is relatively straightforward. Along one dimension of the matrix are the critical tasks (i.e., the technical tasks) which define the particular MOS (e.g., Avionics Navigation and Flight Control Equipment Repairer). For this analysis, we were only concerned with the critical MOS tasks for both skill levels 1 and 2 and not the common soldiering tasks (e.g., first aid). Behavioral elements are included in the second dimension of the matrix.

The behavioral element and task data were entered into the matrix, tasks vertically and behavioral elements horizontally. For each element that is part of a task, an "x" was entered into the matrix (only one "x" per element/per task). These matrices provided the format for analyzing common behavioral elements within and between MOSs for the various equipments maintained. The task by element matrices for MOSs 35L, 35M, and 35R are contained in Appendix B.

Task lists were grouped into three categories of tasks for both skill levels. The categories were: troubleshooting or fault isolation, align/adjust, and remove/replace. The hypothesis

being that behaviors involved in troubleshooting with one MOS would be more similar to troubleshooting behaviors in the other two MOSs than to remove and replace behaviors even within the same MOS. The categorization format also served to make the matrix more readable and interpretable.

Revise matrices--After a preliminary draft of each matrix was constructed, it was shown to a team of subject matter experts at the Signal School and at Honeywell. Discrepancies, inconsistencies, and technical errors were eliminated. Definitions of elements were changed; some elements were merged into more general descriptors; some were further broken down until a consistent economical set of descriptors was developed. This procedure was then repeated for the other two MOSs. After each succeeding MOS was studied, further revisions were carried out on the initial matrix.

Task 2 - Develop Selection Criteria and Select Tasks and Elements for Testing

The task by element matrices developed in Task 1 identified commonalities within and across MOSs. Because the Signal School had to select tasks for testing on the SQTs for 35L, 35M, and 35R shortly after the beginning of this contract, it was not possible to apply the matrix for task selection on these particular SQTs. However, recommendations were made for testing based on the completed matrices. These recommendations can be used by the Signal School in subsequent SQT development or revised versions of the existing tests.

Even though the matrix concept was not applied directly to task selection, it was used successfully in the identification of

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those performance measures (steps) within a task that are most critical to overall task performance. Therefore, individual items in scorable units (task based tests) were in fact developed based on the behavioral elements necessary for successful task performance. Because the contract called for the development of written SQTs, the behavioral elements and tasks recommended for testing had to be amenable to written or pictorial formats.

Though the MOS tasks and elements recommended for testing were identified through matrix analysis, other factors were considered as well. These included: critical personnel or equipment hazard precautions, field maintenance data identifying high failure components (systems), and training deficiencies.

Task 2 produced two prioritized lists, one of tasks and one of behavioral elements. The element list consisted of those elements most amenable to testing in a written or pictorial format. Identification of elements required in many tasks was critical to the development of the prioritized task list. The task list was prioritized on how many and what combination of behavioral elements of an incumbent's job were required in task performance.

Commonality analysis--The behavioral elements were analyzed for commonality according to the number of systems each element supports. Because MOSs are assigned responsibility for systems rather than individual tasks, frequencies were tabulated for elements on a systems basis. Elements occurring relatively infrequently were not included in the revised list of elements.

A cutoff point for inclusion in the final list of common elements was determined by evaluating the number and type of systems, the number of systems each element supports, and the resulting

element list length. These criteria were applied iteratively, and relied heavily on the developer's knowledge of avionics maintenance job requirements. The set of behavioral elements was reviewed by Army subject matter experts at the Signal School and revised based on their recommendations.

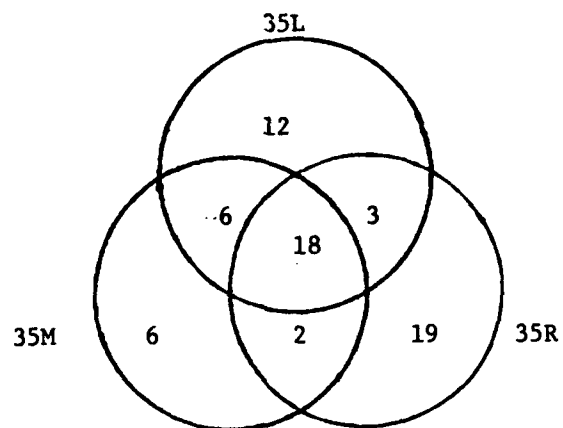
The resulting task by element matrices were used to identify commonality within and across MOSs. Table 2-2 lists the equipment responsibilities of each MOS. By grouping equipment based on its function, estimates of commonality were derived within and across MOSs. Figure 2-1 contains Venn diagrams illustrating the commonality of MOSs 35L, 35M, and 35R. Commonality is defined in terms of behavioral elements shared by MOSs. It may be observed that 35L and 35M have more in common with each other than either has with 35R, particularly in the areas of fault isolation and align and adjust.

Tables 2-3, 2-4, and 2-5 list those common elements occurrences for each of the MOSs. The columns F (fault isolate), A (align and adjust), and R (remove and replace) show the occurrence of elements in those maintenance type classifications. It is clear from these tables that fault isolate and align and adjust tasks are highly related. Table 2-6 lists elements occurring in all three of the MOSs and the columns show the occurrence by MOS and maintenance type. The table allows identification of elements common to MOS, maintenance type, or some combination of these. Table 2-7 is a list of elements which occur in the same maintenance classification of any two, or all three, MOSs.

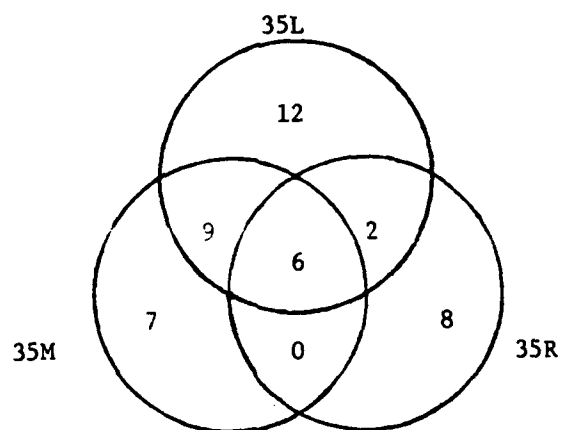
TABLE 2-2. EQUIPMENT BY MOS

<u>MOS 35L</u>	<u>Nomenclature</u>
AN/ARC-51BX	Radio set
AN/ARC-54	Radio set
AN/ARC-102	Radio set
AN/ARC-114	Radio set
AN/ARC-115	Radio set
AN/ARC-116	Radio set
AN/ARC-131	Radio set
AN/ARC-134	Radio set
AN/ARC-164	Radio set
C-1611/A1C	Control, intercommunication set
C-3940/ARC-94	Control, radio set
C-6533/ARC	Control, communication system
 <u>MOS 35M</u>	
AN/ARN-30	Receiving set, radio
AN/ARN-59	Direction finder set
AN/ARN-82	Radio receiving sets
AN/ARN-83	Direction finder set
AN/ARN-89	Direction finder set
AN/ARN-123	Radio receiving sets
AH-1 SCAS	Stability control augmentation system (helicopter)
A2/J2 compass	Compass
AN/ASN-43	Gyromagnetic compass set
AN/ASN-76	Attitude-heading reference set
AN/ASW-12	Automatic flight control system
CH47 SAS	Stability and control augmentation system
CH47 Spd TRIM AMP	Automatic speed trim amplifiers
CV-1275/ARN	Converter radio-magnetic indicator
R-1963/ARN	Radio receiver
R-1041/ARN	Receivers, radio
 <u>MOS 35R</u>	
AN/APM-305A	Test set, transponder set
CP941/ASN-86	Program load computer
RT-711/APN-158	Radar set
RT-804/APN-171	Altimeter set, electronic
RT-895/APX-72	Transponder
RT-1057/ARN-103	Navigational set, TACAN

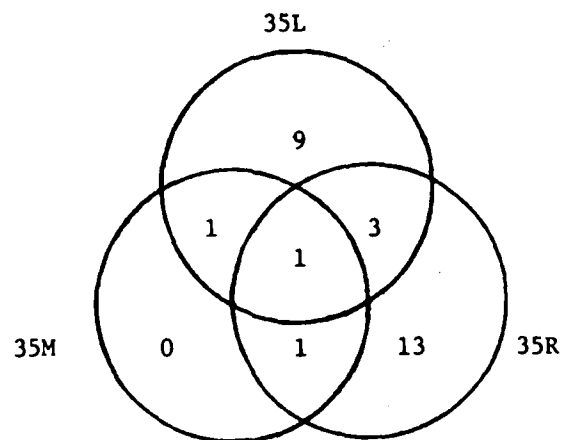
FAULT ISOLATION



ALIGN & ADJUST



REMOVE & REPLACE



NOTE: Number values represent numbers of elements in each group.

Figure 1. Element Commonality by MOS and Maintenance Type

TABLE 2-3. MOS35L COMMON ELEMENTS

	F	A	R
<u>35L COMMON ELEMENTS</u>			
Set-up, Connect, and Operate:			
Voltmeter/multimeter	x	x	
Oscilloscope	x	x	
Frequency counter/meter	x	x	
Wattmeter	x	x	
Signal generator	x	x	
Spectrum analyzer	x	x	
Attenuator	x	x	
Power supply	x	x	
Headset/microphone	x	x	
Modulation meter	x	x	
Test facilities/maintenance kit	x	x	
Radio test set	x	x	
Measure:			
Voltage	x	x	
Resistance	x		
Current	x		
Power output	x	x	
Frequency	x	x	
Continuity	x		
Waveform characteristics	x	x	
Distortion	x		
Frequency deviation	x		
Identify:			
Symptom	x		
Faulty section	x		
Faulty part	x		
Interpret:			
Fault isolation tables/charts	x		
Schematics/wiring/test point diagrams	x		
Calculate gain	x		
Monitor:			
Audio signal w/headset	x	x	
Test set displays	x		
Unit-Under-Test (UUT) displays	x		
F - fault isolate			
A - align & adjust			
R - remove & replace			

TABLE 2-3 (Cont)

	F	A	R
<u>35L COMMON ELEMENTS (continued)</u>			
Adjust:			
Capacitance w/voltmeter			x
Capacitance w/oscilloscope			x
Resistance w/multimeter	x	x	
Resistance w/oscilloscope	x	x	
Resistance w/headset			x
Inductor w/multimeter			x
Test set controls w/multimeter			x
Mechanical alignment		x	x
Remove and Replace:			
Covers/panels			x
Circuit cards	x	x	x
Knobs			x
Ballbearings			x
Screws			x
Nuts/bolts			x
Panel lights			x
Modules/subassemblies	x	x	x
Coaxial cables			x
Soldered:			
Leads/harness			x
Components	x	x	x
Electrical connectors			x
Select components/values	x	x	
Review symptom list	x		
Repair wiring	x		
Record test results in digital format	x		

TABLE 2-4. MOS35M COMMON ELEMENTS

	F	A	R
<u>35M COMMON ELEMENTS</u>			
Set-up, Connect, and Operate:			
Voltmeter/multimeter	x	x	
Oscilloscope	x	x	
Frequency counter/meter	x	x	
Wattmeter	x	x	
Signal generator	x	x	
Power supply	x	x	
Radio test set	x	x	
Pitot-static system tester	x	x	
Gyro-instrument tilt table	x	x	
Decade resistor	x	x	
Measure:			
Voltage	x	x	
Resistance	x		
Continuity	x	x	
Waveform characteristics	x		
Time	x	x	
Identify:			
Symptom	x		
Faulty section	x		
Faulty stage	x		
Faulty part	x		
Interpret:			
Fault isolation tables/charts	x		
Schematic/wiring/test point diagrams	x		
Calculate gain	x		
Monitor:			
Audio signal w/headset	x	x	
Test set displays	x		
Unit-Under-Test (UUT) displays	x		

F - fault isolate

A - align & adjust

R - remove & replace

TABLE 2-4 (Cont)

	F	A	R
<u>35M COMMON ELEMENTS (continued)</u>			
Adjust:			
Capacitance w/voltmeter		x	
Resistance w/multimeter	x	x	
Transformer w/multimeter		x	
Test set controls w/multimeter		x	
Mechanical alignment		x	
Gyro tilt table	x		
Remove and Replace:			
Screws	x	x	x
Modules/subassemblies	x		x
Soldered components	x	x	
Select components/values	x	x	
Test tube w/tester	x		
Apply lubricant			x

TABLE 2-5. MOS35R COMMON ELEMENTS

	F	A	R
<u>35R COMMON ELEMENTS</u>			
Set-up, Connect, and Operate:			
Voltmeter/multimeter	x	x	
Oscilloscope	x	x	
Frequency counter/meter	x	x	
Wattmeter	x	x	
Signal generator	x	x	
Power supply	x		
Pulse generator	x	x	
Radar test set	x	x	
Transponder test set	x	x	
Stopwatch	x		
Headset	x		
Battery	x		
Measure:			
Voltage	x		
Resistance	x		
Power output	x		
Frequency	x		
Waveform characteristics	x	x	
Time	x		
Identify:			
Symptom	x		
Faulty part	x		
Interpret:			
Fault isolation tables/charts	x		
Schematics/wiring/test point diagrams	x		
Mechanical diagram			x
Calculate:			
Gain	x		
Total loop attenuation	x		

F - fault isolate
A - align & adjust
R - remove & replace

TABLE 2-5 (Cont)

	F	A	R
<u>35R COMMON ELEMENTS</u> (continued)			
Monitor:			
Test set displays	x		
Unit-Under-Test (UUT) displays	x		
Signal generator	x		
Recorder waveform	x		
Adjust:			
Resistance w/multimeter	x	x	
Resistance w/test set displays	x	x	
Resistance w/UUT display	x		
Resistance w/oscilloscope			x
Test set control w/UUT display	x		
Test set control w/multimeter	x		
Unit-Under-Test (UUT)	x		
Remove and Replace:			
Covers/panels	x	x	x
Circuit cards			x
Modules/subassemblies	x	x	
Coaxial cables	x		
Components	x		x
Fasteners			x
Clamps			x
Connector pins			x
Lamps	x		
Loosen/tighten screws/nuts		x	
Connect/disconnect cable		x	
Connect/disconnect electrical connectors			x
Assemble/disassemble UUT		x	
Check continuity	x		
Check blower operation	x		
Verify correct performance parameters	x		
Apply lubricant			x
Torque fasteners			x
Stripwire w/thermal stripper			x

TABLE 1. ELEMENTS COMMON ACROSS MOSs

	MOS	35L	35M	35R
Maintenance Type	F A R	F A R	F A R	F A R
Set-up, Connect, and Operate:				
Voltmeter/multimeter	x x	x x	x x	
Oscilloscope	x x	x x	x x	
Frequency counter/meter	x x	x x	x x	
Wattmeter	x x	x x	x x	
Signal generator	x x	x x	x x	
Power supply	x x	x x	x	
Pulse generator				x x
Radar test set				x x
Transponder test set				x x
Radio test set	x x	x x		
Pitot-static system tester		x x		
Test facilities/maintenance kit	x x			
Modulation meter	x x			
Headset/microphone	x x			x
Gyro-instrument tilt table		x x		
Decade resistor		x x		
Stopwatch				x
Battery				x
Attenuator	x x			
Spectrum analyzer	x x			
Measure:				
Voltage	x x	x x		x
Resistance	x	x		x
Power output	x x			x
Frequency	x x			x
Waveform characteristics	x x	x		x x
Time		x x		x
Continuity	x	x x		
Distortion	x			
Frequency	x			
Frequency deviation	x			
Current	x			
Identify:				
Symptom	x	x		x
Faulty part	x	x		x
Faulty section	x	x		
Faulty stage		x		

F - fault isolate

A - align & adjust

R - remove & replace

TABLE 1 (cont)

	MOS	35L	35M	35R
Maintenance Type	F A R	F A R	F A R	F A R
Interpret:				
Fault isolation tables/charts	x	x		x
Schematics/wiring/test point diagrams	x	x		x
Calculate:				
Gain	x	x		x
Total loop attenuation				x
Monitor:				
Audio signal w/headset	x x	x x		
Test set displays	x	x		x
Unit-Under-Test (UUT) displays	x	x		x
Signal generator				x
Recorder waveform				x
Adjust:				
Capacitance w/voltmeter	x	x		
Capacitance w/oscilloscope	x			
Resistance w/multimeter	x x	x x		x x
Resistance w/oscilloscope	x x			x
Resistance w/headset	x			
Resistance w/test set displays				x x
Resistance w/UUT displays				x
Transformer w/multimeter		x		
Test set controls w/multimeter	x	x		x
Test set controls w/UUT display				x
Inductor w/multimeter	x			
UUT	x x	x		
Gyro tilt table		x		
Remove and Replace:				
Covers/panels		x		x x x
Circuit cards	x x x			x
Knobs		x		
Ballbearings		x		
Screws		x	x x x	
Nuts/bolts		x		
Panel lights/lamps		x		x
Modules/subassemblies	x x x	x	x	x x
Coaxial cables		x		x

TABLE 1 (cont)

	MOS	35L	35M	35R
Maintenance Type	F A R	F A R	F A R	F A R
Remove and Replace (continued)				
Soldered:				
Leads/harness		x		
Components	x x x	x x		
Components			x	x
Fasteners				x
Clamps				x
Connector pins				x
Connect/disconnect:				
Cables				x
Electrical connectors		x		x
Select components/values	x x	x x		
Review symptom list	x			
Repair wiring	x			
Record test results in digital format	x			
Test tube w/tester		x		
Apply lubricant			x	x
Loosen/tighten screws/nuts				x
Assemble/disassemble UUT				x
Check continuity			x	
Check blower operation			x	
Verify correct performance parameters			x	
Torque fasteners				x
Stripwire w/thermal strippers				x

TABLE 2. ELEMENTS COMMON TO 2/3 MOSS

Set-up, Connect, and Operate:

- Voltmeter/multimeter
- Oscilloscope
- Frequency counter/meter
- Wattmeter
- Signal generator
- Power supply
- Radio test set
- Headset microphone

Measure:

- Voltage
- Resistance
- Power output
- Frequency
- Waveform characteristics
- Time
- Continuity

Identify:

- Symptom
- Faulty section
- Faulty part

Interpret:

- Fault isolation tables/charts
- Schematic/wiring/test point diagrams

Calculate gain

Monitor:

- Audio signal w/headset
- Test set displays
- Unit-Under-Test displays

Adjust:

- Capacitance w/voltmeter
- Resistance w/multimeter
- Resistance w/oscilloscope
- Test set controls w/multimeter
- Mechanical alignment

TABLE 2 (cont)

Select components/values

Apply lubricant

Connect/disconnect electrical connectors

Remove and Replace:

Covers/panels

Circuit cards

Screws

Modules/subassemblies

Soldered components

Task prioritization--The MOS common elements were noted on each of the matrices and the occurrence of common elements in each task was used to prioritize the tasks. The resulting task lists, one for each maintenance type of each MOS, show which tasks best characterize the behavior requirements of the MOS incumbents. Furthermore, all common elements can be included in an SQT, because tasks can be readily identified in which these elements occur.

Tables 2-8, 2-9, and 2-10 list the prioritized tasks for each MOS, by task number. These numbers correspond to the task numbers contained in the current 35L, 35M, and 35R Soldier's Manuals.

An additional list was developed of elements amenable to written testing. Elements of behavior dealing with understanding, perception, and judgment are most appropriate for written testing. Elements requiring manipulation of tools, components, or alignment of parts would be further analyzed in Task 3 to determine if cognitive aspects existed which were testable. For example, manipulative elements may require knowledge of operation sequence, interpretation of alignment, or observation of safety procedures. These could be tested and so part of the behavior requirements could be measured. Table 2-11 lists the elements, or portions of elements, thus identified.

Task 3 - Develop SQTs

Honeywell developed written components of SQTs for MOSs 35L, 35M, and 35R. Scorable unit construction followed directly from the detailed analyses developed in the earlier tasks. Avionics experts employed by Honeywell's Avionics Division assisted in the SQT construction.

TABLE 2-8. MOS35L PRIORITIZED TASK LIST

FAULT ISOLATION

35L10	35L20
113-586-0003	113-586-0103
-0008	-0104
-0007	
-0043	
-0006	
-0046	
-0011	
-0012	
-0014	
-0024	
-0025	
-0045	
-0047	
-0042	
-0108	
-0005	
-0002	
-0004	
-0009	
-0032	
-0102	
-0106	
-0013	
-0033	
-0038	
-0001	
-0016	
-0141	
-0010	
-0031	
-0044	
-0107	
-0015	
-0034	
-0035	
-0039	
-0105	
-0101	

Note: Soldier's Manual Task Numbers

TABLE 2-8 (Cont)

ALIGN AND ADJUST

35L10	35L20
113-586-5010	113-586-5060
-5007	-5043
-5021	-5058
-5002	-5038
-5061	-5069
-5051	-5025
-5001	-5026
	-5044
	-8033
	-5015
	-5045
	-5057
	-5019

TABLE 2-8 (Cont)

REMOVE AND REPLACE

35L10	35L20
113-586-4027	113-586-4040
-4065	-4047
-4022	-4070
-4038	-4076
-4002	-4119
-4023	-4050
-4032	-4051
-4039	-4020
-4067	-4100
-4119	-4057
-4025	-4042
-4031	-4044
-4058	-4045
-4088	-4052
-5065	-4108
	-4102

TABLE 2-9. MOS35L PRIORITIZED TASK LIST

FAULT ISOLATION

35M10	35M20
113-585-0065	113-585-0219
-0042	-0106
-0044	-0220
-0063	-0221
-0C40	-0202
-0066	-0214
-0011	-0222
-0041	-0215
-0077	-0218
-0084	-0096
-0009	-0216
-0043	-0199
-0095	-0203
-0001	-0206
-0006	-8031
-0012	-0026
-0013	-8032
-0016	-0027
-0056	-8033
-0045	-0030
-0048	-8035
-0062	-0032
-0078	-8036
-0079	-0033
-0085	-8039
-0086	-0034
-0087	-8029
-0088	-0035
-0089	-8030
-0002	-0181
-0003	-0192
-0004	-8037
-0005	-8038
-0007	-8040
-0008	-0179
-0039	-0184
-0094	-0193
-0055	-0208
-0080	-0217
-0081	-0019
-0082	-0021
-0037	-0022
-0074	-0023
-0038	-0024
	-0025
	-0028
	-0029
	-0090
	-0180
	-0182
	-0183
	-0205
	-0213
	-0017
	-0091
	-0092
	-0093
	-0185

NOTE: Soldier's Manual Task Numbers

TABLE 2-9 (Cont)

ALIGN AND ADJUST

35M10	35M20
113-585-5014	113-585-5077
-5015	-5078
-5023	-5052
-5040	-5053
-5022	-5076
-5005	-5065
-5007	-5067
-5024	-5055
-5036	-5056
-5037	-5068
-5069	-5058
-5070	-5062
-5003	-5057
-5006	-5060
-5009	-5061
-5021	-5064
-5025	-5066
-5004	-5071
-5008	-5054
-5011	
-5031	
-5032	
-5033	
-5038	
-5039	
-5074	
-5075	
-5027	
-5028	
-5013	
-5072	
-5073	
-5002	
-5010	
-5034	
-5035	
-5029	
-5001	

TABLE 2-9 (Cont)

REMOVE AND REPLACE

35M10

113-585-4004

-4009

-4027

-4002

-4003

-4008

-4001

-4016

TABLE 2-10. MOS35R PRIORITIZED TASK LIST

FAULT ISOLATION

35R10

113-610-0083

-0026

-0033

-0038

-0027

-0084

-0028

-0029

-0032

-0045

-0044

-8012

-0082

-0030

-0046

-0043

35R20

113-610-0042

-0041

-0040

-8009

-8010

Note: Soldier's Manual Task Numbers

TABLE 2-10 (Cont)

ALIGN AND ADJUST

35R10	35R20
116-610-5019	113-610-5012
-5013	
-5015	
-5008	
-5009	
-5017	
-5014	

TABLE 2-10 (Cont)

REMOVE AND REPLACE

35R10	35R20
113-610-4019	113-610-4022
-4012	-4128
-4020	-4043
-4014	-4127
-4015	
-4016	
-4017	
-4029	
-4174	
-4028	
-4013	

TABLE 2-11. COGNITION ELEMENTS

Identify:

Symptom
Faulty section
Faulty part

Interpret:

Fault isolation tables/charts
Schematic/wiring/test point diagrams

Calculate gain

Monitor:

Test set displays
Unit-Under-Test displays

Select components/values

COGNITIVE PORTIONS OF OTHER ELEMENTS

Set-up, connect, and operate equipment

Measure parameters

Adjust parameters

Remove and replace hardware

Monitor audio signal

The goal of the SQT program is to provide an equitable, reliable and job relevant testing instrument for determining the proficiency of enlisted soldiers. The SQT must be task oriented and focus on behaviors with measurable outcomes. Honeywell developed the three final written components in accordance with the Individual Training and Evaluation (ITE) Directorate procedures and specifications for the development, editing, and production of skill qualification tests as stated in Chapter 5 of SQT GUIDELINES, 1 December 1977. HumRRO conducted a five-day workshop at Honeywell during the beginning of the development process to insure that the SQTs would be consistent with current guidance, procedures, and policy.

The HumRRO workshop resulted in the generation of fifteen sample scorable units (SU), five for each of the three MOSs. The sample scorable units were reviewed by HumRRO, the Signal School, and the Individual Training and Evaluation (ITE) directorate at Ft. Eustis. Review of the scorable units led to the following recommendations that were incorporated in all subsequent SU development.

- Increase the use of personal pronouns
- Consider including some part of the situation as part of the question narrative
- Keep the reading level at or below seventh grade ability
- Consider supporting questions with line drawings or photographs.

During a four month effort Honeywell developed 91 scorable units (SU) required by the test plans for MOSSs 35L, 35M, and 35R. Four hundred ninety-nine (499) measurable items were generated with an average of 5.5 items per SU. The SQTs for MOSSs 35M and 35R were submitted 25 August 1979, and the SQT for MOS 35L submitted 25 September 1979. All packages were delivered in camera ready form and included an index of SUs and an answer key. An iterative process of SQT development was followed. The steps involved are outlined below:

- identified all materials and references required for each scorable unit
- defined preliminary measurable items and any additional materials required
- developed initial drafts of SUs
- internally reviewed, critiqued, and edited each SU
- produced all necessary graphics and art work
- established a final format; final typed and printed all SQTs
- submitted the SQTs for Army review

Identify all materials--The first step in the SQT development process was to identify all materials and references required for each SU. Given the set of tasks selected for the written component, it was necessary to organize the Soldier's Manual task descriptions and all supporting technical material by scorable unit. Once completed, the definition of preliminary measurable items was initiated.

Define measurable items--Potential measurable items were selected on the basis of key elements. Key elements were isolated by

studying the task procedures, the task by element matrices produced in Task 1, and the commonality analyses completed in Task 2. Developing the SQT around key elements insured that testing would concentrate on those aspects of task performance most critical to an incumbent's MOS duties. It also increased the face validity of the test and consequently its acceptance. Key elements for the written component were primarily tasks involving task elements having grave negative consequences if performed incorrectly (e.g., related to personnel and equipment safety), and other task elements whose consequences are not as extreme, but nevertheless are performed incorrectly with high frequency. The latter category of elements identify the major performance deficiencies. The SQT guidelines identify four basic areas of performance deficiencies. These relate to where, when, what, and how to perform. More specifically:

- Soldiers may not know where to perform a task. They may be having difficulty locating objects and differentiating between objects.
- Soldiers may not know when to perform a step. They may be unfamiliar with the sequence of activities in a given situation.
- Soldiers may not know what the product is for a given task. They may not realize what the result should be.
- Soldiers may not know how to perform a procedure. They may not remember the correct set of actions required to execute a task.

Another variable moderating the selection of key elements for testing was the behavioral element commonality analysis. Unique SUs were not always required for each task common across MOSSs.

In many of these cases the same SU was used in more than one SQT. This facilitates more equitable scoring and standardization of written components by building on commonality.

Common behavioral elements occurring in many distinct tasks were not tested in every task. For example, if a key element had been satisfactorily covered in a previous scorable unit within the same MOS, it was not retested on all subsequent opportunities. This helped to reduce the total number of questions on an SQT and thus shortened the testing time required without reducing the generalizability of the test. It also offered the opportunity to test on a wider range of behavioral elements. This preliminary definition of measurable items also identified supporting documentation such as line drawings, schematics, and background material useful in drafting the SUs.

Develop draft scorable units--Once the potential test questions were selected, initial drafts of the SUs were generated. There are two basic modes of testing the key elements. The first mode is written performance. This type of question measures the examinee's ability to perform a task. The item requires the examinee to perform all steps of a task/task element as he would perform it on the job and to select the correct answers from a set of real world alternatives. The second mode of testing used is performance based. This type of question measures how an examinee would perform a task given a specific situation. When written correctly both modes of testing can provide a comprehensive evaluation of key elements. Of the two testing modes, performance based questions were written most frequently. This was due to the nature of the tasks and the limitations imposed by the written component environment. The following criteria define whether written performance or performance based items are appropriate:

1. Can the entire task be performed at the written component station?
2. Can a task element be performed at the written component station?
3. Can the correct task product be recognized without actually performing the task or task element?

The final criterion has a significant implication for the written component of the SQT. Questions are constrained by answers which are amenable to a multiple choice recognition response. That is, the examinee will read the question, formulate an answer, compare his answer with the list of alternatives, and select the alternative which corresponds with his answer. If the correct task product can be recognized from a list of alternatives without performing the task, there is no benefit in having him perform it.

When developing initial drafts of the measurable items, the correct answer was determined for a key element, the situation was described, the question written, and real-world alternatives were selected. Draft SUs consisted of two to ten measurable items.

Conduct internal review--Once a draft SU was completed, it was submitted for internal review. Honeywell SMEs used the following guidelines for critiques and editing.

- Technical accuracy: the right alternative is absolutely correct and the wrong alternatives are absolutely incorrect. Each measurable item has only one correct answer and is capable of distinguishing between performers and non-performers.

- Doctrinal accuracy: only task elements specified in or implied by the Soldier's Manual are tested.
- Items must test the application of knowledge rather than knowledge alone.
- The job situation provides only information necessary to establish the framework for the questions.
- Test language is as simple as possible, but does not omit routinely used technical terms and job language.
- Questions are written in the active voice.
- Art work and graphics are used appropriately.
- The letter code sequence of the correct answers is random and evenly distributed.
- Incorrect alternatives are common and/or reasonable errors. (The goal was to guarantee that if the examinee figures out a wrong answer, based on clearly incorrect yet plausible false assumptions, that it can be found among the alternatives presented.) Three to five alternatives were developed for each question.
- Items must be independently solved. This implies (a) the stem of one item should not cue the examinee to the answer in another item, (b) items should not contain cues to their own answers, (c) answers should not be interdependent.
- Items within an SU are ordered in operational sequence.
- Included are all necessary technical extracts that are authorized and routinely used on the job--(not to exceed thirty pages/SU).

Produce art work--After the draft scorable units were reviewed, all necessary graphics and art work were produced. To support the narratives, drawings, tables, diagrams, and schematics were used for presenting cues. This allowed the opportunity for innovative job oriented questions including:

- meter/scope reading
- test equipment setup and operation
- schematic interpretation
- observation of safety precaution
- module alignment
- component location/identification
- theory application.

Establish final format and submit SQTs to Signal School--Honeywell established a final format for the SQTs and final typed and printed the scorable units. Answer sheets and an index of SUS were included in the package that was submitted to the Army for review.

There are two basic modes of scorable units; written performance and performance based. There are five major categories of key elements related to incorrect task performance and adverse consequences of incorrect task performance. These categories include where, when, what, and how to perform, as well as personnel and equipment safety. Table 2-12 depicts the frequency with which various question types were written. Figure 2-2 is a set of sample measurement items representing the categories defined in Table 2-12. The completed SQT written components are not included because of their proprietary nature. In order to assure standardization and

TABLE 2-12. QUESTION TYPE FREQUENCY

Key Elements

	Incorrect Task Performance				Consequences of Faulty Task Performance
	Where to Perform	When to Perform	What the Product Is	How to Perform	
Written Performance	3.1%	0%	4.7%	10.4%	0%
Class-ification	I	II	III	IV	V
Performance Based	10.4%	18.2%	27.6%	22.4%	3.2%
Class-ification	VI	VII	VIII	IX	X

Testing Mode

Table 8
Classification

SAMPLE MEASUREMENT
ITEMS

- I. You are doing the zero altitude alignment on tracker card
A1. Which resistor in figure 17-1 should you adjust for
 0.000 ± 0.007 Vdc?
- A. resistor A C. resistor C
B. resistor B D. resistor D

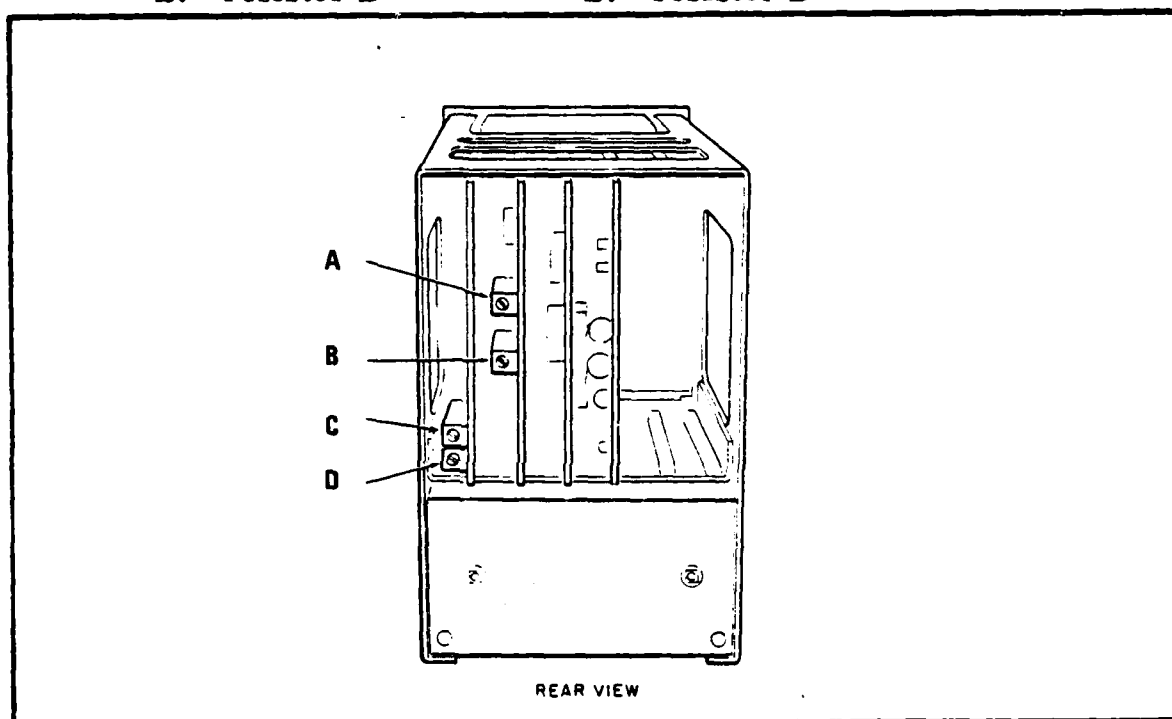


Figure 17-1

- II. No measurement item.

Figure 2-2

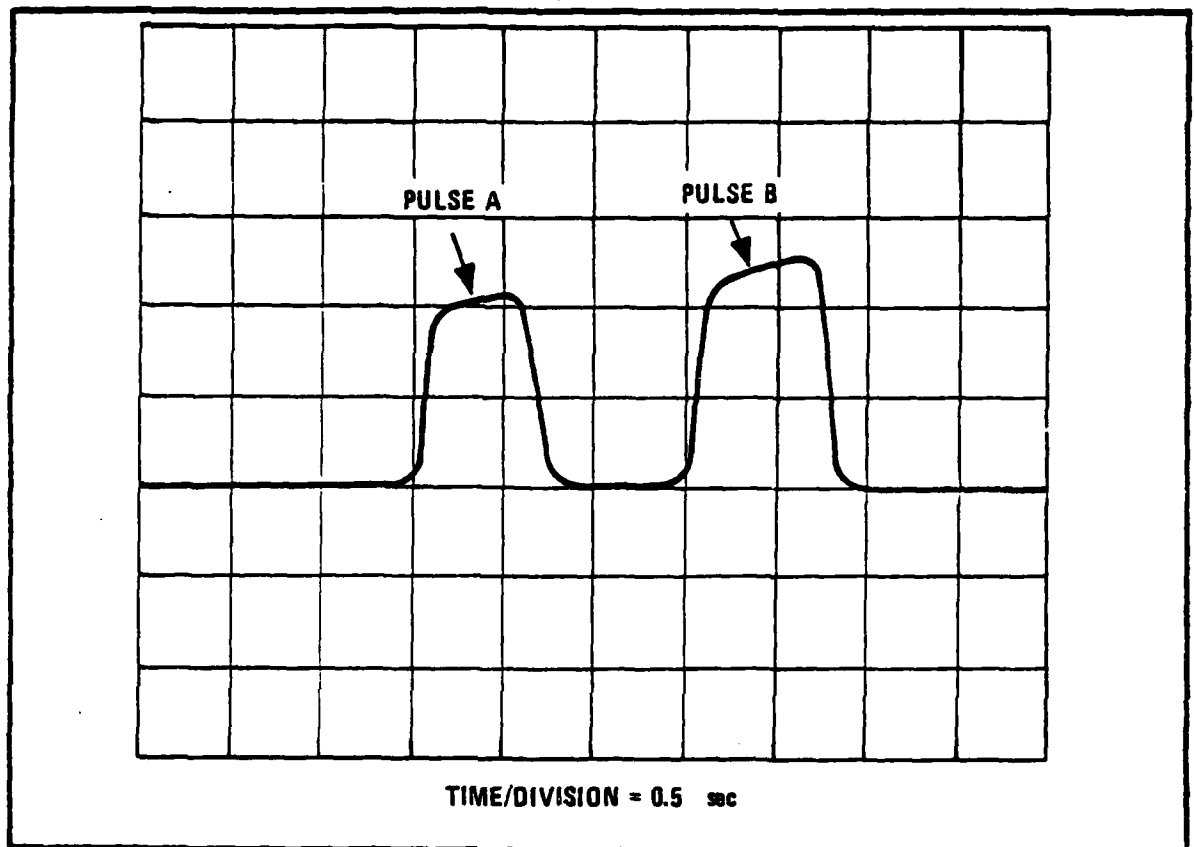


Figure 22-2

III. What is the pulse width of pulse A in figure 22-2 at the 50 percent amplitude point?

- A. 0.50 sec
- B. 0.65 sec
- C. 0.75 sec
- D. 1.00 sec

Figure 2-2 (cont.)

IV. You have connected the audio oscillator and VTVM to the appropriate test points to measure the stage gain of Q13. You have adjusted the signal output to 400 cps and an output level of 33 mv. You get a VTVM reading as shown in figure 15-2. What is the stage gain of Q13?

A. 0.047

D. 21.0

B. 2.1

E. 26.0

C. 6.0

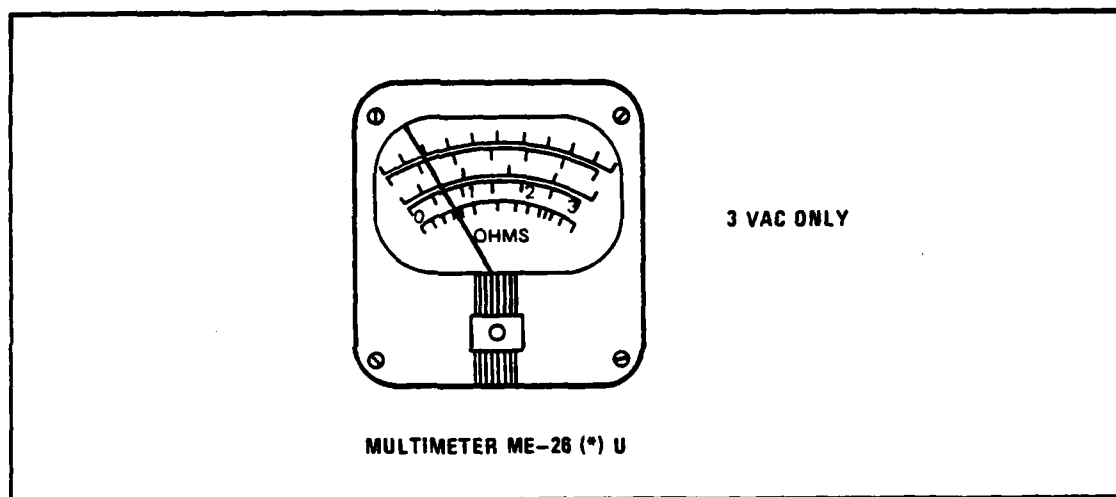


Figure 15-2

V. No measurement item.

Figure 2-2 (cont.)

VI. Which test point in figure 15-3 is the emitter of transistor Q13? Use schematic (figure 15-4) to help answer this question.

- A. test point A
- B. test point B
- C. test point C
- D. test point D

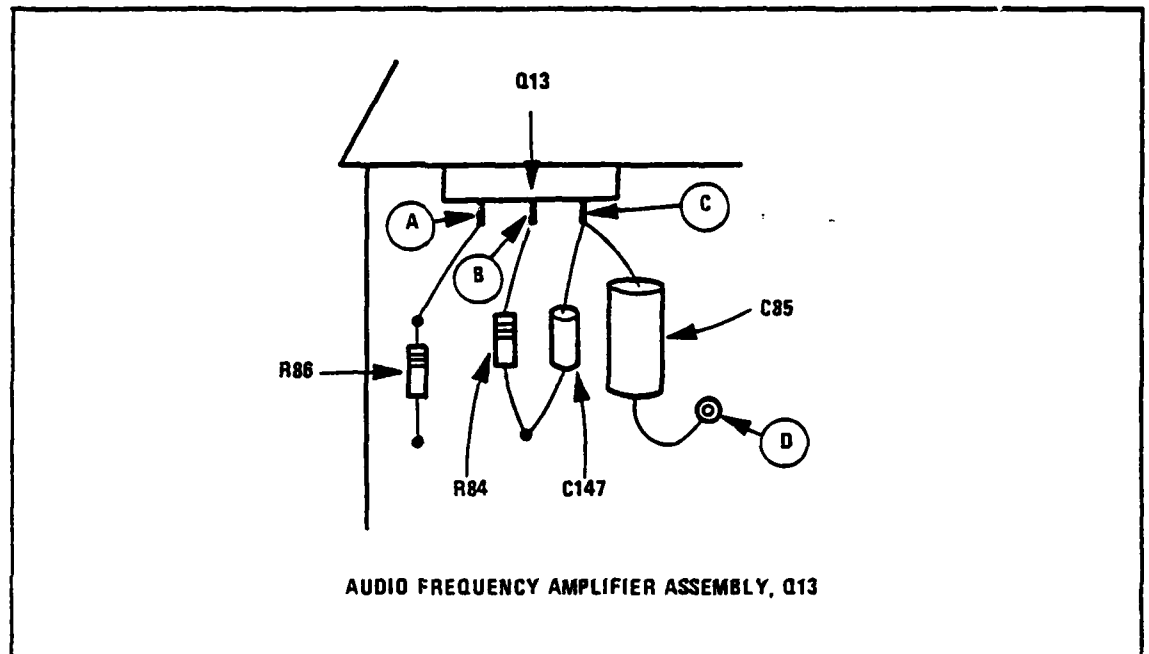


Figure 15-3

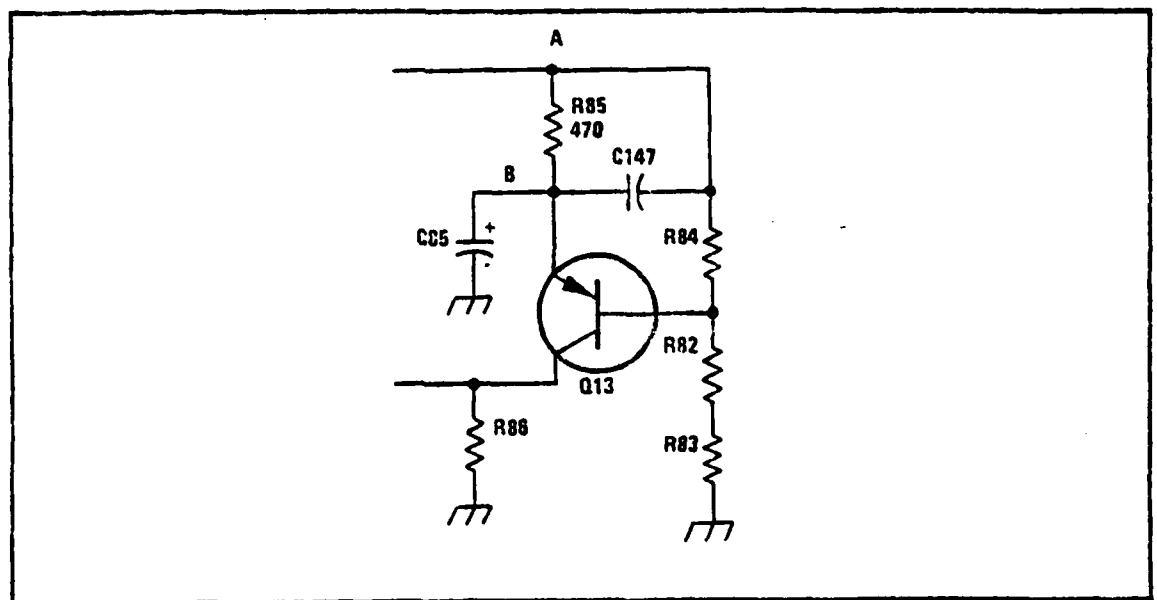


Figure 15-4

Figure 2-2 (cont.)

VII. During performance of step 3-7g(9) of the synchronization test, you read 333° on the angle position indicator. What is your next step?

- A. perform step 3-7h(1)
- B. synchronize the ASN-43 system
- C. measure voltage at test points
- D. measure resistance at test points

VIII. You are setting the MK-733 controls required for the Control Unit Test. Which of the following switch configurations is correct?

Figure 2-2 (cont.)

A.

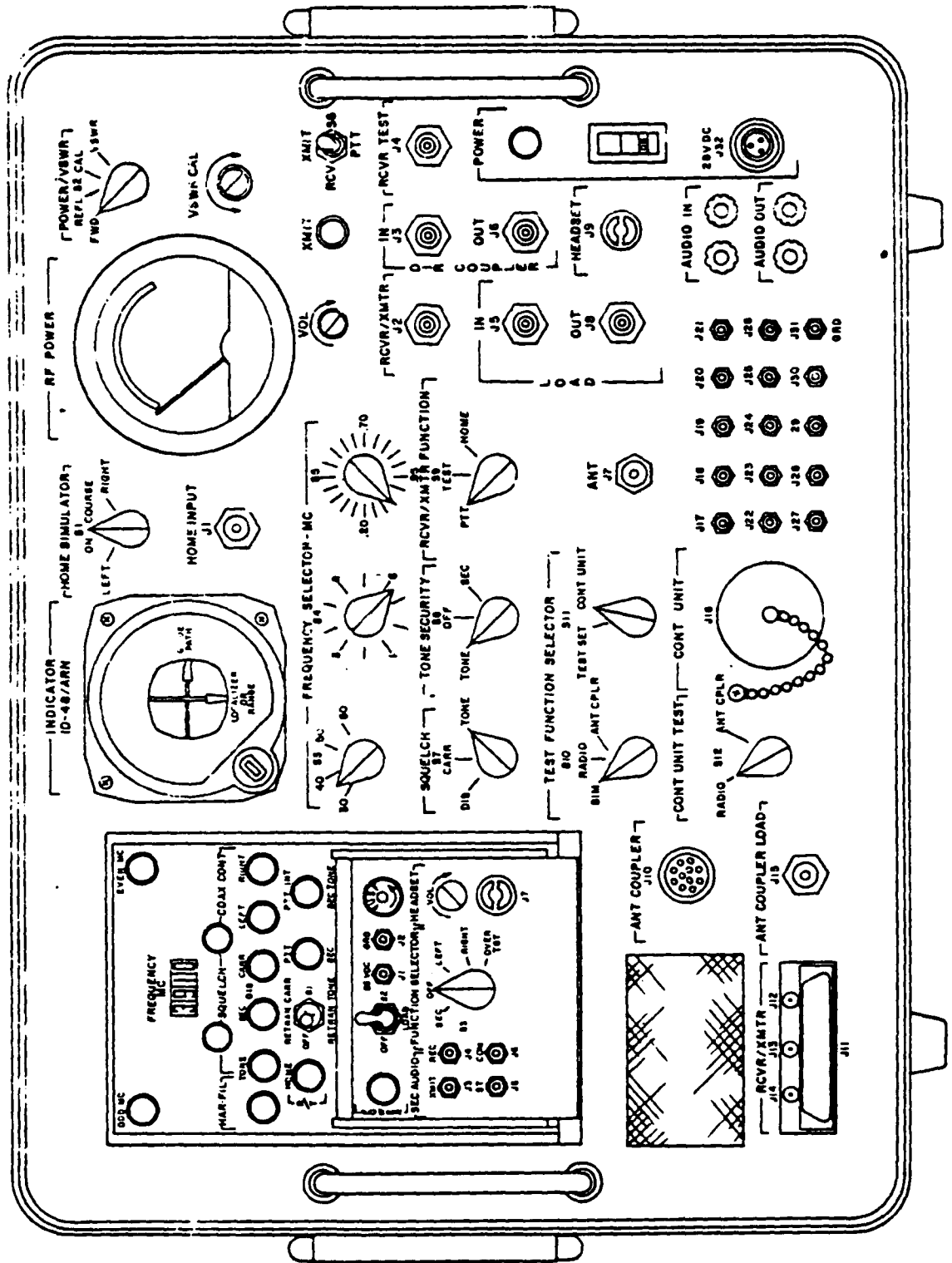


Figure 2-2 (cont.)

B.

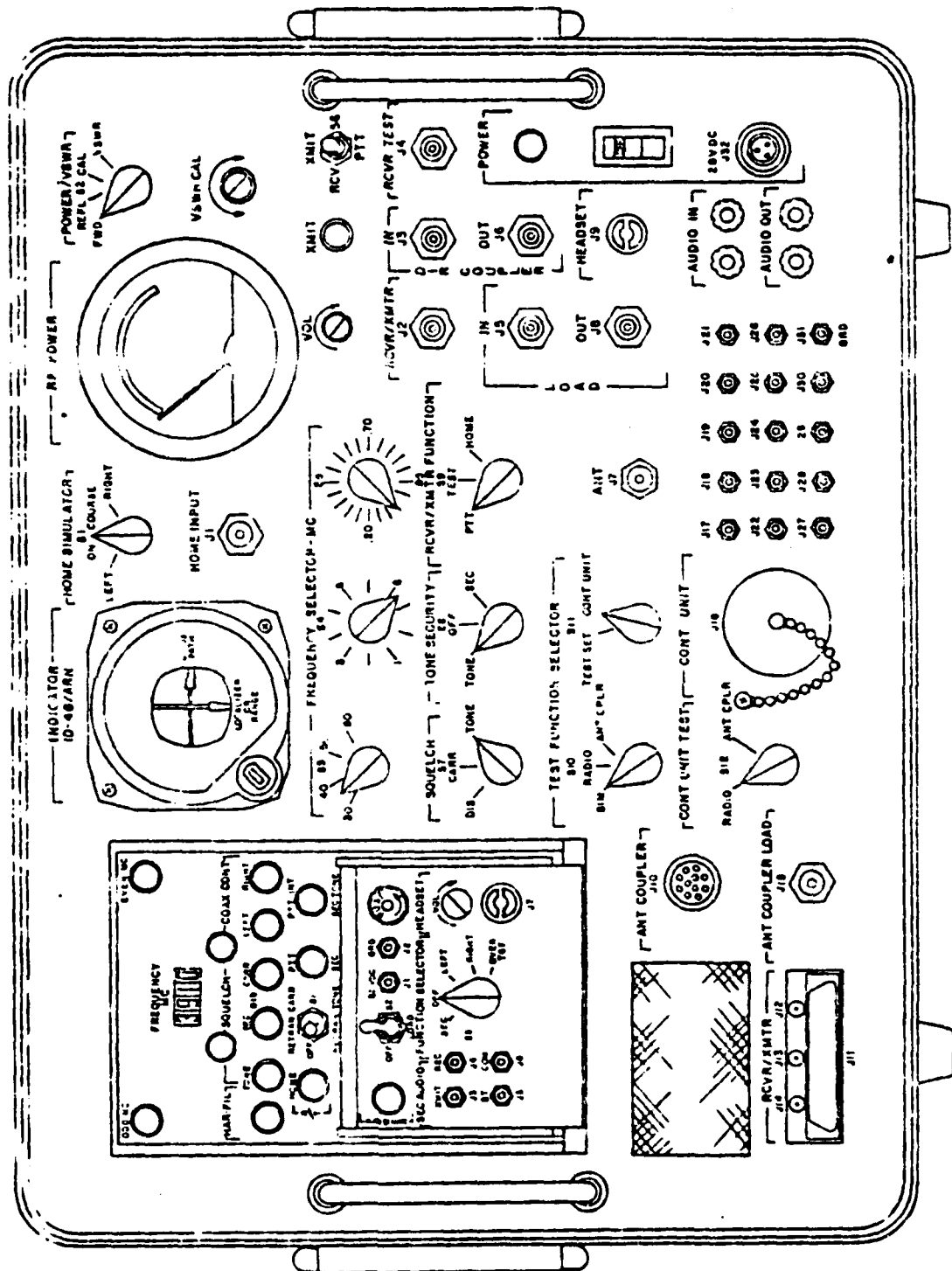


Figure 2-2 (cont.)

C.

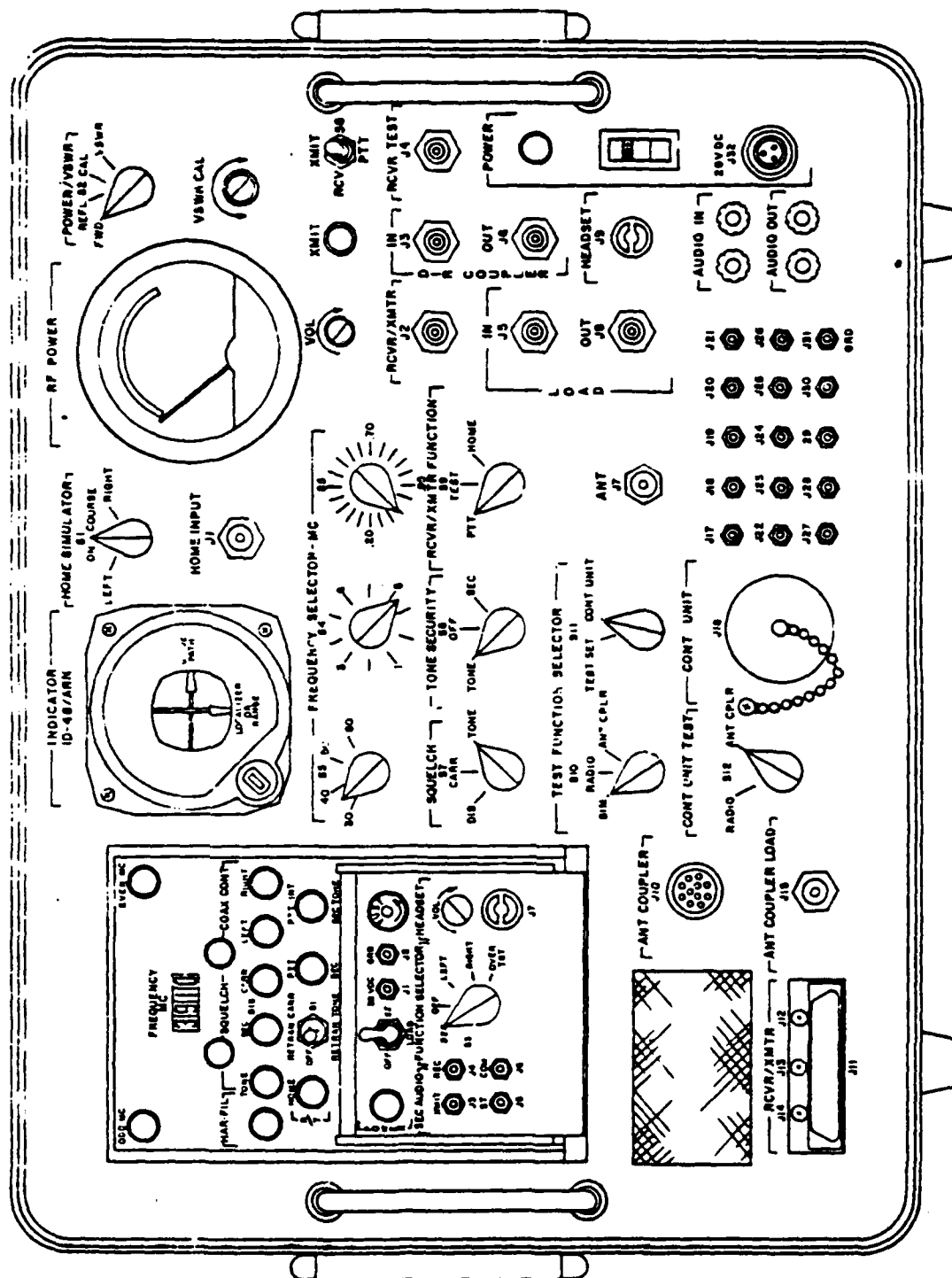
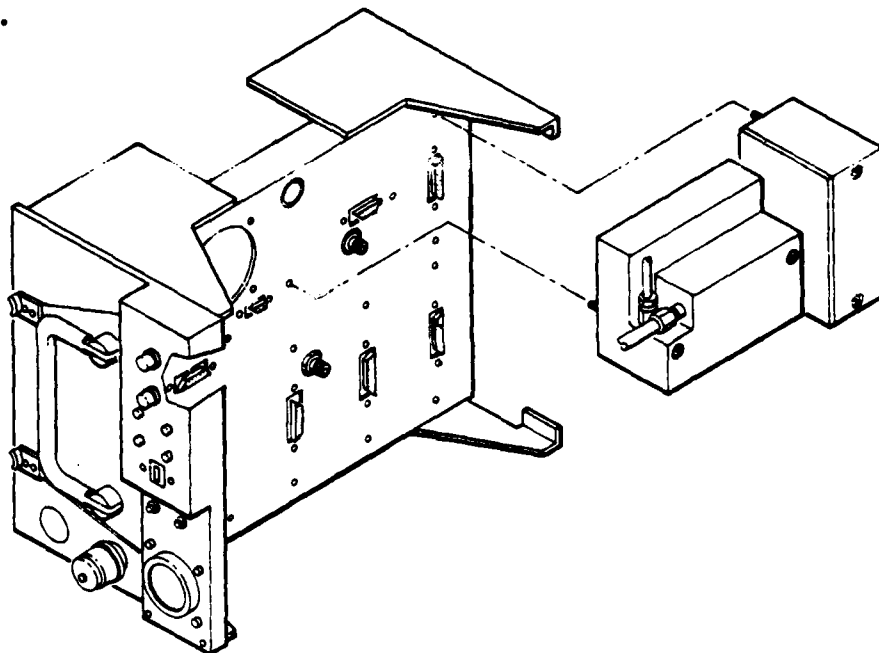


Figure 2-2 (cont.)

IX. You are installing receiver 1RE1. How should you position receiver 1RE1 with respect to the chassis assembly?

A.



B.

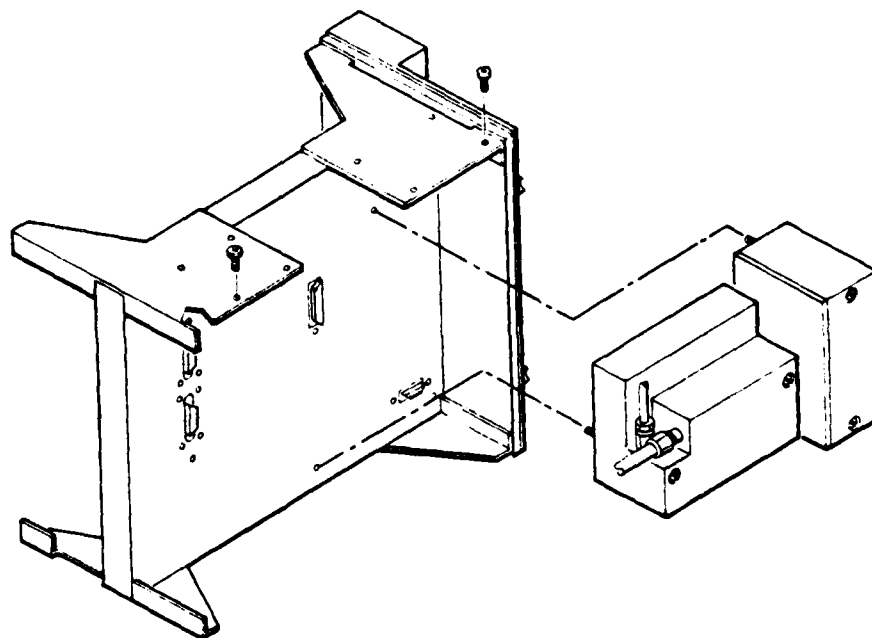
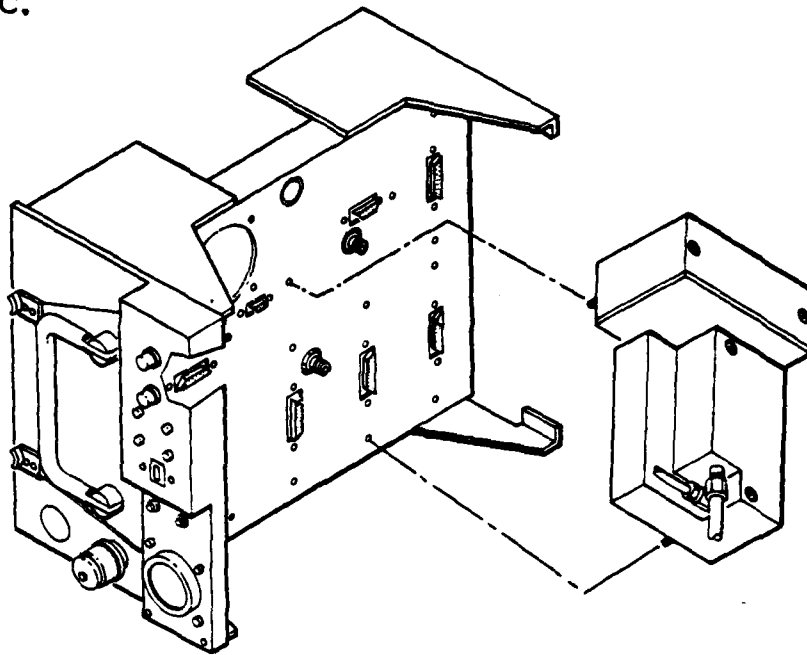


Figure 2-2 (cont.)

C.



- X. What precaution should you take to prevent the RF power output of the radio set from damaging test equipment?
- A. insert a 20 dB power attenuator between the radio set and the test equipment
 - B. always press the front panel TONE button with the RADIO TEST selector switch in position 6
 - C. ensure that the power source does not exceed 115 Vac
 - D. insert an RF coupler between the power amplifier Q2 and the low pass filter L4-L13

Figure 2-2 (cont.)

fairness, release of the actual test contents must be controlled by the Signal School and TRADOC. Table 2-13 shows the distribution of the correct alternative letter codes for the SQT written components.

Task 4 - Evaluate Specificity of Required Task Analysis Documentation

Develop interview protocol--An interview protocol was developed to examine aspects of the task analysis documentation, including degree of specificity and detail required, and the adequacy of SQTs developed from the task analysis. The interview protocol was designed as a stimulus for discussion in these areas and to guide rather than inhibit discussion. Consequently, the questions were presented in an open ended format.

The interview questions covered two main areas: 1) the position of the individual within the organization and his particular responsibilities. Included were questions on the individual's staff, resource constraints, student involvement (if any), regulation of tasks by doctrine, and type of documents used and produced; and 2) the individual's use and/or view of potential for task analysis methodologies such as the Generalizable Job Proficiency Matrix (GJPM). This area included questions on possible use of the GJPM, its resultant effect, and its relationship to governing doctrine. Included also were questions on the required level of specificity for the GJPM to show maximal usefulness.

The interviewer was supplied with a partially coded version of the protocol, designed so that he could enter information into particular response categories quickly, and also record

TABLE 2-13. RESPONSE CODE DISTRIBUTION.

Correct Alternative Code

SQT	MOS	# UNITS	A	B	C	D	E	TOTAL
2	35L	9	13	12	12	10	4	51
	35M	32	30	41	30	31	13	145
	35R	18	20	32	33	35	5	125
	TOTAL	59	63	85	75	76	22	321
3	35L	10	10	12	15	9	4	50
	35M	13	12	21	18	11	5	67
	35R	9	14	19	10	15	3	61
	TOTAL	32	36	52	43	35	12	178
GRAND TOTAL		91	99	137	118	111	34	499
		%	$\frac{20}{20}$	$\frac{27}{27}$	$\frac{24}{24}$	$\frac{22}{22}$	$\frac{7}{7}$ *	$\frac{100}{100}$

* A total of 106 of 499 measurement items had 5 alternatives.

any elaboration (and/or relevant digression) that may occur during the course of the interview.

Appendix C gives the complete protocols for the interviewer and interviewee.

Conduct interviews--Interviews were conducted with personnel at the U.S. Army Signal School at Ft. Gordon.

Personnel interviewed represented three organizations:

- Avionics Task Analysis Division
- Avionics (Training) Design and Development Division
- Instructors for 35B, 35L, 35R, and 35K MOSs.

Personnel from the Avionics Task Analysis Division and instructors were interviewed individually. Personnel from the Design and Development Division participated in a large group discussion with the interviewers. The results of the interviews are summarized below:

SQT development--Written portions of the SQTs for MOSs 35R, 35L, and 35M were judged very positively by all individuals who responded. Areas viewed particularly favorably include:

- The use of tech manual abstracts for a portion of the questions. These questions required that the examinee find the relevant information in the abstract for answering the question. This method was viewed positively since it was more representative of the type of actions that the soldier would actually do in the field.

- The use of graphics depicting actual equipment configurations.
- The range and representativeness of the questions.
- Coverage of different generations of equipment (e.g., obsolete but still used tube type equipment to latest generation equipment).
- Representation of some of the skills necessary in troubleshooting.

Negative comments on the SQTs were minimal. The question was raised about the reading level of the SQT items. TRADOC demands that SQTs be written at a 7th grade reading level. However, the use of actual technical manual extracts in the questions may to some degree violate this principle, since technical manuals are often written at a higher reading level. This problem was viewed more as indicative of the variation in technical manuals than of the SQT use of technical manual extracts, and it was suggested that the reading level of technical manuals be subjected to greater standardization for future equipment.

Generalizable Job Proficiency Matrix--The Generalizable Job Proficiency Matrix (GJPM) was in general judged to be a useful conceptual device for the task analysis used to define MOS related skills. Four areas of possible use of the GJPM were proposed by the interviewer, and were discussed with the participants. These were:

- SQT development and skill evaluation
- Training requirements
- Training media requirements
- MOS management.

The use of the GJPM for constructing the written portion of the SQTs for MOSs 35L, 35M, and 35R was viewed very favorably. However, it was pointed out that the GJPM could not be used in the development of all SQT; those at higher skill levels, especially those which are not easily proceduralized such as a supervisory MOS, do not lend themselves as well to GJPM analysis, and therefore the GJPM is less useful in such SQT developmental activities.

The topics of what was to be trained, and the methods to go about training were discussed together. The GJPM was viewed as a useful device in defining training requirements due to its orientation to actual task performance rather than abstract knowledge. Consequently, the GJPM would be most relevant in the Design and Development Division. The suggestion by the interviewer that the GJPM could be used to define training device requirements and aid in device design considerations was viewed with interest tempered by limited familiarity with maintenance training simulators in general. However, the need was expressed for devices to aid in the hands-on portion of the SQTs, especially in fault isolation.

A common statement was made that the MOS system must be oriented to better match the specific needs of the field, the assignment of skill levels to job requirements, and the accommodation of new generation equipment to MOS creation or allocation. In general, the GJPM was viewed as a potentially useful device for MOS management, both within an MOS and across MOSs. It was decided that the GJPM would be a useful tool for documenting the necessity for MOS examination, especially since changes are typically proposed with less formal documentation.

Specificity of the GJPM--A major issue concerns the degree of task analysis specificity required in the GJPM for it to be a useful analysis device. Since the GJPM is most useful in discerning commonalities and differences in tasks at the generic level, the question becomes how generic are those tasks; that is, where along a specificity-genericness dimension would the task analysis be most useful.

The consensus in the specificity issue during the interviews was that the level of the task analysis represented in the GJPM was sufficient for the development of the particular SQTs addressed, but that the specificity may need to be altered for other applications. The level of specificity in the GJPM was viewed particularly favorably since it pointed out the degree to which technical manuals differed in the description of the same tasks; the GJPM could therefore serve as a device to document the necessity for standardization of technical information. The necessity for subject matter experts (SMEs) at all stages of GJPM development, both from the Signal School and from the contractor, was pointed out very strongly, to monitor appropriateness of task selection and specificity, both from a technical standpoint and from the standpoint of the purpose for which the particular GJPM was to be used.

The present contract specified that the task by element matrices developed for the three Army avionics MOSSs would be used to develop scorable units for the written component of the three SQTs. This requirement had a major impact on the development of the matrix concept. The purpose for which the matrix would be used, the available task analysis documentation, the Soldier's Manual and technical manuals, and the MOS structure

all served to impose constraints or boundary conditions on the structure, form, and level of specificity of the analysis.

The approach followed in defining behavioral elements is logical, straightforward, easily interpretable, and easily applied. Yet it must be stressed that the concept and definition of a behavioral element must always be a function of both the technical data available and the ultimate purpose to which the matrix will be applied. For example, a person concerned with MOS reorganization would use different behavioral elements from one preparing a functional specification. In the first case, behavioral elements for the matrix may be subtasks of the critical tasks in the MOS (e.g., critical task - adjust RT-XXX - may be broken down into the following elements--adjust gain, adjust squelch, adjust carrier signal, etc.) whereas someone concerned with defining a functional specification for a training simulation facility would be concerned with more discrete behaviors (e.g., monitor test set meter, push reset button in, turn homing knob to 270°). Other potential developers and users of the GJPM concept must always adjust their use of the concept based on their specific requirements.

SECTION III

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The objectives of this study were to develop task by behavioral element matrices (Generalizable Job Proficiency Matrices (GJPM) for three avionics MOSs 35L, 35M, and 35R) and to use the task commonality to develop written components of SQTs for those MOSs. The following three major conclusions can be drawn from the performance of the study.

1. The Generalizable Job Proficiency Matrix was a significant aid in developing written SQTs that were representative and exhaustive of the tasks necessary for adequate performance within the MOS. Specifically, the GJPM allowed (and demanded) the analysis of the MOS such that the task results were at the behavioral level most useful for the development of scorable units. Moreover, the use of the standard Soldier's and technical manuals for the source of the tasks helped to assure that the SQTs would conform to acceptable training standards and formats. The use of extracts and graphics from the technical manuals and Soldier's Manuals as part of the SQT question stems added further to the representation in the SQT of the type of tasks that the soldier would be performing in the field.

2. The process of constructing the GJPM itself led to greater understanding of the skills and responsibilities of each MOS. Constructing the GJPM demanded an in depth analysis of the requirements of each MOS, including the types of equipment used, the particular actions to be performed, and the necessary knowledge base to perform adequately in the MOS. However, the use of subject matter experts (SMEs) in the process was required due to the judgments that were necessary on the nature of equipment, actions, and knowledge commonalities and differences. The GJPM served the purpose of consensual validation for the developers to the extent that it provided in matrix form a recognizable description of major MOS elements, but also pointed out areas of commonality that were not previously apparent, and, conversely, areas of difference where commonality was assumed. The GJPM therefore served a large function as a documentation device describing in an objective manner MOS elements that were hitherto treated in a more informal manner.
3. The specificity of the task analysis in the GJPM was appropriate for SQT development, but may be altered as the use for which the GJPM is intended varies. A major question in the development of a "generic task" matrix is the level at which tasks are judged similar. Greater similarity judgments are appropriate when the goal is to compare MOSs than when the goal is to define scorable units within an MOS. The process of deciding the level of specificity also will lead to greater understanding of a given MOS and its relationship to other MOSs.

Recommendations

The success of the GJPM concept in the development of SQTs for three avionics MOSSs suggests further application of the concept. Specifically, these applications may include:

1. Extension of the GJPM to other MOSSs, both with the objective of further SQT development and as a general analysis tool. Ft. Gordon is responsible for the training and evaluation of 54 MOSSs. The use of the GJPM (with appropriate SMEs) to analyze these MOSSs would allow determination of commonalities that could be exploited in both training and SQT development. Computerization of the GJPM concept would allow ready analysis, and revision of MOS requirements as new generation equipment is added and obsolete equipment deleted.
2. The GJPM concept can be used for determining training requirements and for the design of training media and devices to meet the training requirements. A useful addition to the training of maintenance functions would be bench-type simulated actual equipment trainers with high structured fidelity, but with functional capability to meet major training requirements. The capabilities of the media and training devices are determined using the GJPM to identify major training requirements; the media are then chosen and the training devices are designed to meet the major training requirements. The use of the GJPM in conjunction with specially designed training equipment could also serve as the medium for the hands-on component of the SQTs. Such training equipment

has the advantage over actual equipment of greater fault insertion for demonstration of troubleshooting skills. Devices designed using generic GJPM elements may also serve training across MOSs.

3. The GJPM can be used as a method for the analysis and documentation of MOS management. The MOS system is faced with the accumulation of new technology, lower skill levels of students, and meeting the needs of the field. The GJPM can describe the task requirements of these sources as well as the task elements present in existing MOSs either to lead to the best match to existing MOSs, or to support the need for MOS revision in the creation of new MOSs. The GJPM can serve as a standardized documentation device supporting recommendations generally relevant to MOSs.

REFERENCES

- Austin, H. A computation view of the skill of juggling. Artificial Intelligence Memo No. 330. Massachusetts Institute of Technology, Cambridge, Massachusetts, December 1974.
- Bloom, B. S. (Ed.). Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain. New York: David McKay Company, 1956.
- Bownas, D. A. and Cooper, M. A. Review of reported behavior and performance taxonomies. Minneapolis, MN: Personnel Decisions Research Institute, 1978.
- Branson, R. K. The interservice procedures for instructional systems development. Educational Technology, XVIII, 3, March 1978, 11-14.
- Cunningham, J. W. Development and validation of the Occupational Analysis Inventory: An "ergometric" approach to an educational problem. Occasional Paper No. 15. National Center for Occupational Education, North Carolina State University, Raleigh, North Carolina, 1972.
- Ekstrom, R. B., French, J. W., & Harman, H. H. An attempt to confirm five recently identified cognitive factors. Technical Report No. 8. Educational Testing Service, Princeton, New Jersey, June 1975.
- French, J. W. Toward the establishment of non-cognitive factors through literature search and interpretation. Technical Report No. 1. Educational Testing Service, Princeton, New Jersey, July 1973.
- Guilford, J. P., & Hoepfner, R. The analysis of intelligence. New York: McGraw-Hill, 1971.
- Maier, M. H. and Hirshfeld, S. F. "Job Proficiency Testing for Training and Personnel Management," Army Research Institute Technical Report, 1978.
- Maier, M. H. and Hirshfeld, S. F. "A Large-Scale Application of Criterion-Referenced Testing and Measurement," Proceedings of the 23rd Conference on the Design of Experiments in Army Research, Development and Testing, Monterey, California, ARO Report 78-2, 1978.

McCormick, E. J., Jeanneret, P. R., & Mecham, R. C. A study of job characteristics and job dimensions as based on the Position Analysis Questionnaire. Report No. 6 (old series). Occupational Research Center, Purdue University, West Lafayette, Indiana, June 1969.

Miller, E. E. A taxonomy of response processes, (HumRRO Tech. Rep. 69-16). Fort Knox: Human Resources Research Organizations, September 1969.

Powers, T. E. Selecting presentation modes according to personnel characteristics and the nature of job tasks: Part 1. Job tasks. University of Maryland, College Park, Maryland, January 1977.

Theologus, G. C., Romashko, T., & Fleishman, E. A. Development of a taxonomy of human performance: A feasibility study of ability dimensions for classifying human tasks. American Institutes for Research, Washington, DC, 1970.

West, L. J. Review of research in typewriting learning with recommendations for training (AFPTRC Res. Rep. TN-57-69). Lackland AFB, TX, Air Force Personnel and Training Research Center, June 1957.

APPENDIX A

GENERALIZABLE TROUBLESHOOTING GUIDE

Honeywell

79SRCM-5

May 1979

GENERALIZABLE TROUBLESHOOTING GUIDE

**SYSTEMS & RESEARCH CENTER
2600 RIDGWAY PARKWAY
MINNEAPOLIS, MINNESOTA 55413**

PRINTED IN USA

TROUBLESHOOTING

INTRODUCTION

This guide is written to help you repair and maintain avionics equipment in the field. It is not intended to be a repair manual for every piece of electronic equipment you will see in the field. It is intended to aid you and to answer, in general, the question: "What do I do next?". This guide gives a simple, easy to follow, step-by-step method to find and repair faulty equipment.

BEFORE YOU START

To do a job well, you must have the right tools. Most beginning technicians know that screwdrivers, wrenches, pliers, and soldering irons are tools used to repair electronic equipment. There are some other tools that the technician uses that aren't as obvious. You need to know how to use these tools before starting to work on any piece of avionics equipment. These tools are:

Knowledge of Electronic Fundamentals: This does not mean detailed theory and mathematics of electronics. It means understanding how the basic circuit parts (resistors, capacitors, transistors, etc.) work and what happens when they don't work.

Knowledge of the Equipment: Most equipment can be broken down into a few basic circuits (power supply, amplifier, oscillator, etc.). Knowledge of the equipment means knowing how these basic circuits are put together to make the equipment you're working on. It also means knowing what equipment should do in all modes of operation and knowing when it's not being done. Block diagrams and functional theory of operation give you this information.

Knowledge of Test Equipment: Most avionics equipment needs general test equipment for troubleshooting. This includes multimeters, oscilloscopes, signal generators, etc.. You will probably run into many different types and models of test equipment even though their function is the same. You may know how to use one type of oscilloscope but have an entirely different one in your shop. If this happens, the best thing you can do is read the operation manual for that oscilloscope or ask a co-worker who is familiar with the equipment to show you how to use it.

Some avionics equipment also has special testers which are designed only for that unit. The technical manuals will tell you how to hook up and use these special testers. The technical manuals also tell you how to make readings and what to do if they are not correct.

The Technical Manual: The technical manual is the most important tool you have. It contains theory of operation, operation, testing procedures, schematics, block diagrams, charts, and other information you need. You should be familiar with where everything is in the technical manual and know how to use its information.

Logical Troubleshooting Method: The logical troubleshooting method is what this guide is all about. If you have all of the tools mentioned, then this is the easy part. The method breaks down into six easy steps. When you follow the method using all of these tools, the troubleshooting job is done.

The Technician: Nothing fixes itself. A skilled technician is always needed to find and repair a piece of equipment that is not working right. The soldier who uses these tools, thinks clearly, and makes the right decisions will repair the equipment every time. Anyone else is just lucky.

TROUBLESHOOTING STEPS

Once you have all the tools you need, you are ready to tackle a troubleshooting problem. The logical troubleshooting method includes these six steps:

1. Symptom Recognition
2. Performance Check/Bench Check
3. Listing Probable Faulty Functions
4. Finding the Faulty Function
5. Finding the Faulty Circuit
6. Repairing/Replacing Faulty Component(s)

Step 1. Symptom Recognition: Symptom recognition means finding or realizing that a piece of equipment or an equipment system is not doing the job it is supposed to do. Most of the time this step is performed by the pilot or operator using the equipment. This means that when you get a piece of equipment you will already know that something is wrong with it. Finding out

what is wrong with it is your job. Don't count on getting very much information from the pilot or operator. They are not trained in your field and can't be expected to know what is wrong. Most of the time you will be given information like: "VHF doesn't work" or "warning light on."

But there are some problems that aren't so easy to see. These are normally called "degraded performance" problems. They can include problems like a radio transmitter that has lost some of its range or has a decrease in signal/noise ratio. You should notice these degraded performance problems during routine alignment/adjustment or bench test of the equipment. You should take extra care to find degraded performance problems.

Step 2. Performance Test/Bench Check: In this step you must pin down exactly what the equipment is or is not doing correctly. In some cases you can do this step in the aircraft and in others you must do it on the bench.

This is where you must start using your tools. You must know how to operate the equipment and know what it is supposed to do.

You should power up the equipment and operate it in all possible modes. All frequency ranges, control settings, positions, etc. should be observed. Take careful notes on switch settings and meter readings and any other visual information you can get. This information will be of great value to you later.

You should make a visual inspection at this point. Look for burned or broken parts, broken wires, loose cards or connections. If the equipment has plug-in cards, reseating them will often solve the problem. Cards are often shaken loose if the unit gets a lot of vibration when it's operating.

You may also find out at this point that there is no problem with the unit or that a simple adjustment cures the problem. If you find no problem, this usually indicates an operator error. You should point this out to the operator to prevent it from happening again. Another possibility is that the unit fails only under certain conditions. For example, the cooling air in the aircraft may be blocked, causing the equipment to overheat after an hour in flight. These failures are hard to find because the equipment will usually bench-check O.K. Repeated writeups on a piece of equipment that bench-checks O.K. should lead you to a problem like this.

If the unit or system has built-in-test equipment (BITE), you can get good information from using this function also.

When you're checking the unit out by trying all the modes and switch settings, make sure you only change one setting at a time. This way, you won't get a wrong reading or miss something.

Step 3. Listing Probable Faulty Functions: Now that you know exactly what the unit is or is not doing, you must figure out which functions of the equipment could cause this problem. To find these faulty functions, you need another tool. This tool is understanding how the equipment works. You will also need a functional block diagram from the technical manual.

You have to start doing some thinking now. Use your knowledge of the equipment and the information you gathered in the last step. Now you should decide which function(s) of the equipment could be faulty. Sometimes this is a very simple job. For example, a receiver has gone dead and during Step 2 you notice that the meter on the front panel that monitors the power to the system reads zero. From this information, you should go to the power supply. Most of the time, however, there will be two or more functional units in the equipment that could be faulty. Some units are more likely to be faulty than others, but don't make the mistake of not considering a probable fault just because you've never seen it happen before. If your shop keeps maintenance records (and they should), refer to the records on that unit. Sometimes you will find a probable fault that you didn't think of. If your shop doesn't keep records, then you should keep a detailed notebook of everything you repair. Over a period of time, this notebook can become a very valuable tool.

You may find it easier in some cases to list what isn't a probable fault. For example, you have a radio transmitter that provides a good, clean carrier signal but no modulation. You would not need to check the RF oscillator, RF power amp, or power supplies to these sections. This leaves you with the microphone circuit, audio section, and modulator section as probable faults.

The technical manual may also provide some information in the form of a "sectionalization chart." These charts (see Figure 1) basically perform Steps 3 and 4 for you during the bench-check. These charts won't always be 100 percent correct, but they will lead you in the right direction and save you some time.

In any event, once you find out which sections or functions have probable faults, you can go to Step 4.

Item	Symptom	Probable cause	Sectionalization procedure
1	Test power supply draws excessive current when 28 volts is applied to vhf navigation set. <i>Note.</i> When test power supply is used, excessive current drain will be indicated by a high (7 amperes or more) dc ammeter reading or by tripping of the test power supply circuit breaker.	Defective test power supply, vhf navigation receiver, converter, vhf control unit, or rack.	a. Disconnect the test power source from the vhf navigation receiver; apply low-voltage input power again. If current drain is reduced, replace test power supply; if not, perform b below. b. Reconnect the test power supply to the vhf navigation receiver and disconnect the converter from the rack. Apply low-voltage input power again. If current drain is reduced, replace the converter; if not, perform c below. c. Reconnect the converter to the rack and disconnect the vhf navigation receiver from the rack. Apply low voltage again. If current drain is reduced, replace the vhf navigation receiver; if not, perform d below. d. Reconnect the vhf navigation receiver to the rack and disconnect the cable at connector J2 of the vhf navigation receiver. Apply low-voltage power again. If current drain is reduced, replace vhf navigation control unit; if not replace the rack.

Figure 1. Sectionalization Chart

Step 4. Finding the Faulty Function: Now you are faced with the problem of finding the faulty function or section. This is sometimes called sectionizing. If during Step 3 you find that only one function or section has a probable fault, then you would go to Step 5.

Up to this point, you have not used any test equipment other than what has been built into the equipment itself. Now you will have to add another tool, the knowledge of how to use test equipment, to continue the troubleshooting job. The test equipment is used to find out which function is faulty. You will again need the equipment functional block diagram. A system block diagram is shown in Figure 2. Now you will have to do more logical thinking. If you just dive in and make random measurements in the hope of finding a bad signal, you will be very lucky to fix anything.

Choosing where to start testing to find the faulty function depends on several things. One of the most important things is to find the function that will give you the most information. In other words, you should ask the question, "Which signal should I check in order to lower the number of probable faults?". For example, you have a receiver with no output. A functional block diagram of the receiver is shown in Figure 3.

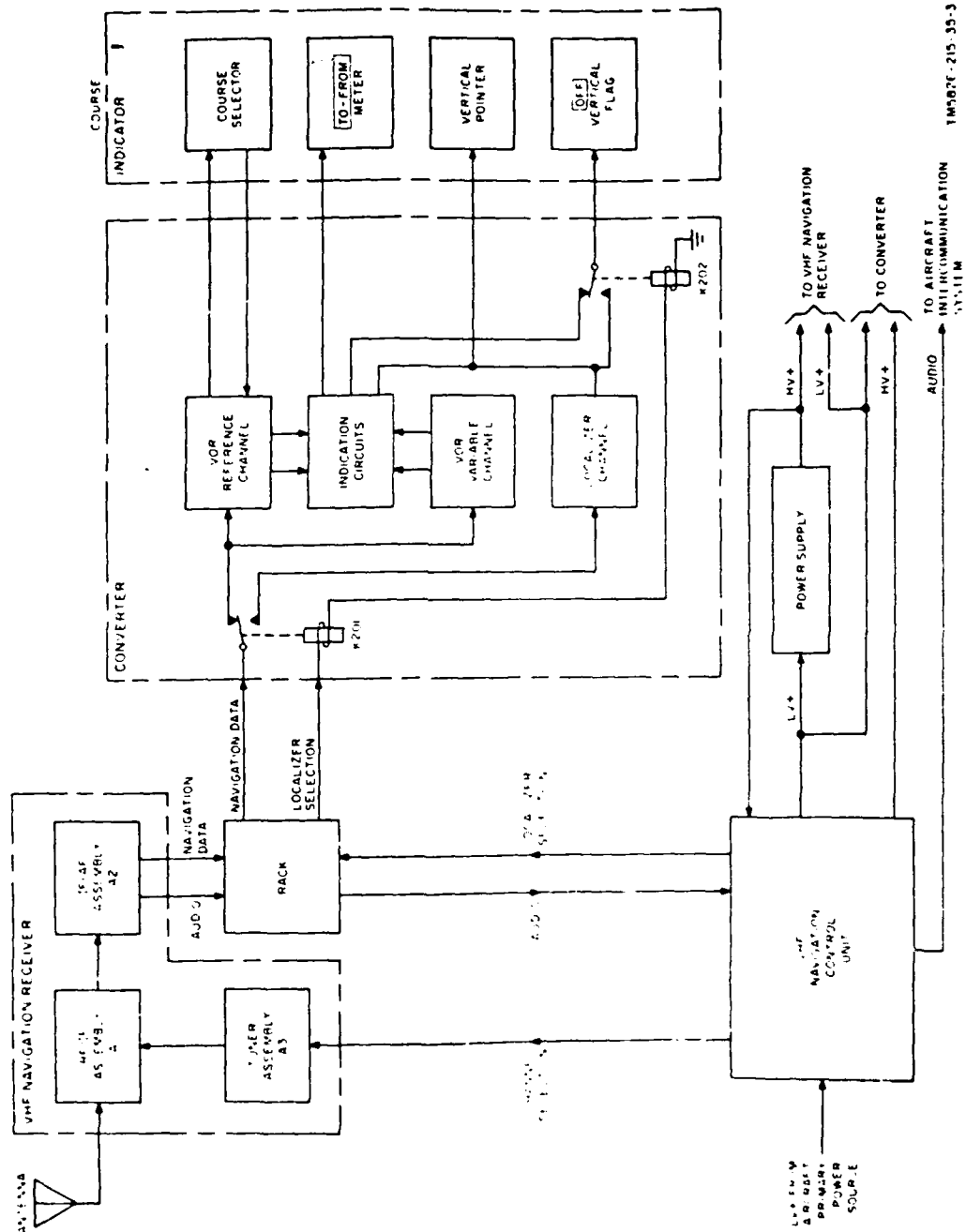


Figure 2. System Functional Block Diagram

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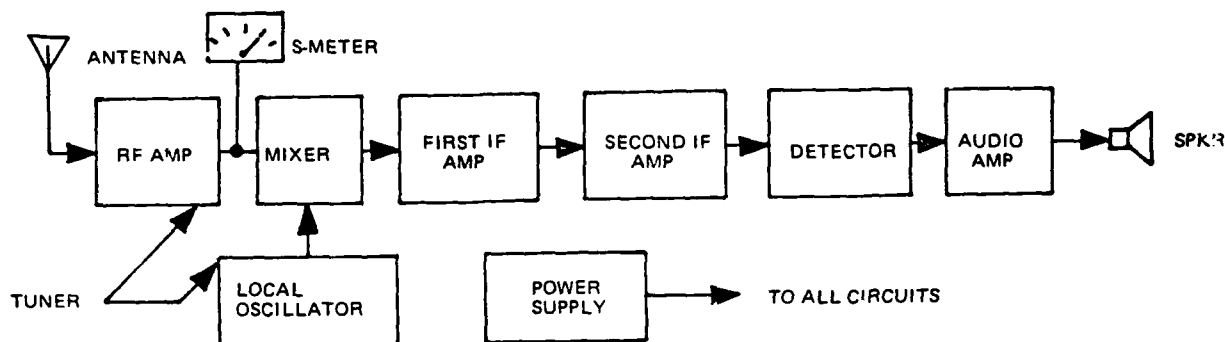


Figure 3. Receiver Block Diagram

The "S-Meter" in Figure 3 shows a strong incoming signal and since it is at the output of the RF amplifier you can be sure that the antenna and RF amp are O.K. It is also likely that the power supply is O.K. unless all of the circuits are at different voltages. This leaves the local oscillator, mixer, first IF amp, second IF amp, detector, audio amp, and speaker. Starting at the speaker and working backwards, or starting at the local oscillator and working forward, will work. But it will take you a lot of time if the fault is at the other end. Checking the signals between the first and second IF amp will give you a lot more information. If the signals are good, then you know that the first IF amp, mixer, and local oscillator are O.K. If the signals are bad, then you know that the second IF, detector, and audio amp/speaker are O.K. With one measurement (or set of measurements) you have eliminated half of the probable faults. Some technicians call this the halving technique.

There are some things that may make you check somewhere else first. These include available test points, ease of access, etc. The technical manual should include a list of test points and what signals should be present.

An important point to remember is that you will normally be testing the output of a circuit. Just because the output is bad doesn't mean that the circuit you're testing is bad. An amplifier's output will always be wrong if its' input is bad! Don't jump to conclusions. Work carefully and think about every step. It will save you a lot of time and confusion later.

One other possibility for finding the faulty function is to use a troubleshooting chart like the one shown in Figure 4. These charts are very general and are designed to help you find the fault most of the time. They should be used to help you find the faulty function but should not be taken as gospel.

Step 5. Finding the Faulty Circuit: Once you have found the faulty function, you must find the circuit that is causing the problem. To do this, you will repeat Steps 3 and 4.

Here you must consider these possibilities:

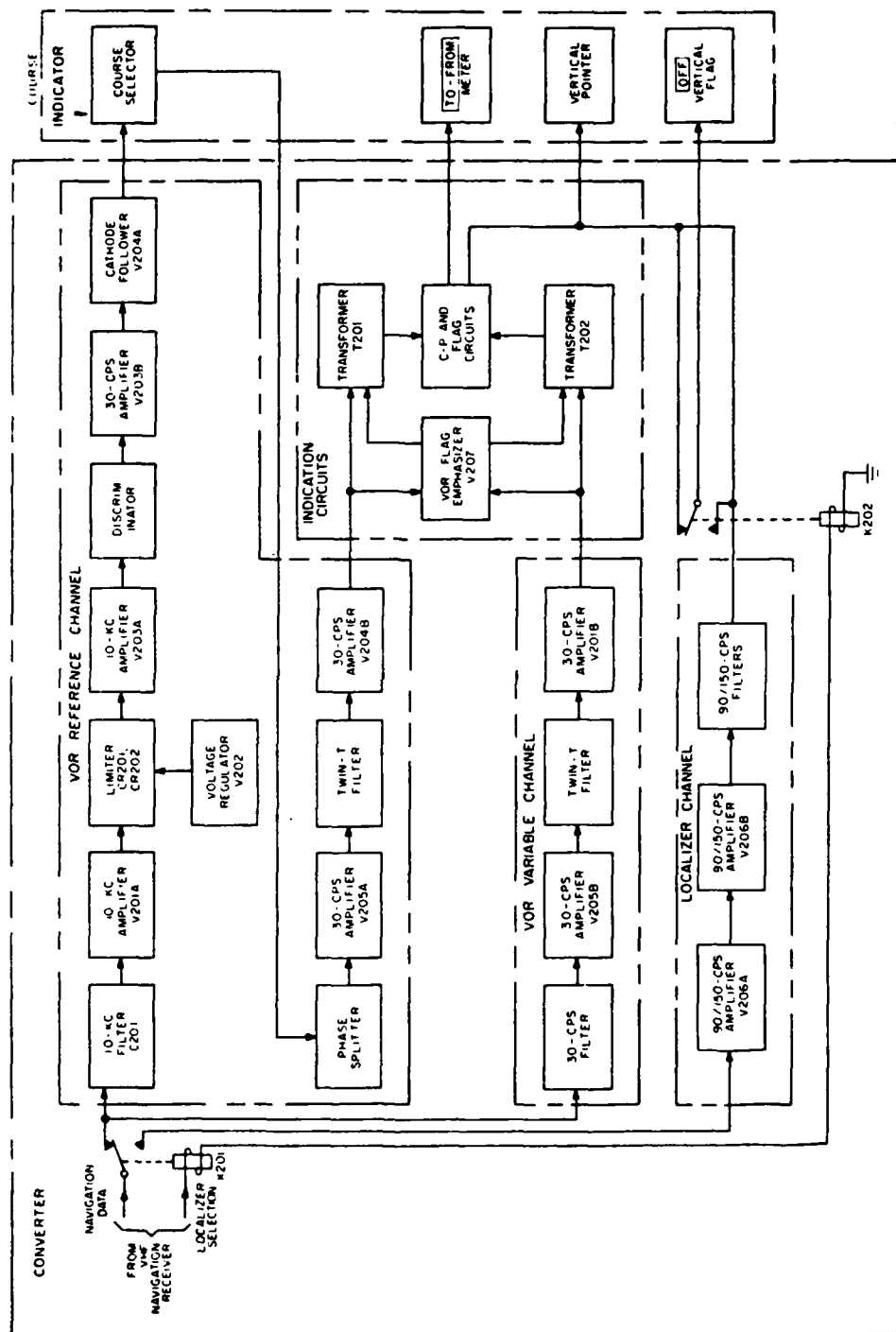
1. The faulty function may have only one circuit. In this case you can go directly to Step 6.
2. The faulty function may have only one signal path. In this case the halving technique described in Step 4 works quite well.
3. The faulty function may have many signals and signal paths and only one or two of them may be faulty. This case will be described to you more later.

Before you can start troubleshooting the function, you will need detailed block diagrams of the function (a converter block diagram is shown in Figure 5) or you will need the schematic diagram. The schematic diagram is sometimes better because it usually shows the location and expected signals of the circuit test points.

Again, if there is only one signal path you can start at a convenient middle point (use the halving technique) and work from there. Be careful to select the proper test equipment for the signal you're measuring. Using a low-impedance VOM on a high-impedance circuit is likely to give you some interesting, but wrong, results. If the function unit must be separated from the rest of the system so it can be tested, you will usually need a bench tester or a signal generator, power supply, etc. to do these tests. The technical manual will normally list the equipment and signal connections/levels you need to do these tests.

Item	Indication	Probable trouble	Procedure
1	OFF vertical flag on the course indicator is visible at all times and the TO-FROM meter on the course indicator is always at neutral, even though audio can be heard on both VOR and localizer channels.	Defective tube filament in VOR reference channel, VOR variable channel, or flag emphasize stage V207. Capacitor C219B (fig. 35) shorted to ground.	Visually check tubes (fig. 34) to see that all light. Check for short circuit (para 68c).
2	OFF vertical flag on the course indicator is visible and the TO-FROM meter on the course indicator is at neutral during localizer, but not during VOR operation.	Defective localizer channel. Defective relay K201 (fig. 49) or K202.	Check tube V206 (fig. 34) by substitution. Make signal-substitution tests on localizer channel (para 71a). Make voltage and resistance measurements on localizer stages (fig. 37). Check operation of relays K201 and K202 (para 97). Check coil resistance measurement for relays K201 and K202 (para 73).
3	OFF vertical flag on the course indicator is visible and the TO-FROM meter on the course indicator is at neutral during VOR, but not during localizer operation.	Defective VOR variable channel. Defective VOR reference channel. Defective VOR flag emphasize stage V207. Defective transformer T201 or T202. Defective crystal diode CR205 or CR206.	Check tubes V205 (fig. 37) and V201 by substitution. Make signal-substitution tests on VOR variable channel (para 71c). Make voltage and resistance measurements on VOR variable channel stages (fig. 37). Check tubes V201 (fig. 37), V202, V203, V204, and V205 by substitution. Make signal-substitution tests on VOR reference channel (para 71b). Make voltage and resistance measurements of VOR reference channel stages (fig. 37). Check tube V207 (fig. 37) by substitution. Make voltage and resistance measurements of VOR flag emphasize stage V207 (fig. 37). Check resistance of transformers T201 and T202 windings (para 73).
4	TO-FROM meter on the course indicator does not deflect, although vertical pointer on the course indicator deflects and OFF vertical flag on the course indicator is out of sight.	Defective resistor R235, R236, or R233. Defective capacitor C235.	Measure front-to-back resistance of crystal diodes CR205 (fig. 35) and CR206; ratio of resistance readings should be 10,000 to 1 or greater. Check resistance of resistors R235 (fig. 35), R236, and R253. Check capacitor C235 (fig. 35) for shorted condition.
5	OFF vertical flag on the course indicator is visible during VOR operation, but not during localizer operation, although the TO-FROM meter deflects and VOR signal strength is reliable enough for vhf navigation set operation.	VOR FLAG control R268 out of alignment. Defective crystal diode CR207 or CR208. Defective resistor R237, R238, R239, or R240.	Check alignment of VOR FLAG control R268 (para 107). Measure front-to-back resistance of crystal diodes CR207 (fig. 35) and CR208. Resistance ratio should be 10,000 to 1 or greater. Check resistance of resistors R237 (fig. 35), R238, R239 (fig. 36), and R240 (fig. 35).
6	Vertical pointer on the course indicator does not indicate correctly and the TO-FROM meter on the course indicator operates erratically (deflects correctly part of the time and incorrectly other times) during VOR operation.	VOR reference channel and/or course indication circuits out of alignment.	Check alignment of VOR reference channel and course indication circuits (para 107 through 110).
7	Vertical pointer on the course indicator does not indicate correctly during localizer operation.	Localizer channel and/or course indication circuits out of alignment.	Check alignment of localizer channel and course indication circuits (para 108 through 111).

Figure 4. Troubleshooting Chart



TM5826-215-35-16

Figure 5. Converter Block Diagram

If there is more than one signal or signal path, you will again have to do some thinking. You have to find out which circuits could cause the problem and eliminate the others. Consider all circuits that generate, modify or control the bad signal. For example, if you have a triangular wave without a linear slope you might consider the shaping network. Look back at your results from Step 2. If there was a control that caused the problem in the unit, the circuit it is connected to is a likely source of the problem. Once you find the probable faulty circuits, use the halving technique to find the one that's causing the problem.

Step 6. Repairing/Replacing the Faulty Component(s): Once you have found the faulty circuit, you will have to find the specific component or components that failed. You will need the schematic diagram and component layout drawing to do this step.

Since almost all circuits have an active component (for example, tubes, transistors, integrated circuits) and most faults involve an active component, this part should be checked first. Tubes and plug-in transistors can be checked on the proper tester out-of-circuit. Soldered-in transistors and integrated circuits should be checked in-circuit. If you find a bad active component, don't forget that many transistors or IC failures are caused by the failure of other components (shorted loads, shorted coupling capacitors, etc.).

The technical manual usually has a resistance chart that will help you a lot in finding faulty components.

Once you have found the faulty component(s), you must replace them with the proper new part. Be very careful when using a soldering iron to remove/replace components. You can do more harm than good if you get a hot soldering iron too close to a wire bundle or a printed circuit board.

AFTER YOU HAVE REPAIRED THE EQUIPMENT

You're not through yet. Now you should do a complete bench check to make sure that your work has indeed repaired the unit. You may have to do a realignment, at least of the repaired function. When the unit checks out, then you're through.

APPENDIX B

TASK BY ELEMENT MATRICES

MOS 35L10 Avionics Communication Repair Fault Isolate Tasks	Behavioral Elements														Set up, connect & operate:
	Voltmeter/multimeter	Oscilloscope	Frequency counter/meter	Wattmeter	Signal generator	Spectrum analyzer	Attenuator	Dummy load	Power supply	Headset/microphone	Modulation meter	Frequency comparator	Decade resistor	Test facilities/maintenance kit	
Task #113-586-															
RT-742/ARC-51BX	X		X	X	X	X	X	X	X	X	X	X	X	X	X
0032	X		X	X	X			X	X	X				X	
0033	X				X									X	
0034	X														
0035				X										X	
0038	X		X	X	X			X	X	X				X	
C-6287/ARC-51BX															
0039	X							X						X	
0105					X			X						X	
RT-823/ARC-131	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0042	X	X	X	X	X	X	X		X	X				X	
0043	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
C-7088/ARC-131															
0106	X								X					X	
RT-857/ARC-134	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0044	X							X	X					X	
0045	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0046	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
0047	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
C-7197/ARC-134															
0101	X				X	X	X							X	
RT-1167/ARC-164 (V)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0102	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
0108	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

[illegible]

Behavioral Elements	Set up, connect & operate:																			
	Voltmeter/multimeter	Oscilloscope	Frequency counter/meter	Wattmeter	Signal generator	Spectrum analyzer	Attenuator	Dummy load	Power supply	Headset/microphone	Modulation meter	Frequency comparator	Decade resistor	MK-733/ARC 54 test facilities	Radio test set	Module tester (AN/ARM-87)	Radio interference measuring set	Test set (AN/URM-120)	Test set (TS-1967)	Remove receiver-transmitter dust cover
MOS 35110 Avionics Communication Repairer Fault Isolation Tasks																				
Task #113-586-																				
C-1611D/AIC	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0001	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0141	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C-6533/ARC	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0002	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0004	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AN/ARC-114	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0003	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0005	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0006	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0010	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AN/ARC-115	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0007	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0008	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0009	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AN/ARC-116	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0011	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0012	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0013	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0014	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
PT-348/ARC-54	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0015	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0016	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0024	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0025	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C-3835/ARC-54	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

[illegible]

Task #113-586- MOS 35110 Avionic Communi- cation Repairer Align/ Adjust Tasks	Behavioral Element	Set up, connect, and operate:																
		Voltmeter/multimeter	Oscilloscope	Power supply	Signal generator	Frequency counter/master	Spectrum analyzer	Frequency comparator	Watmeter	Distortion analyzer	Headset/microphone	Sweep signal generator	Modulation meter	Attenuator	Standing wave ratio ind.	Test facilities/maint. kit	Module test set	Radio test set
Task #113-586- C-6533/ARC 5001 AN/ARC-114 5002 5007 AN/ARC-115 5010 AN/ARC-116 5021		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
RT-823/ARC/131 5051 RT-1167/ARC-164 5061		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Behavioral Element	Measure:		Adjust:																				Behavioral Element							
	Task #113-586-		Voltage	Frequency	Waveform characteristics	Output	Capacitance - Bend tags w/met.	Capacitance w/frequency meter	Capacitance w/voltmeter	Resistance w/multimeter	Resistance w/oscilloscope	Resistance w/headset	Inductor w/oscilloscope	Inductor w/multimeter	Oscillator tuning slug w/meter	Test set controls w/multimeter	Test set controls w/oscillo.	Attenuation	Mechanical alignment	UUT control/monitor multimeter	Select components/values	Monitor tone on headset	Remove and replace:	Components	Circuit boards	Modules	Memory drum pins	Fabricate test circuit (diode)	Desal/seal with RTV component	Calculate (signal+noise)/noise
MOS 35L10 Avionic Communication Repairer Align/ Adjust Tasks	C-6533/ARC							X							X						X									
	5001																													
	AN/ARC-114		X	X				X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X		
	5002							X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X		
	5007		X	X				X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X		
	AN/ARC-115				X			X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X		
	5010				X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
	AN/ARC-116							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
	5021							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
	RT-823/ARC-131									X																				
	5051								X																					
	RT-1167/ARC-164								X	X	X	X																		
	5061								X	X	X	X																		

[illegible]

Task #113-586- RT-698/ARC-102	Behavioral Elements	
	Set up, connect and operate:	
MOS 35L20 Avionics Communication Repair Fault Isolation Tasks	Voltmeter/multimeter	X
	Oscilloscope	X
	Frequency counter/meter	X
	Wattmeter	X
	Signal generator	X
	Spectrum analyzer	X
	Attenuator	X
	Dummy load	X
	Power supply	X
	Headset/microphone	X
	Modulation meter	X
	Frequency comparator	X
	Decade resistor	X
	Test facilities/maintenance kit	X
	Radio test set	X
	Module tester (AN/ARM-87)	X
	Radio interference meas. set	X
	Test set (AV/CRM-120)	X
	Test set (TS-1967)	X

Figure 2

Task #113-586- Behavioral Elements	Measure:															
	Voltage	Resistance	Current	Power	Frequency	Continuity	Waveform characteristics	Distortion	Frequency deviation	Mechanical/angular position	Vacuum tube characteristics	Identify:	Symptom	Faulty section	Faulty part	Interpret:
MOS 35120 Avionics Communication Repairer Fault Isolation Tasks	X	X			X	X	X						X	X	X	X
	X	X			X	X	X						X	X	X	X
RT-698/ARC-102	X	X			X	X	X									X
0103																
0104																

Task #133-586- Behavioral Element	Set up & connect:															
	Voltmeter/multimeter	Oscilloscope	Power supply	Signal generator	Frequency counter/meter	Spectrum analyzer	Frequency comparator	Wattmeter	Distortion analyzer	Headset/microphone	Sweep signal generator	Modulation meter	Attenuator	Standing wave ratio indicator	Test facilities/maintenance kit	Radio test set
AN/ARC-115	X	X	X	X										X		
5015	X	X	X											X		
5019																
AN/ARC-116	X	X	X	X	X	X	X	X	X	X				X		
5025	X	X	X	X	X									X		
5026	X	X	X	X		X	X	X	X	X				X		
RT-348/ARC-54	X	X	X	X	X	X								X		
8033	X		X	X	X	X								X		
5038	X	X	X	X	X									X		
RT-742/ARC-51BX	X	X	X	X			X	X	X	X				X		
5043	X	X	X	X			X							X		
5044	X		X	X			X	X	X	X				X		
5045	X		X	X					X	X				X		
RT-823/ARC-131							X							X		
5057	X	X	X	X	X		X				X			X		
RT-857/ARC-134	X	X	X	X	X									X		
5058	X	X	X	X	X		X				X			X		
5060	X	X	X	X	X		X				X			X		
RT-698/ARC-102	X	X	X	X	X	X	X	X	X					X		
5069	X	X	X	X	X	X	X	X	X					X		

Task #113-586- MOS 35L20 Avionic Communication Repairer Align/ Adjust Tasks	Behavioral Element	Measure:																														
		Voltage	Frequency	Waveform characteristics	Output	Adjust:	Capacitance-Bend tabs w/MI	Capacitance w/frequency meter	Capacitance w/voltmeter	Capacitance w/oscilloscope	Resistance w/multimeter	Resistance w/oscilloscope	Resistance w/headset	Inductor w/wand and meter	Inductor w/oscilloscope	Inductor w/multimeter	Oscillator tuning slug w/meter	Test set controls w/multimeter	Test set controls w/oscillo.	Attenuation	Mechanical alignment	Select components w/values	Monitor tone on headset	Remove and replace:	Components	Circuit boards	Modules	Memory drum pins	Fabricate test circuit (Diode)	Desol/seal with rty component	Calculate (signal+noise)/noise	
AN/ARC-115			X				X	X	X																							
5015			X					X	X	X																						
5019																																
AN/ARC-116			X					X	X	X	X	X	X				X	X												X	X	
5025			X					X	X	X	X	X	X				X	X														
5026			X					X	X	X	X	X	X																			
RT-348/ARC-54			X	X	X			X	X	X	X	X	X	X																		
5033			X					X						X																		
5038			X	X	X				X		X			X	X	X		X												X	X	
RT-742/ARC-51BX			X	X	X		X	X	X	X	X	X	X				X	X	X	X	X											
5043			X				X	X	X		X			X	X	X	X	X	X	X												
5044			X						X	X	X	X																				
5045									X		X						X	X	X													
RT-523/ARC-131								X									X															
5057			X	X	X			X			X	X	X				X															
RT-857/ARC-134			X	X	X																											
5058			X						X	X	X	X	X																			
5060			X	X	X				X	X	X	X	X																			
RT-698-ARC-102			X	X							X																					
5069			X	X																												

[illegible]

MOS 35M10 Avionics Navigation and Flight Control Equipment Repairer Fault Isolation Tasks	Behavioral Element	Set up, connect, and operate:	Voltmeter/multimeter	Oscilloscope	Power supply	Signal generator	Frequency counter/meter	Watt meter	Spectrum analyzer	Recorder w/preamps	Headset	Output meter	Radio test set	VOR test set	SCAS test set	Pitot-static system tester	Transistor test set	Amplifier test set	Direction finder test set	Test facilities/maintenance kit	Stabilization equipment test set	Rotary actuator test set	Attitude heading reference t.s.	Accelerometer test set	Reference control tester	Gyro-magnetic compass test set	Gyro & compass signal simulator	Gyro instrument/tilt table	Precise angle/angle position ind.	Electron tube test set	Decade resistor	Decade capacitor
Task #113-585-																																
R-1391/ARN-83			X	X	X	X											X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0001			X																													
0002			X																													
0003			X																													
0004			X																													
0005			X																													
0006			X																													
0007			X																													
0008			X																													
0009			X																													
0011			X																													
0012			X																													
C-6899/ARN-83																																
0016			X																													
0013			X		X																											
R-1496/ARN-89			X	X	X	X																										
0039																																
0040			X	X	X	X																										
0041			X	X	X	X																										
0042			X	X	X	X																										
0043			X	X	X	X																										
0044			X	X	X	X																										
C-7392/ARN-89																																
0045			X	X	X	X																										
R-1963/ARN																																
0037																																
0038																																
R-1041.A.R/ARN																																

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MOS 35M10 Avionics Navigation and Flight Control Equipment Repairer Align/ Adjust Tasks	Behavioral Elements	Set up, connect, and operate:																
		Voltmeter/multimeter	Oscilloscope	Power supply	Signal generator	Frequency counter/meter	Wattmeter	Modulator	Spectrum analyzer	Headset	Direction finder test set	Stabilization equipment test set	Radio test set	Pitot-static system test set	Amplifier test set	Aircraft displacement simulator	Test facilities/maintenance kit	Resistance bridge
Task #113-585-																		
R-1391/ARN-83		X		X	X	X	X		X	X	X							
5001			X	X							X							
5002			X	X							X							
5003		X		X							X							
5004				X	X		X		X		X							
5005				X	X		X		X		X							
5006				X	X		X				X							
5007				X	X		X		X		X							
5008				X	X		X		X		X							
5009				X	X		X		X		X							
5010				X	X						X							
5011				X	X						X							
C-6899/ARN-83																		
5013				X							X							
R-1388/ARN-82		X	X	X	X	X	X	X										
5014		X	X	X	X	X	X	X										
5015		X	X	X	X	X	X	X										
5021		X	X	X	X	X	X	X										
5022		X	X	X	X	X	X	X										
5023		X	X	X	X	X	X	X										
5024		X	X	X	X	X	X	X										
5025		X	X	X	X	X	X	X										

Set up, connect, and operate:
 Voltmeter/multimeter
 Oscilloscope
 Power supply
 Signal generator
 Frequency counter/meter
 Wattmeter
 Modulator
 Spectrum analyzer
 Headset
 Direction finder test set
 Stabilization equipment test set
 Radio test set
 Pitot-static system test set
 Amplifier test set
 Aircraft displacement simulator
 Test facilities/maintenance kit
 Resistance bridge
 Decade resistor
 Rotary actuator test set
 Gyro test set
 Gyro tilt table
 Electron tube test set
 Attenuator
 Maintenance kit

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Task #113-585-	Behavioral Elements
C-6899/ARN-83	Set up, connect, and operate: Oscilloscope Power supply Radio test set TACAN test set Headset Remove and replace: Retaining ring Fasteners Covers, panels Circuit cards Thumbwheels Connector pins Gaskets Stable element Wiring Clamps Handling fixture Support clamp Safety block Knobs Resistor Cams Ballbearings Gears/gear train Set screws Panel/mount screws Nuts/bolts Panel lights Meters Coaxial cables Brus fasteners Modules/subassemblies Soldered: Leads/harness Components Semi-conductors Monitor test set displays Monitor audio signal Verify blower operation Check continuity Apply: Potting compound Sealant Heat conducting compound Lubricant Mix lubricant Solder/desolder parts Torque fasteners Clean gasket & mate surface Store assembly on foam pad Connect/disconnect: Electrical connectors Coaxial connectors Stripwire w/thermal stripper Adjust: Mechanical alignment Resistor w/headset Resistor w/test set display Interpret mechanical diagrams Assemble/disassemble UUT
4001	X
4002	X
R-1391/ARN-83	X
4003	X
4004	X
R-1388/ARN-82	X
4008	X
4009	X
R-1496/ARN-89	X
4015	X
CH-47 SAS	X
4027	X

MOS 35M20 Avionics Navigation and Flight Control Equipment Repairer Fault Isolation Tasks	Behavioral Element	Set up, connect, and operate:	Voltsmeter/multimeter	Oscilloscope	Power supply	Signal generator	Frequency counter/meter	Watt meter	Spectrum analyzer	Recorder w/preamps	Headset	Modulator	Frequency converter	Radio test set	VOR test set	SCAS test set	Pitot-static system tester	Transistor test set	Amplifier test set	Direction finder test set	Test facilities/maintenance kit	Stabilization equipment test set	Rotary actuator test set	Module test set	Attitude heading reference t.s.	Accelerometer test set	Reference control tester	Gyro-magnetic compass test set	Gyro & compass signal simulator	Gyro instrument/tilt table	Precise angle/angle position ind	Electron tube test set	Decade resistor	Decade capacitor
Task #113-585-		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
R-1382/ARN-82		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0018		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0019		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0020		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0021		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0022		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0023		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0024		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0025		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0026		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0027		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0028		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0029		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0030		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0032		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0033		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0034		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0035		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
R-2023/ARN-123		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0090		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0091		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0092		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0096		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C-10048/ARN-123		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
or		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C-10049/ARN-123		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0093		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Figure 2 (cont)

[illegible]

MOS 35M20 Avionics Navigation and Flight Control Equipment Repairer Fault Isolation Tasks	Behavioral Element	Set up, correct, and operate:																																				
		Voltmeter/multimeter	Oscilloscope	Power supply	Signal generator	Frequency counter/meter	Wattmeter	Spectrum analyzer	Recorder w/breamps	Headset	Demodulator	Stopwatch	Bench test set	Radio test set	VOR test set	SCAS test set	Pitot-static system tester	Transistor test set	Amplifier test set	Direction finder test set	Test facilities/ maintenance kit	Stabilization equipment t.s.	Rotary actuator test set	Module test set	Attitude heading reference test set	Accelerometer test set	Reference control tester	Gyro-magnetic compass t.s.	Gyro & compass signal simulator	Gyro instrument/tile table	Precise angle/angle position ind.	Electron tube test set	Decade resistor	Decade capacitor	Navigational coupler	subassembly test set		
Task #113-585-																																						
CV-265A/ARI-30		X	X	X	X	X			X	X																												
0221		X		X	X	X			X																													
R-1031/ARI-30		X		X	X	X				X																												
0220		X		X	X	X																																
CN-601/ASN-12		X		X	X	X			X																													
0202		X		X																																		
0203		X																																				
CV-792/ASW-12		X																																				
0205		X																																				
0206		X																																				
0207		X																																				
0208		X																																				
0209		X																																				
C-3106/ASW-12		X																																				
0217		X																																				
MX-2917, 8, 9/ASW-12		X																																				
0193		X																																				
0196		X																																				
0199		X																																				
C-3107/ASW-12		X																																				
0201		X																																				
TG-78, 79, 80, 81/ ASW-12		X																																				
0186		X																																				
0192		X																																				
C-3106/ASW-12 (V)		X																																				
8036		X																																				
8037		X																																				
8038		X																																				
8039		X																																				
8040		X																																				

[illegible]

Behavioral Element	Set up, connect, and operate:	Volts/meter/multimeter	Oscilloscope	Power supply	Signal generator	Frequency counter/meter	Wattmeter	Spectrum analyzer	Recorder w/preamps	Headset	Bench test set	Radio test set	VOR test set	SCAS test set	Pilot-static system tester	Transistor test set	Amplifier test set	Direction finder test set	Test facilities/ maintenance kit	Stabilization equipment	Rotary actuator test set	Module test set	Attitude heading reference test set	Accelerometer test set	Attitude reference control tester	Gyro-magnetic compass c.s.	Gyro & compass signal simulator	Gryo instrument/tilt table	Precise angle/angle position ind.	Electron tube test set	Decade resistor	Decade capacitor	Auto pilot altitude control bench test analyzer	Test set sub assembly	Attenuator	Navigation set mount	
MOS 35420		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Avionics		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Navigation		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
and Flight		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Control		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Equipment		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Repairer		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Fault		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Isolation		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Tasks		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Task #113-585-		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CV-1275/ARN		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0222		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
R-8320/ARN-59		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0219		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C-3108/ASN-12		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0213		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0214		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0215		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0218		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8034		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
A2/J2 Compass		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0216		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AM-4682/ASN-76		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0181		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0182		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0183		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C-8099/ASN-76		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0184		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0185		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C-1151/ASN-76		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0179		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0180		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C-6873/ARN-82		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0017		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C-3106/ASN-12		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8035		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8029		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8030		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8031		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8032		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8033		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Figure 2 (cont)

[illegible]

MOS 35M20 Avionics Navigation and Flight Control Equipment Repairer Align/ Adjust Tasks	Behavioral Elements		Set up, connect, and operate:																									
	Task #113-585- R-836/ARN-59	5052	ACW-12	5053	5054	5055	5056	5057	5058	5060	5061	5062	5064	5065	5066	5067	5068	J2 Compass	5071	CV-265/ARN-30	5076	C-1021/ARN-30	5077	CV-1275/ARN	5078			

Behavioral Element	Measure:																																		
	Angular speed (o/sec.)	Time	Angular/mechanical position	Leakage (rate)	Continuity	Adjust:	Capacitance w/frequency meter	Capacitance w/meter	Capacitance w/headset	Resistance w/gear train	Resistance w/angular speed	Resistance w/meter	Inductor w/frequency meter	Inductor w/headset	Inductor w/wand and meter	Transformer w/meter	Test set controls w/meter	Test set controls w/headset	Resolver	Pressure w/gauge	Mechanical alignment	Cams/slipclutch	Thermal delay relay	Gear w/meter	Remove and replace:	Components	Soldered covers	Connect/disconnect pressure line	Drill hole in cam and shaft	Fabricate and install shims	Safety wire components	Select components/values	Monitor tone on headset		
MOS 35M20 Avionics Navigation and Flight Control Equipment Repairer Align/ Adjust Tasks																																			
Task #113-585-																																			
R-836-ARN-59	X									X																									
ASW-12	X	X			X					X																									
5052	X	X			X					X																									
5053																																			
5054																																			
5055																																			
5056																																			
5057																																			
5058																																			
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5065																																			
5066																																			
5067																																			
5068																																			
J2 Compass																																			
5071																																			
CY-265/ARN-30																																			
5076																																			
R-1021/ARN-30																																			
5077																																			
CV-1275-ARN																																			
5078																																			

MOS 35R10
Avionics
Special
Equipment
Repairer
Fault
Isolation
Tasks

Task #113-610-

N/ATN-305A

8012
0082
0083
0084

Set up, connect, and operate:				
Voltmeter/multimeter	X	X	X	X
Oscilloscope	X	X	X	X
Signal generator	X	X	X	X
Wattmeter	X	X	X	X
Frequency counter	X	X	X	X
Power supply	X	X	X	X
Pulse generator	X	X	X	X
Frequency comparator	X	X	X	X
Time mark generator	X	X	X	X
Standing wave indicator	X	X	X	X
Transfer oscillator	X	X	X	X
Square law detector	X	X	X	X
Echo box	X	X	X	X
Variable attenuator	X	X	X	X
Recorder w/preamps	X	X	X	X
Tape reader	X	X	X	X
Decade synchro bridge	X	X	X	X
UUT	X	X	X	X
Radar altimeter test set	X	X	X	X
Module test set	X	X	X	X
TACAN test set	X	X	X	X
Radio test set	X	X	X	X
Radar test set	X	X	X	X
Transponder test set	X	X	X	X
Simulator test set	X	X	X	X
Pulse power/c.s./calibrator	X	X	X	X
meter	X	X	X	X
RF power t.s./RF power meter	X	X	X	X
Inertial navigation test set	X	X	X	X
Gyro stabilized platform t.s.	X	X	X	X
Differential voltmeter	X	X	X	X
Test facilities kit	X	X	X	X
Gyro stabilized platform	X	X	X	X
test stand	X	X	X	X
Computer mount	X	X	X	X
Purge and fill unit	X	X	X	X
Stopwatch	X	X	X	X
Test tapes	X	X	X	X
Thermistor mount	X	X	X	X
Antenna mounting fixture	X	X	X	X
10K ohm resistor	X	X	X	X
Carriage	X	X	X	X
Slotted section	X	X	X	X
Headset	X	X	X	X
Probe	X	X	X	X
Battery	X	X	X	X
Disconnect/connect cable/	X	X	X	X
connector	X	X	X	X
Check: Sweep sync	X	X	X	X
RF source marker	X	X	X	X
RF input	X	X	X	X
R/R screws, nuts, lockwashers	X	X	X	X
Tag wires	X	X	X	X
R/R pad, filter	X	X	X	X
Load	X	X	X	X

[illegible]

MOS 35R10 Avionics Special Equipment Repairer Align/ Adjust Tasks	Behavioral Elements	Set up, connect, and operate:																													
Task #113-610-		Voltmeter/multimeter	Oscilloscope	Signal Generator	Wattmeter	Pulse generator	Sweep frequency generator	Headset	Recorder w/preamps	Frequency counter/meter	Horizontal situation indicator (HSI)	Variable transformer	TACAN test set	Radio test set	Radar altimeter test set	Module test set	Transponder test set	Radar test set	Test facilities/maintenance kit	Dummy load tester	Simulator test set	Gyro stabilized platform test set	Differential voltmeter	Square detector	Pulse power calibrator set	RF power test set	10 K ohm resistor	Digital voltmeter	Transfer oscillator	Comparator frequency	
RT-804/APN-171		X	X	X	X										X																
5008		X	X												X																
5009			X	X	X										X																
RT-1057/APN-103		X						X			X		X	X																	
5017		X	X					X			X		X	X					X												
SN-358/APN-158A		X	X	X		X													X												
5013			X	X		X													X												
IP-724/APN-158A																															
5014																			X												
RT-859A/ 4-72		X	X	X	X		X			X								X	X	X	X										
5015		X	X	X	X		X			X								X	X												
AN/APM-305A		X	X	X	X		X			X		X						X						X	X	X	X	X	X	X	
5019		X	X	X	X		X			X		X						X						X	X	X	X	X	X	X	

Behavioral Elements	Measure:																																			
	Waveform characteristics	Voltage	Suppression count	Power	Adjust:	Resistor w/UUT display	Resistor w/meter	Resistor w/oscilloscope	Resistor w/test set display	Transformer w/oscilloscope	Tuning screw w/oscilloscope	Capacitor w/oscilloscope	Capacitor w/test set display	Test set control w/oscilloscope	Test set control w/UUT display	Test set control w/meter	UUT	Remove & replace covers	Monitor recorder waveforms	Assemble/disassemble UUT	Remove and replace module	Calculate:	Total loop attenuation	Bandwidth	Center frequency	Power w/calibration curves	Drift direction	Drift in arc minutes	Drift rate (o/Hr)	Required adjustment	Loosen/tighten: Screws/nuts	Monitor test set displays	Connect/disconnect cable	Scrape RTV/coat w/RTV		
Task #113-610-																																				
RT-804/APN-171	X					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
5008	X						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
5009																																				
RT-1057/ARN-103						X								X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
5017						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
SN-358/APN-158A	X					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
5013	X						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
IP-724/APN-158A																																				
5014						X								X																						
RT-859A/APX-72	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
5015	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
AN/APM-305A	X																X																			
5019	X																X																			

MOS 35R20
Avionics
Special
Equipment
Repairer
Align/
Adjust
Tasks

Task #113-610-

MX-8123/ASN-86

5012

Behavioral Element			
Set up, connect, and operate:			
Voltmeter/multimeter			
Oscilloscope			
Signal generator			
Wattmeter			
Pulse generator			
Sweep frequency generator			
Headset			
Recorder w/preamps	X		
Frequency counter/meter			
TACAN test set			
Radio test set			
Radar altimeter test set			
Module test set			
Transponder test set			
Radar test set			
Test facilities/maintenance kit			
Dummy load tester			
Simulator test set			
Gyro stabilized platform test set and stand	X	X	
Measure:			
Waveform characteristics	X	X	
Voltage			
Suppression count			
Power			
Adjust:			
Resistor w/UUT display	X	X	
Resistor w/meter	X		
Resistor w/oscilloscope			
Resistor w/test set display			
Transformer w/oscilloscope			
Tuning screw w/oscilloscope			
Capacitor w/oscilloscope			
Capacitor w/test set display			
Test set control w/oscillo.			
Test set control w/UUT display			
Test set control w/meter			
Remove & replace covers	X	X	
Monitor Recorder waveforms	X		
Assemble/disassemble UUT			
Calculate:			
Total loop attenuation			
Bandwidth			
Center frequency			
Power w/calibration curves			
Drift direction	X	X	
Drift in arc minutes	X	X	
Drift rate (o/hr)	X	X	
Required adjustment	X	X	

[illegible]

APPENDIX C

INTERVIEWER AND INTERVIEWEE PROTOCOLS

FOR INTERVIEWER:

INTERVIEWEE _____ DATE _____

TITLE _____

ORGANIZATION _____ PHONE _____

INTERVIEWER _____

MAJOR AREA OF RESPONSIBILITIES:

	(MOS)	SYSTEM
TRAINING DEVELOPMENT	_____	_____
MEDIA SELECTION AND DEVELOPMENT	_____	_____
TRAINING ANALYSIS/EVALUATION	_____	_____
SQT CONSTRUCTION	_____	_____
TRAINING	_____	_____
OTHER _____	_____	_____

WHAT IS YOUR OFFICE'S POSITION IN THE SCHOOL SYSTEM RELATIVE TO
TRAINING SUPPORT OF A GIVEN SYSTEM?

EXAMPLES OF TASKS YOU DO AND THEIR SEQUENCE:

HOW OFTEN DO YOU DO THOSE TASKS?

DAILY _____

WEEKLY _____

MONTHLY _____

YEARLY _____

OTHER _____

HOW LONG DOES IT TAKE TO DO THEM?

DAY _____

WEEK _____

MONTH _____

YEAR _____

OTHER _____

HOW MANY PEOPLE ON YOUR STAFF ARE INVOLVED IN EACH TASK?

WHAT IS YOUR STAFF'S BACKGROUND?

MOS IDENTIFIED FOR JOB _____

OTHER MOS HOLDER _____

NON MOS HOLDER _____

EDUCATION BACKGROUND _____

WHAT ARE YOUR MOST SIGNIFICANT RESOURCE CONSTRAINTS/PROBLEMS?

TIME _____
OF PEOPLE _____
QUALIFICATION OF PEOPLE _____
MONEY _____
SYSTEM RELATED _____

WHAT KIND OF STUDENTS ARE YOU INVOLVED WITH?

1. NEW TRAINEE _____
2. CROSS TRAINED _____
3. UPGRADE TRAINEE _____
4. COMBINATION (#s) _____

HOW MANY STUDENTS PER YEAR (BY TYPE)?

HOW MUCH OF YOUR TASK IS GOVERNED BY POLICY AND HOW MUCH
BY REGULATION (%)? _____

WHICH DOCUMENTS DO YOU USE ON YOUR JOB (REGULATIONS, SOPs, MIL SPECS, HANDBOOKS, DATA ITEM DESCRIPTIONS (DIDS), REQUIREMENTS, DOCUMENTS, LETTERS/MEMOS, OTHER?

DO YOU PREPARE ANY OF THE ABOVE DOCUMENTS?

HOW IS THE INFORMATION YOU PRODUCE USED?

WHO RECEIVES IT?

DOCUMENT SAMPLES.

HOW WOULD YOU USE A MATRIX SUCH AS THE GENERALIZED JOB PROFICIENCY MATRIX?

- o SELECTION OF SQT TASKS _____
- o TRAINING SYSTEM DEVELOPMENT _____
- o TRAINING SYSTEM EVALUATION _____
- o TRAINING EQUIPMENT DEVELOPMENT _____
- o TRAINING EQUIPMENT EVALUATION _____
- o TECHNICAL DOCUMENTATION EVALUATION _____
- o MOS MANAGEMENT _____

HOW WILL THE MATRIX CONCEPT'S EMPLOYMENT AFFECT THE DEVELOPMENT TIME OF THE USES YOU HAVE IDENTIFIED:

Shorten _____ Lengthen _____ No change _____

HOW IMPORTANT IS TECHNICAL QUALIFICATION TO THE USE OF THE MATRIX YOU HAVE IDENTIFIED?

No correlation _____ Very important _____
Depends on use (1 to 10 scale) _____

DOES THE USE OF A MATRIX FIT IN WITH THE REGULATIONS GOVERNING
YOUR JOB?

Yes _____ No _____ If no, why: _____

HOW SPECIFIC WOULD YOU NEED THE MATRIX CONTENT: EQUIPMENT
CLASSIFICATIONS AND BEHAVIOR IDENTIFICATIONS?

Examples:

HOW DO YOU DETERMINE THE SPECIFICITY?

HOW ARE THE TASKS YOU HAVE IDENTIFIED ACCOMPLISHED NOW?

INTERVIEW PROTOCOL

INTERVIEWEE _____ DATE _____

TITLE _____

ORGANIZATION _____ PHONE _____

INTERVIEWER _____

MAJOR AREA OF RESPONSIBILITIES

HOW MANY PEOPLE ON YOUR STAFF ARE INVOLVED IN EACH TASK?

WHAT IS YOUR STAFF'S BACKGROUND?

WHAT ARE YOUR MOST SIGNIFICANT RESOURCE CONSTRAINTS/PROBLEMS?

WHAT KIND OF STUDENTS ARE YOU INVOLVED WITH?

HOW MANY STUDENTS PER YEAR (BY TYPE)?

HOW MUCH OF YOUR TASK IS GOVERNED BY POLICY AND HOW MUCH BY REGULATION (%)?

WHICH DOCUMENTS DO YOU USE ON YOUR JOB (REGULATIONS, SOPs, MIL SPECS, HANDBOOKS, DATA ITEM DESCRIPTIONS (DIDS), REQUIREMENTS, DOCUMENTS, LETTERS/MEMOS, OTHER)?

DO YOU PREPARE ANY OF THE ABOVE DOCUMENTS?

HOW IS THE INFORMATION YOU PRODUCE USED?

WHO RECEIVES IT?

HOW WOULD YOU USE A MATRIX SUCH AS THE GENERALIZED JOB PROFICIENCY MATRIX?

HOW WILL THE MATRIX CONCEPT'S EMPLOYMENT AFFECT THE DEVELOPMENT TIME OF THE USES YOU HAVE IDENTIFIED?

HOW IMPORTANT IS TECHNICAL QUALIFICATION TO THE USE OF THE MATRIX YOU HAVE IDENTIFIED?

DOES THE USE OF A MATRIX FIT IN WITH THE REGULATIONS GOVERNING YOUR JOB?

HOW SPECIFIC WOULD YOU NEED THE MATRIX CONTENT: EQUIPMENT CLASSIFICATIONS AND BEHAVIOR IDENTIFICATIONS?

HOW DO YOU DETERMINE THE SPECIFICITY?

HOW ARE THE TASKS YOU HAVE IDENTIFIED ACCOMPLISHED NOW?