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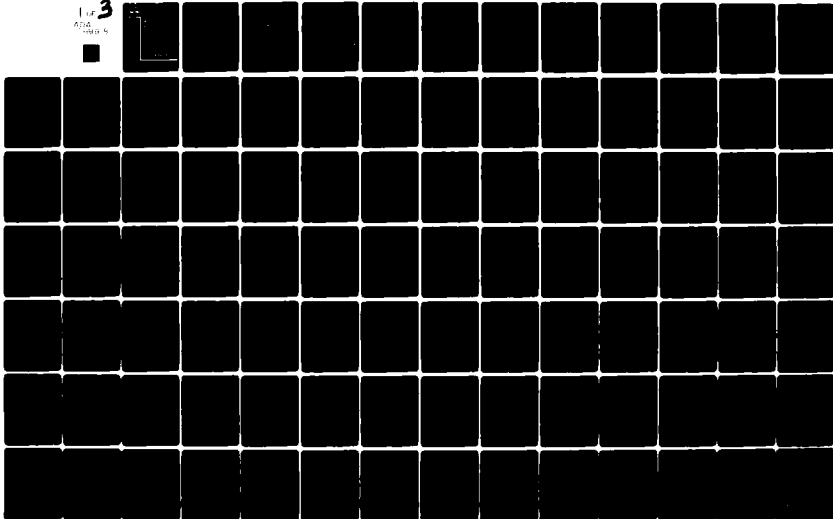
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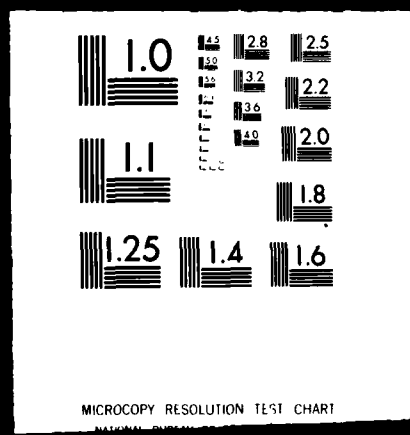
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**GUIDANCE FOR MAINTENANCE  
TASK IDENTIFICATION AND ANALYSIS:  
ORGANIZATIONAL AND INTERMEDIATE MAINTENANCE**

By

**Joseph F. Mulligan  
John B. Bird**

**Management and Technical Services Company  
P.O. Box 7507  
Philadelphia, Pennsylvania 19101**

**LOGISTICS AND TECHNICAL TRAINING DIVISION  
Logistics Research Branch  
Wright-Patterson Air Force Base, Ohio 45433**

September 1980

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This final report was submitted by the Management and Technical Services Company, P.O. Box 7507, Philadelphia, Pennsylvania 19101 under contract F33615-78-C-0015, Project 1710, with the Logistics and Technical Training Division, Logistics Research Branch, Air Force Human Resources Laboratory (AFSC), Wright-Patterson Air Force Base, Ohio 45433. SMSgt Robert C. Guy (LRLM) was the Contract Manager for the Laboratory.

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

ROSS L. MORGAN, Technical Director  
Logistics and Technical Training Division

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job guide manual	logistic support analysis	user analysis	
job performance aids	quality assurance		
in-process review	task analysis		
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<p>This report was to develop guidance for Air Force, other DoD agencies, and industry in the use of specifications contained in AFHRL-TR-79-50 to fulfill the requirements for maintenance task identification and analysis (MTI &amp; A). Several new types of technical data, such as job guide manuals (JGMs) and logic tree troubleshooting aids (LTTAs), have been adopted for use by the Air Force. The development of accurate and effective JGMs and LTTAs requires that a thorough MTI &amp; A be accomplished to prepare the data base from which JGMs and LTTAs are developed. At present the only suitable data specification available to establish JGMs and LTTAs is AFHRL-TR-79-50. The guidance developed here is to assist in the application of that specification.</p>			

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This report is to be used as a handbook. An overview of MTI & A processes is presented followed by a listing of fundamental requirements to be performed prior to the actual start of MTI & A. Once the analyst has become knowledgeable of the preliminary requirement of MTI & A the handbook provides the directions on how to perform MTI & A. It includes definitions, procedures, planning data, staffing criteria, checklists, suggested forms, and guidelines for review, evaluation, and quality audit of MTI & A products. Guidance is provided for conducting MTI & A for programs with Logistics Support Analysis data available and for programs which do not have this data. The guidance provided by the specification and its guide book are suitable for the procurement of MTI & A for both organizational and intermediate levels of maintenance.



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PREFACE

This draft Handbook, dated June 1980, prepared by Management and Technical Services Company (MATSCO) as agent of Air Force Human Resources Laboratory, has not been approved and is subject to modification. Contract No. F33615-78-C-0015.

The authors express their appreciation to SMSgt. R. Guy, AFHRL, for his guidance and support throughout the project. Appreciation is also extended to Mr. Robert Johnson and Dr. Donald T. Thomas, both of AFHRL, for their knowledgeable consultation and guidance during the project. Special recognition is also due to the early research efforts of MATSCO's Mr. Arnold E. Lobel and also to the assistance of Mr. Al Mincer and Mr. Edward Rykaczewski, of MATSCO-TDS at Valley Forge, PA.

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## **DRAFT MILITARY HANDBOOK FOR MAINTENANCE TASK IDENTIFICATION AND ANALYSIS: ORGANIZATIONAL AND INTERMEDIATE MAINTENANCE**

### **1. SCOPE**

**1.1 Scope of the Handbook.** This handbook covers the development of maintenance task identification and analysis in accordance with the requirements of and used in conjunction with the Draft Military Specification for Maintenance Task Identification and Analysis, AFHRL-TR-79-50. The Draft Specification defines the requirements for content and format of Task Analysis, which is used as a basis for preparation of Organizational and Intermediate Job Performance Aid (JPA) manuals and other types of Technical Orders.

Job Performance Aids (JPAs) are manuals that provide detailed, step-by-step instructions. Because JPAs are, by definition, thorough and complete, they require a detailed task analysis phase before manual development can begin. Two of the major types of JPAs, Job Guide Manuals and Logic Tree Troubleshooting Aids, are referred to throughout this handbook by the abbreviations JGM and LTTA, respectively, or by the more general category, JPAs. Maintenance Task Identification and Analysis is also referred to in general terms as "task analysis" or abbreviated to MTI&A in this handbook and in the Draft Specification.

Job Guide Manuals (JGMs) provide instructions for fixed-procedure tasks such as adjustment, removal and installation, and repair. The instructions are presented in a step-by-step format and are supported by detailed illustrations. LTTAs provide instructions for Checkout and Troubleshooting tasks in a detailed, step-by-step format. They provide the technician with the steps to follow to check out the system and to isolate malfunctions to replaceable or repairable units. Both types of JPAs and other types of technical manuals cannot be effectively prepared unless the detailed analytical process known as task analysis provides a total data base for use by the manual developer.

This handbook provides explanation of the planning and implementation of the requirements of the MTI&A Draft Specification. Therefore, the user of this handbook should have or acquire an understanding of the JPA concept, be thoroughly familiar with the requirements of the MTI&A Specification, and have a copy of the Draft Specification available for reference while using this handbook.

**1.2 Purpose of the Handbook.** This handbook is intended to assist contractor personnel who are required to perform task analyses on a system or on equipment. MTI&A must be developed in accordance with the requirements of the Draft Specification (AFHRL-TR-79-50). The handbook provides guidance to its user, usually referred to herein as the task analyst, or analyst, with many relevant procedural and format aids. It does not necessarily enable persons who have never performed maintenance task identification and analysis to do an effective job just by following the procedures outlined in the handbook. The task is not that simple. Certain important qualifications are required for the understanding of the technical aspects of maintenance analysis. It is possible to develop an MTI&A that meets the superficial criteria of format and identifiable types of content, but which would lead to ineffective technical manuals.

To guard against such an approach, a contractor should assign only task analysts who have the proper technical background and qualifications and should require a data, configuration control, and quality control system that will ensure a solid data base and a quality analysis. The qualifications, techniques, and systems that have been found to be suitable are suggested in this handbook.

The handbook is intended for use by contractors with some experience in preparing conventional technical data or maintenance manuals and with working knowledge of DoD maintenance terminology, policies, and systems. However, one should not assume that expertise in any of these areas is all that is required to permit effective identification and analysis of maintenance tasks. Some developers of conventional technical literature must reprogram themselves to the disciplined and careful approach that task analysis requires. Having done so, a good engineering or technical writer will ordinarily perform task analysis effectively and completely and appreciate its benefits to the quality and real usefulness of the final product. Subject matter experts, such as engineers or technicians, educators, and behavioral scientists are also capable of effective task analysis.

MTI&A can be more effectively and economically performed if it is coordinated with a Logistic Support Analysis (LSA) program as explained in the specification. Properly implemented and kept current, the detailed data base provided by LSA input data and output report summaries is an important asset to MTI&A. For that reason, this handbook discusses LSA-based MTI&A separately (in Section 5) from MTI&A without an LSA base (in Section 6). Many MTI&A analyses and products are performed differently when complete LSA data are available. In



order to keep both sections self sufficient, therefore, some redundancies will be found between the sections. In actual use, the analyst should decide whether the LSA data are complete and available for use and then follow the guidance in Section 5. If it is not, the analyst should disregard Section 5 and follow the guidance in Section 6.

Throughout the handbook and the specification, the process of analysis is distinguished from the products of that analysis. The analyst must first perform the research and study involved in the analysis and then record the results of that analysis in the form of analysis products. The handbook also describes all development processes as though they are to be performed only once, from beginning to end, and in neat sequence. In practice, however, many iterations and revisions of steps may be required and several analysis steps will be in process simultaneously. Updating is, of course, a recycling process that can be treated as separate from the initial development process.

**1.3 Background.** The development of JGMs, LTTAs, and other types of technical manuals containing detailed procedures requires a rational, systematic means of first identifying the job tasks and then determining the scope, content, method of performance, and other details of the tasks. MTI&A provides this means by defining a systematic process of data collection, analysis, and decision making. Essentially, the analysis answers these questions:

- a. What tasks are required?
- b. Which should be included in a JPA?
- c. At which maintenance level are they performed?
- d. What are the preconditions?
- e. What support equipment is needed?
- f. What instructions must be provided for its use?
- g. What are the most efficient, understandable steps for the technician to follow when performing a troubleshooting or nontroubleshooting task?
- h. What follow-on maintenance is needed?

The more complete, accurate, and understandable the task analysis, the easier the job of the JPA developer and the more effective the final product, the JPA, or technical manual.

The validity of the MTI&A, and therefore of the subsequent JPAs, is assured by the following key requirements for MTI&A development:

- a. Use of the actual equipment in representative configuration for "hands-on" analysis and validation of maintenance tasks

- b. Early identification and definition of the user population and its information needs
- c. Use of the same logistics data base and analyses that are used for other logistics purposes, assuring commonality and eliminating redundant effort
- d. Early and continuing evaluation and guidance through Contractor quality assurance (QA) and Government reviews
- e. Timely update to accommodate changes to equipment or software and to correct errors
- f. Thoroughness of the effort and skills and experience of those performing the analysis.

A degree of analysis has always been performed by technical writers and planners attempting to define the content of conventional technical manuals. The difference between those manuals and JPAs or other advanced forms, however, is that a much more thorough, realistic analysis effort is needed to provide a high degree of assurance that all components and significant maintenance tasks are identified and their performance requirements established at an early stage of development. MTI&A provides this assurance by making use of system analysis techniques, systematizing and formalizing the process, and recording the results in a consistent, structured fashion.

The analyses are recorded or documented on a number of products prepared by the analyst. These products then become the criteria for the content, structure, and completeness of the ultimate maintenance aid. They will be used as planning documents and source data during development, and as checks on their completeness later on.

MTI&A may be applied to development of other types of technical manuals as well as to JPAs, and its use for this purpose is encouraged. When used as a basis for conventional technical manual development, the major difference is the degree of detail required, particularly in the task detail analysis. A further use of MTI&A is as a tool for evaluating existing technical manuals, ascertaining that all needed maintenance tasks have been covered and that the amount and kinds of detail are appropriate to the actual user population.

The intent of the MTI&A Specification is to define the analyses required to be performed and to provide guidelines for their content, preparation, and use. The specific details and methods by which the analyses are actually developed are not so important as the effectiveness and thoroughness with which they are carried out and the usefulness of the final results.

## **2. APPLICABLE DOCUMENTS**

**2.1 Issues of Documents.** Unless specified otherwise in the contract, the following documents, of the issue in effect on the date of the invitation for bids or request for proposal, form a part of this handbook to the extent specified herein:

### **SPECIFICATIONS**

#### **MILITARY**

MIL-M-38784A	Manuals, Technical: General Style and Format Requirements
MIL-M-3880A (USAF)	Manuals, Technical: Organizational Maintenance Instructions
MIL-M-83495 (USAF)	Manuals, Technical, Organizational Maintenance Manual Set: General Requirements for Preparation of
AFHRL-TR-79-49	Manuals, Technical: Logic Tree Troubleshooting Aid (LTTA): Organizational and Intermediate Maintenance
AFHRL-TR-79-50	Maintenance Task Identification and Analysis: Organizational and Intermediate Maintenance
MIL-I-45208A	Inspection System Requirements
MIL-Q-9858A	Quality Program Requirements

#### **STANDARDS**

MIL-STD-863A	Preparation of Wiring Diagrams and System Schematic Diagrams
MIL-STD-1388-1 and -2	Logistic Support Analysis
MIL-STD-785A	Reliability Program for Systems and Equipment Development and Production
MIL-STD-882A	System Safety Program Requirements

## OTHER DOCUMENTS

AFR 36-1

Officer Classification Manual

AFR 39-1

Airman Classification Manual

(Government Contractors may obtain copies of the above documents from the American National Standards Institute, 1430 Broadway, New York, New York 10018. Government activities may obtain copies from the Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.)

## 3. DEFINITIONS

**3.1 Terms and Definitions.** The following important terms and definitions are used throughout this handbook. An understanding of each is necessary to enable the contractor to perform effective MTI&A.

**3.1.1 Action tree.** A branching tree diagram for a fault symptom showing the procedural steps required to isolate each fault that can cause that symptom to a replaceable component.

**3.1.2 Analyst (task).** An individual qualified by training and experience to perform the task analysis process. Personnel assigned this position (or are detailed to assist in this process) should have an understanding of: 1) analysis techniques; 2) documentation research techniques; and 3) interview techniques. An analyst need not be an equipment expert, but must have access to equipment experts.

**3.1.3 Assembly.** A number of parts or subassemblies, or combination, joined together to perform a specific function and which can be disassembled. (Examples: Power shovel-front, fan assembly, audio frequency amplifier.)  
**NOTE:** The distinction between an assembly and subassembly is determined by the individual application. An assembly in one instance may be a subassembly in another where it forms a portion of an assembly.

**3.1.4 Automated test equipment (ATE).** Automatically sequenced test equipment used, usually at intermediate (shop) level, to check out and troubleshoot assemblies of a system, such as Line Replaceable Units (LRUs).

**3.1.5 Built-in test equipment (BITE).** Test equipment built into a system that enables it to perform a check on itself automatically.

**3.1.6 Failure mode.** One of the ways in which a component can fail. For example, a solenoid can have three failure modes: (1) a broken coil, (2) broken

insulation, or (3) restricted mechanical movement. Each of the three failure modes can produce a different fault symptom.

**3.1.7 Fault symptom.** An observable or measurable abnormal indication, operation, or function caused by a fault in an equipment or system. Note that in some systems, for any given system state, the same symptom may appear as the result of any one of many possible faults.

**3.1.8 Function.** A group of functional entities and functional devices or circuit elements that work together to accomplish a portion of a system or an equipment-assigned objective. For example: transmit, receive, display, hoist, train, generate power, and control actions.

**3.1.9 In-process review.** A review of an MTI&A project conducted at critical points for the purpose of evaluating the status of the project, accomplishing effective coordination, and facilitating proper and timely decisions required during the task analysis. Also includes evaluation of work in progress and provision of guidance.

**3.1.10 Intermediate maintenance.** (See 'Maintenance levels').

**3.1.11 Job.** The composite of duties and tasks expected of an individual within a particular rating or specialty and at a particular skill level or rate.

**3.1.12 Job guide manual (JGM).** A specialized technical manual containing illustrated, highly detailed, step-by-step procedures for the accomplishment of maintenance tasks other than checkout and troubleshooting.

**3.1.13 Job performance aid (JPA).** Illustrated, highly detailed, step-by-step instructions for the performance of maintenance tasks, including both nontroubleshooting and troubleshooting tasks. The two types of JPAs (Job Guide Manuals and Logic Tree Troubleshooting Aids) are designed to provide, in one place, the information that a technician needs to do all of the job tasks on a system/equipment.

**3.1.14 Logic tree troubleshooting aid (LTTA).** A specialized troubleshooting manual based on logic trees and containing coordinated sets of troubleshooting aids such as checkout procedures, logic trees, fault symptom lists, locator diagrams, and sometimes supporting reference information and troubleshooting rationales.

**3.1.15 Maintainable.** Capable of being adjusted, aligned, calibrated, checked, tested, trouble-isolated, serviced, repaired, or replaced.

**3.1.16 Maintenance function.** A group of maintenance tasks performed on a system or a component of the system. Standard maintenance function verbs for use in the Task Identification Matrix (TIM) are:

a. **Adjust.** (1) To bring to a specified position or state; (2) to bring to a more satisfactory state; to manipulate controls, levers, linkages, etc.; to return equipment from an out-of-tolerance condition to an in-tolerance condition.

b. **Align.** To bring into line, to line up; to bring into precise adjustment, correct relative position, or coincidence.

c. **Assemble.** To fit and secure together the several parts of; to make or form by combining parts.

d. **Calibrate.** To determine, and restore if necessary, accuracy by special measurement or by comparison with a standard. Usually applied to test and measurement equipment but also applies to other highly accurate equipment.

e. **Checkout.** To perform specified operations to verify operational readiness of a subcomponent, component; subsystem, or system.

f. **Disassemble.** To take to pieces; to take apart to the level of the next smaller unit or down to all removable parts.

g. **Install.** (1) To perform operations necessary to properly fit an equipment unit into the next larger assembly or system; (2) to place and attach.

h. **Operate.** To control equipment in order to accomplish a specific purpose.

i. **Reassemble.** To refit and secure the parts of the item after they have been taken apart.

j. **Reinstall.** To perform operations necessary to properly refit into a system or subsystem, an item that was previously removed.

k. **Remove.** (1) To perform operations necessary to take an equipment unit out of the next larger assembly or system; (2) to take off or eliminate; (3) to take or move away.

l. **Repair.** To restore an equipment item to operable condition by means other than total replacement.

m. **Replace.** To substitute serviceable equipment for malfunctioning, worn out, or damaged equipment.

n. Service. Operations required periodically to keep an item in proper operating condition, such as the following:

- (1) **Balance**. To equalize in weight, height, number, or proportion.
- (2) **Bleed**. To extract from or let out some or all of a contained substance.
- (3) **Charge**. To restore the active materials in a storage battery by the passage of a direct current through in the opposite direction to that of the discharge.
- (4) **Check**. (1) To confirm or establish that a proper condition exists; to ascertain that a given operation produces a specified result; to examine for satisfactory accuracy, safety or performance; to confirm or to determine measurements by use of visual or mechanical means; (2) to perform a critical visual observation or check for specific conditions; to test the condition of.
- (5) **Clean**. To wash, scrub, or apply solvents to; remove dirt, corrosion, or grease.
- (6) **Coat**. To cover or spread with a finishing protecting layer.
- (7) **Drain**. To draw off (liquid) gradually or completely.
- (8) **Flush**. To pour liquid over or through; to wash out with a rush of liquid.
- (9) **Inspect**. To perform a critical visual observation or check for specific conditions; to test the condition of.
- (10) **Lubricate**. To put lubricant on specified locations.
- (11) **Paint**. To apply color or pigment (suspended in suitable liquid) to the surface of.
- (12) **Pressurize**. To apply pressure within by filling with gas or liquid.
- (13) **Purge**. (1) To free of sediment or trapped air by flushing or bleeding; (2) to remove fuel or fuel vapors from engine by motoring engine with fuel switch off.
- (14) **Tune**. To adjust for precise functioning.

o. Test. To perform specified operations to verify operational readiness of a component, subcomponent, system, or subsystem.

p. Troubleshoot. To localize and isolate the source of a malfunction or breakdown.

**3.1.17 Maintenance levels.** The three basic levels of maintenance — Organizational, Intermediate, and Depot (not covered in this handbook) — into which all maintenance activity is divided. The scope of maintenance performed within each level must be commensurate with the personnel, equipment, technical data, and facilities provided.

a. **Organizational maintenance.** Maintenance which is the responsibility of, and performed by, a using organization on its assigned equipment. Its phases normally consist of inspecting, servicing, lubricating, adjusting, and replacing of parts, assemblies, and subassemblies.

b. **Intermediate maintenance.** Maintenance which is the responsibility of and performed by designated maintenance activities for direct support and general support of using organizations. Its phases normally consist of calibration, repair, or replacement of damaged or unserviceable parts, units or assemblies or subassemblies; the emergency manufacture of nonavailable parts; and providing technical assistance to using organizations. Intermediate maintenance is normally accomplished in fixed or mobile shops.

**3.1.18 Maintenance step.** (See 'Task step').

**3.1.19 Maintenance task.** (See 'Task').

**3.1.20 Maintenance task analysis.** (See 'Task analysis').

**3.1.21 Maintenance task identification.** (See 'Task identification').

**3.1.22 MTI&A products.** The recorded results of Maintenance Task Identification and Analysis. Includes: Task Identification Matrix (TIM) or Expanded TIM (optional); Definitized User Profile; Level of Detail Guide; Support Equipment Guide; Task Analysis Worksheets; Checkout Summary; Fault Symptom List; Action Trees; and Task Identification Summaries (optional).

**3.1.23 Part.** One piece, or two or more pieces joined together which are not normally subject to disassembly without destruction of designed use.

**3.1.24 Performance parameters.** Range of acceptable values for a system or equipment function which, when measured or observed, indicate satisfactory operation.

**3.1.25 Skill.** The mastery of, or proficiency in, a technique. Skills involve physical or manipulative activities. They often require knowledge for their execution. All skills are actions having special requirements for speed, accuracy, or coordination.



**3.1.26 Skill level.** The type and degree of skill representing the extent of qualification within the total Air Force Specialty Code (AFSC). It reflects the skills typically required for successful performance at the grade with which the skill level is associated.

**3.1.27 Subassembly.** Two or more parts which form a portion of an assembly or a unit replaceable as a whole, but having a part or parts which are individually replaceable.

**3.1.28 Subsystem.** A major functional subassembly or grouping of items of equipment which is essential to the operational completeness of a system.

**3.1.29 Subtask.** Any group of related behaviors which fulfills a limited purpose within a task. For example, "open access doors" or "set up test equipment" may be subtasks within an inspection or checkout task.

**3.1.30 Support and test equipment (SE).** Referred to as 'support equipment' in this handbook. One of the nine principal elements of Integrated Logistics Support (ILS). Consists of tools, metrology and calibration equipment, performance monitoring and fault isolation equipment, maintenance stands and handling devices required to support the operation and maintenance of systems. Items are categorized as peculiar (to the system under development) and common (commercially available or currently in the defense inventory). Includes equipment categorized as Ground Support Equipment (GSE) or Aerospace Ground Equipment (AGE).

**3.1.31 Symptom.** (See 'Fault symptom').

**3.1.32 System/equipment.** The item under analysis, be it a complete system or any portion thereof being procured.

**3.1.33 Target population.** (See 'User population').

**3.1.34 Task.** A set of steps describing a complete start-to-finish, step-by-step maintenance action.

**3.1.35 Task analysis.** Also referred to as Maintenance Task Analysis. A systematic procedure for analyzing an identified maintenance task to determine what the task consists of, what is needed to perform it, and how it should be performed. Includes defining the user population, support equipment requirements, and level of detail required. The recorded results of task analyses are the basis for development of Job Guide Manuals and Logic Tree Troubleshooting Aids.

**3.1.36 Task identification.** Also referred to as Maintenance Task Identification. The ascertainment and itemization of the troubleshooting and nontroubleshooting tasks required to maintain a system/equipment at the organizational and intermediate levels.

**3.1.37 Task step.** The single, smallest logically definable maintenance action, such as setting a switch to the OFF position. Generally, a step is comprised of one action but in certain cases may be a series of identical actions, such as removing seven bolts.

**3.1.38 Troubleshooting.** The process of detection, diagnosis and isolation of equipment malfunctions for repair.

**3.1.39. User population.** Also referred to as Target Population. Representative members of the using commands, organizations or units for whom the Job Performance Aids will be developed, and therefore at whom the MTI&A is aimed.

**3.1.40 Validation.** The process by which the contractor ensures the adequacy, accuracy, and completeness of the MTI&A and their suitability for the intended purpose. Procedural data are validated by actual performance on the subject system/equipment, while nonprocedural data are validated by such methods as comparison with source data, analysis by experts, etc.

**3.1.41 Verification.** The process by which the Government assures the accuracy, adequacy, completeness and suitability of the MTI&A products and their conformance with contract and specification requirements. This includes Government action to assure proper validation by the contractor, actual comparison with the hardware, and other suitable actions.

#### **4. GENERAL DESCRIPTION AND PLANNING OF TASK ANALYSIS**

**4.1 Overview of the MTI&A Process.** Figure 1 shows the six basic analyses, the products that are required to document each, and their interrelationships. Some of the analyses can be prepared independently of others, some require prior completion of other analyses, and the preparation of some analyses may overlap. For Job Guide Manual (JGM) type of JPAs, which cover only fixed procedure tasks, such as adjustment, alignment, disassembly, all of the analyses except the troubleshooting analyses are performed. For LTTAs or other manuals that will provide detailed trouble diagnosis procedures, the troubleshooting analyses are added to determine the number and content of fault diagnosis procedures. The first step in task analysis is the development of a Task Analysis Plan, which describes the planned use of resources, equipment, subject matter experts, as well as schedules and quality control.

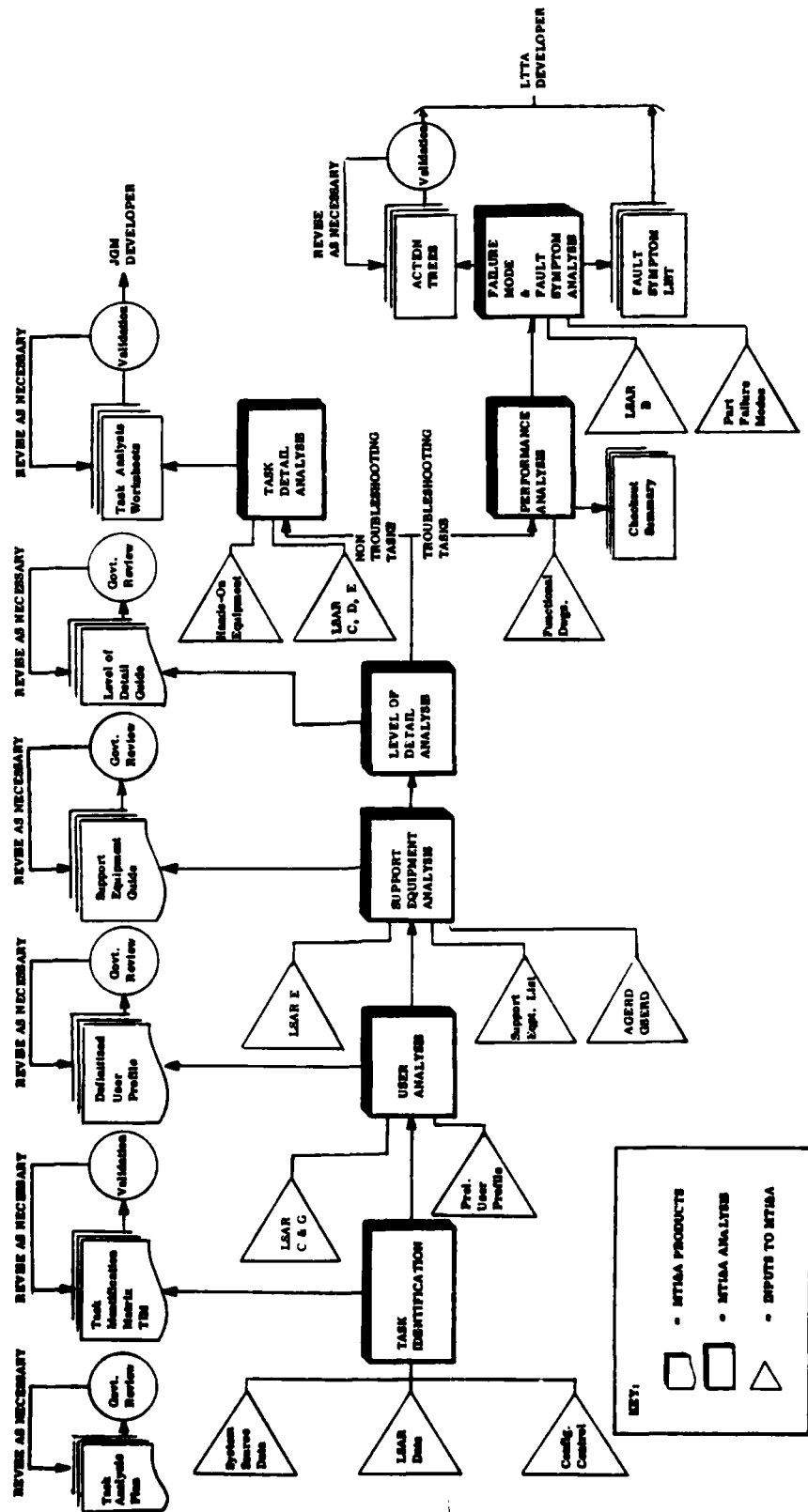


FIGURE 1. Detailed MTI&A process.

Task identification is the first analysis to be performed. Each task identified at this stage as a candidate for maintenance coverage and possible inclusion in the JPAs is subsequently examined in the task detail analysis and if appropriate, in the troubleshooting analysis. The task identification is based upon an equipment breakdown, a listing of maintenance functions applicable to the subject system, and the maintenance concept. The Task Identification Matrix (TIM) is a matrix of all equipment and items maintainable at the maintenance levels (Organizational or Intermediate) under consideration. As each task is identified, it is recorded on the TIM, which is the product of the task identification process. Cell entries in the matrix identify all of the possibilities for tasks and indicate the level of maintenance at which each task is performed. Although it is extremely important in completing MTI&A to do further analysis of each identified task, task identification can be developed independently for several special applications. For example, a comprehensive TIM can be an important aid in developing or evaluating the completeness of maintenance coverage in conventional technical manuals.

Next, the User Analysis carefully describes the expected user of the maintenance aid (i.e., the Job Performance Aid or technical manual). Before the identified tasks can be further detailed, it is essential to define the abilities, knowledge, and skills of the target user population for whom the JPA, and therefore the task analysis, will be prepared. The Government should provide a Preliminary User Profile, which is further refined by the developer based on the technical needs of the system. Eventually, the final product of user analysis, called a Definitized User Profile, is produced. It is used as a reference when conducting the level of detail analysis, the support equipment analysis, and the task detail analysis. Furthermore, it is a definitive document used by developers when writing procedures. The user analysis can be performed concurrently with task identification, as they are not interdependent.

The Support Equipment Analysis is performed to identify all test equipment, special tools, and special ground support equipment required during performance of the identified maintenance tasks. It determines the assumptions to be made about the user's ability concerning the required tools and equipment and, based on these assumptions, develops standard statements to be used when writing task steps involving the use of the equipment. The product of this analysis is called a Support Equipment Guide, and the User Analysis must be completed before it can be finalized.

Given the skills, knowledge, and abilities of the target users as defined in the Definitized User Profile, a Level of Detail Analysis is performed to determine the kinds and amount of detailed information needed by these users to successfully perform the required tasks. The product of this analysis is called a Level of Detail Guide. It contains guidelines, or rules, to be used in writing Task Analysis Worksheets and task steps (other than those involved in use of support equipment) for both nontroubleshooting and troubleshooting tasks.

Each nontroubleshooting task that was identified in the TIM as needing a procedure for inclusion in a Job Guide Manual is subjected to a searching analysis, called a Task Detail Analysis, to answer the questions posed earlier about each identified task. The product of this analysis is a set of Task Analysis Worksheets that provide the basis for the corresponding procedure in the subsequent JGM. The worksheets provide data on equipment condition and performance prerequisites; support equipment and materials needed, safety precautions, personnel requirements, basic task steps with performance standards, and follow-on tasks. Essential inputs to this analysis are provided by the User Analysis, Level of Detail Analysis, and the Support Equipment Analysis.

In troubleshooting task analysis, the task analyst must literally solve all of the troubleshooting problems that the maintenance technician is likely to encounter. Task analysis for troubleshooting consists of Performance Analysis and Failure Mode and Fault Symptom Analysis, which are documented in the form of Action Trees and result in the description of branched-procedure tasks for use by the LTTA developer. Each hardware item with checkout/troubleshoot task entry identified in the TIM for inclusion in a LTTA is subjected to a troubleshooting analysis. The objective of this analysis is to determine how many different ways that component can fail (its failure modes) and how many measurable performance parameters of the system its failure modes can affect.

Performance Analysis identifies functional characteristics of the system, in terms that can be checked and these checks are developed to see if the system functions are being performed properly. This analysis is recorded on a Checkout Summary.

By analyzing each failure mode and the symptom(s) each can cause (its fault symptoms), the analyst can determine how each normal, performance parameter can be measured to show whether the component is failing and the elements that can cause the failure. This phase of analysis is known as Failure Mode and Fault Symptom Analysis. From this analysis, a Checkout Summary and a Fault Symptom List are produced. The Checkout Summary, when considered along with the check/troubleshoot tasks identified in the TIM, establishes the scope of the LTTA checkout. The fault symptom list defines the fault symptoms that must be addressed during development of the troubleshooting Logic Trees in the LTTA. It also provides the LTTA preparer with the list of systems and units that must be tested and considered for corrective action within the Logic Tree guidelines.

Action Trees are the final product of troubleshooting task analysis and are the basis for later development of the LTTA. There is an action tree (AT) for each fault symptom in the fault symptom list. An AT is a branching tree trouble diagnosis outline depicting the most orderly approach for diagnosing the fault presented by the fault symptom.

The troubleshooting analysis also includes data resulting from considerations of hazardous components such as energy sources, fuels, propellants, explosives, and pressure systems and reliability analysis data.

The results of MTI&A are recorded in various forms known as Task Analysis Products. The specification (AFHRL-TR-79-50) calls out a number of sample forms such as the TIM form and Task Analysis Worksheet form that are used in collecting and storing data and in presenting MTI&A intermediate products for review by various subject matter experts and the Acquisition agency. As explained, it is not as important to use the exact form or format provided in the specification as it is to supply all of the data required by the specification. Other formats for the data required may be permitted by the Acquisition agency if they are clear, easy to understand, easy to update, and easy for a JPA developer to use.

**4.2 Fundamentals of Task Analysis.** Keys to establishing an effective MTI&A capability or evaluating an organization's ability to become effective are

- a. Understanding the MTI&A concept and believing in its importance
- b. Careful selection of lead task analyst personnel
- c. Separation of the MTI&A function from normal documentation or publications work
- d. Careful planning and scheduling
- e. Ensuring a firm technical support function for data input and dedicated subject matter experts
- f. Proper application of the techniques outlined in this handbook.

A major contribution of MTI&A resides in its rational, systematic, analytic foundation for developing effective JPAs or manuals. Only complete, accurate, and understandable task analyses can ensure JPAs that are totally reliable for the maintenance technicians in the field.

MTI&A procedures focus the attention of the task analyst on small steps. The analyst must identify and describe what the technician perceives and what the technician should do. The analyst must communicate optimal work tasks and a set of steps that will permit the technician to achieve task goals.

The difficulties in doing task analysis are not in following the prescribed procedures — they are in the resistance the task analyst encounters in gaining access to equipment, in getting permission to have equipment disassembled, in requiring detailed graphics, and in making detailed descriptions when grosser descriptions might superficially appear to be adequate. The more completely

the analyst understands the user's job, what the analyst is told, and what the analyst observes, the better is the analysis. The analyst will find that most tasks can be performed in several ways and that much task-relevant information can be interpreted in more than one way. However, the analyst must constantly concentrate on determining the methods that will work best in the field and on communicating those methods in sufficient detail to guarantee effective task performance. The difficulties that a task analyst encounters and solves in this process are the very difficulties that technicians in the field would encounter and would have to solve many times over if the task analyst had not done it once and produced a maintenance aid designed to avoid those problems.

The process of troubleshooting task analysis is largely a matter of defining and designing the diagnostic tasks and is a research and organizing effort rather than a writing effort.

This is true even when one of the data sources is existing conventional technical manuals, since they may not contain much of the information required for an effective MTI&A. When analyzing some technical manuals, the task analysts may find that they are not based on the user's needs in performed tasks, but on what engineering data existed. They may reflect, for example, in testing procedures, test equipment that is not available to the field technician or that does not address fault diagnosis in depth.

Conventional technical manuals are frequently directed to an audience presumed to be generally technically knowledgeable and more familiar with the subject equipment than is presumed in the case of the typical JPA user. Furthermore, the major emphasis of many conventional technical manuals is on description of the subject equipment rather than on instructions for the tasks the user must perform. Task descriptive information found in the technical manuals is often inadequate, and the procedural data that does exist must be modified to serve the needs of the prospective users. Task analysts should consider existing technical manuals as no more than a suspect data source in the MTI&A process — until the manuals prove themselves to be otherwise. The analyst must rely on direct interaction with the equipment itself and must assume the role and problems of the user, by direct observation of hands-on task performance, and by interviews with task performers.

Now that some of the pitfalls and problems of the task analyst and some techniques have been identified, guidelines can be provided for selecting a candidate for the task analyst function.

**4.3 Staffing for Task Analysis.** *The contractor must consider the complexities of MTI&A and perceive the kind of person who will be most effective as a resourceful, penetrating researcher and who will examine all sides of a maintenance problem before deciding on the best approach. It is unlikely, for example, that*

manual writers will succeed at task analysis if they are usually content to "edit" the work of others without ensuring its technical integrity and completeness. The function requires someone who will test each data input for appropriateness, currency, and completeness before using it. Of course, many technical writers can perform effectively in MTI&A; but others with years of technical manual development experience may not possess the interest or understanding to do it well. During the MTI&A phase, the function should be performed by an analyst, not a writer. In the MTI&A, there is little writing ability required and if a technical writer is assigned to do the job, all must understand that the technical writer functions as an analyst during that phase, even though the technical writer may later function as a writer and utilize MTI&A products to develop JPAs. The distinction is important because altogether different talents are required for task analysis than for communicating procedural ideas to a reader (the job of a writer).

**4.3.1 Task Analyst Qualifications.** An MTI&A staff can be comprised of analysts with various technical or research experience. Some developers find that creative technical writers do fine task analysis; others use subject matter experts, such as engineers or technicians, and still other analysts come from backgrounds and professions such as educators, behavioral scientists, etc. In any case, qualifications can vary, and as a result, the kind of person required is described, rather than a peculiar discipline or job title.

The preparation of maintenance task analyses requires persons who possess most of the following:

- a. Skilled in understanding and identifying behaviors with which technicians can satisfactorily perform maintenance tasks
- b. Able to identify critical discriminations, decisions, contingencies, and responses required of the technician, and document this information in the form of instructions which can be followed with a minimum of error
- c. Familiar with the characteristics of users of the instructions so that they can limit tasks to those behaviors which are within the users' capabilities
- d. Familiar with electronic and mechanical systems, their technical language, and principles
- e. Resourceful in ferreting out the data required by task analyses -- data which may exist in a wide variety of forms and locations
- f. Able to develop tasks when documentary data about tasks do not exist
- g. Familiar with analysis techniques, documentation research techniques, and interview techniques.



**4.3.2 Lead Analyst.** Ideally, the MTI&A staff should be led by someone with at least the equivalent of a Bachelor's degree in some field of science or applied psychology, such as in electronic engineering, human engineering, or science education. In addition, this person should have some working experience in operation or maintenance of technical devices, such as those possessed by a technician. The preparation of most JPA packages will require more than one task analyst to handle the large amounts of data and it is advisable for at least one of these persons to have performed task analyses for other systems.

Realistically, all task analysts cannot possess all of these attributes and the Lead Task Analyst can be supported by assistants with the following qualifications:

**4.3.3 Assistant Task Analyst.** Assistants should have:

- a. At least two years of college and/or completion of military or industrial tech schools
- b. At least one year of experience in behavioral task analysis
- c. Experience with electronic and mechanical systems and some exhibited skill in handling tools and performing technical procedures
- d. Experience (over two years) as an engineering writer, publications engineer, or technical writer who has been responsible for developing procedural data without benefit of existing written inputs.

**4.4 Task Analysis Planning.** An effective MTI&A program must begin with a definitive plan for use of resources, data, hardware, and scheduling. The Task Analysis Plan is a planning and control document that specifies the requirements necessary to effect a logical approach, organization and implementation of the process. The plan is the responsibility of the task analysis supervisor. It must delineate what is to be done, how it is to be done, and establish milestones to be applied in the conduct of the analysis. The plan must be periodically reviewed to ensure that it is up to date with the system design situation and reflects the latest maintenance concepts.

**4.4.1 Task Analysis Plan.** The Task Analysis Plan must be developed to reflect the contract requirements for maintenance, to explain the developer's resources and schedule, and to comply with the specification for MTI&A. It should delineate the contractor's plans for performing the MTI&A and for ensuring its quality. The developer should discuss in the plan, each type of analysis to be performed and the product of each analysis. Included should be the methods, procedures, and data sources to be used, the equipment plan, the procedures for coordinating the MTI&A development with the developer's Logistic Support Analysis (LSA or ILS) function, qualifications of assigned analysis personnel, the Quality Assurance Plan, and schedules for MTI&A development, review, and delivery.

The plan and the program it defines should assure the government that the MTI&A will be well organized, capably staffed, technically accurate and complete in all respects, and in compliance with the specifications. The plan should include an organizational flow diagram showing the contractor's understanding of the relationship of the task analysis function to other contract data and hardware requirements, especially with LSA functions, and sample forms indicating the methods the contractor will use and produce in the MTI&A efforts.

4.4.1.1 Initial Planning. The contractor's plan shall discuss the planning that will take place immediately after contract award and describe and include samples of all development and quality control forms with which MTI&A will be developed and monitored for quality control and schedule compliance.

4.4.1.2 Technical Review. The contractor shall describe in the plan the methods and personnel to be used to ensure the technical accuracy of each step in task development. Describe the frequency and depth of technical reviews and the technical knowledge of the personnel who will conduct the reviews. The contractor shall also explain scheduling of the technical reviewer's quality monitoring so that it can effectively coincide with government in-process reviews and validation.

4.4.1.3 Control of Subcontractor's Task Analysis. The contractor shall describe in this section the methods to be used for ensuring that contract and quality control requirements will be invoked on subcontractors that supply equipment or services, or are otherwise involved in the MTI&A development.

4.4.1.4 In-Process Review, Validation, and Verification. The plan shall describe the system to be employed to inspect, validate, and correct task analysis products. The plan must demonstrate that cognizant contractor personnel understand the requirements of specification paragraphs 4.2, Contractor Inspection, 4.6, Validation, 4.7.1, In-Process Review, and 4.7.2, Verification. It should also explain the process and scheduling of re-review, re-validation, or re-verification of any incorrect or inappropriate data found during these checks of the task analysis products.

4.4.1.5 Changes to the Task Analysis Plan. The contractor shall not modify the organization or methods described after it has been accepted by the Acquisition agency, without prior approval of that agency.

4.4.1.6 Review and Acceptance of the Plan. The Acquisition agency will indicate acceptance or rejection of the plan with comments within the time specified in the contract. If the plan is rejected, the contractor must modify and resubmit it for Government review until it is accepted.

**4.4.1.7 Equipment Plan.** The contractor shall include in the Task Analysis Plan, an equipment plan that describes the extent to which the actual system or equipment will be employed during MTI&A development and validation. The MTI&A process requires scheduled availability of actual equipment to permit hands-on research of tasks by the analyst, to ensure that the user can perform identified tasks quickly and effectively. The plan should discuss the contractor's equipment development schedule. Include in the plan, evidence that task analysts understand that the actual equipment must be used to test behavioral cues of procedural task steps during development of task analysis worksheets.

Note that the specification permits the use of alternate equipments or mockups, but only if approved by the Acquisition agency. Especially on developing systems, the hands-on phases of MTI&A may precede the availability of final versions of the actual hardware. It is, nonetheless, important that task analysis research be done on a similar or simulated equipment to test the accuracy of component location, accessibility of corrective measures or adjustments, and other concerns of the maintenance user. Therefore, identify in the plan the specific equipment to be used including its stage of development, where it will be used, whether it is government- or contractor-owned, and describe why an alternative equipment or mockup must be used. Also, the plan must identify all support equipment and when test equipment, tools, and ground support equipment will be ready for MTI&A use. If it is possible that the equipment may become unavailable, the plan must discuss how the contractor will ensure the accuracy of task analysis.

**4.4.1.8 Equipment Availability for Validation.** The plan must also demonstrate that the contractor has dedicated specific time periods to hands-on validation of task analysis products as required by the specification. All procedures and illustration references of the Task Analysis Worksheets and the Action Trees must be validated 100 percent by actual performance on the subject system or equipment to ensure the accuracy of the subsequently prepared JPA.

**4.4.1.9 Source Data.** The plan must include the contractor's plan for assembling, checking, and using data in task analysis. Describe in the plan the types of data to be used.

**4.4.1.10 Personnel.** The resumes of task analysts and assistant task analysts, including their pertinent qualifications, must be included in the plan. Also, the organization within which the MTI&A group functions must be explained including its relationships to other cognizant organizations, such as ILS or LSA department, Engineering, and Publications.

**4.4.1.11 QA and Scheduling.** The plan must discuss the systems, procedures, and personnel with which QA will be accomplished in accordance with specification Section 4. Detailed schedules for each MTI&A phase, including QA, must be provided.

**4.5 Data Sources.** The sources of data for MTI&A will range from rough engineering sketches, preliminary bills of material, and verbal information (on developing programs) to full data packages including complete technical manuals and parts breakdowns, LSAR data, and field maintenance experience and logs (on fielded systems). If the task analysis is being performed for a system still under development, early MTI&A depends heavily on engineering data and interviews with designers. Sometimes, an analyst works among the design team and affects design decisions (e.g., those with human engineering considerations). The contractor must understand, however, that regardless of the stage of equipment development at which MTI&A begins, it cannot be considered complete until all input data required by the specification have been supplied and validated. Therefore, system design, hardware design, and the overall maintenance concept must be firm before the requirements of the MTI&A specification can be finally met. The system documentation available for the preparation of maintenance task analyses may vary among systems. In any case, the task analyst should obtain the most current revisions of system documents, and thereafter ensure, through rigorous configuration control, that the latest drawings and information are used.

Effective MTI&A requires that the analyst make a thorough search for and make full use of all valid information that can contribute to a complete data base. On many contracts, much of the input data for MTI&A will be found in the formal requirements of LSAR, required by the Contract Data Requirements List (CDRL). The CDRL, on DD Form 1423, specifies data to be delivered by the contractor. Section 5 of this handbook deals with the efficient performance of MTI&A when LSAR data are available to the analyst. Section 6 provides guidance to the analyst when LSAR data are not available as a foundation for MTI&A.

**4.5.1 Source Data on New Systems.** Typically, the analyst can look for the following types of source data to be available in some form for developing systems:

- a. **Logistic Support Analysis Record (LSAR)** — A variety of summaries and specialized output data that, if properly developed and coordinated with MTI&A, provide data pertinent and important to the entire task analysis process. LSAR data and their uses are explained more fully in Section 5 of this handbook.
- b. **Design and Engineering Data** — Drawings, lists, specifications, and other information, including functional block diagrams, schematics, timing diagrams, mechanical or physical layouts and equipment specifications generated by designers, engineers, or vendors, to communicate technical details to other functions (manufacturing, integrated logistics, purchasing, etc.)

- c. **Support equipment requirements/recommendation data such as Aerospace Ground Equipment Recommendation Data (AGERD), and Ground Support Equipment Recommendation Data (GSERD) — Data required to explain and justify the need for support equipment, including standard and specialized test equipment.**
- d. **Provisioning Parts List (PPL) — Equipment parts breakdowns compiled from early engineering design documents to enable planning and purchasing of provisioning spares.**
- e. **Test Specifications, Test Reports — That reflect equipment design details and requirements and reports that report testing of various kinds.**
- f. **Preliminary User Profile — A government-generated document that explains the level(s) of technician determined capable of maintaining the system in the field.**
- g. **Maintenance Concept — Plans, scope, policies, personnel, and constraints for all maintenance activities on a given system.**
- h. **Subject System Equipments — Any hardware such as mockups, prototypes, development models, etc., that is sufficiently similar in function, parts, size, controls, etc., to provide early insight into maintenance requirements and tasks.**
- i. **Photographs — Of the system/equipment to help identify its physical characteristics.**
- j. **Manufacturers' Literature — Commercial data such as sales brochures, data sheets, technical manuals, parts catalogs, etc., for off-shelf equipment or assemblies manufactured by the contractor or contractor's vendors.**
- k. **Technical Manuals — Either MIL-Spec (e.g., TOs, TMs) or commercial quality manuals that provide operation and maintenance data on government-furnished equipment.**
- l. **Interviews — With subject matter experts such as designers, engineers, maintenance specialists, programmers involved in development or design and can provide insight into maintenance procedures and tasks.**
- m. **Technical Proposals — Developed by the contractor or contractor's suppliers, frequently provide early descriptive data to the analyst. Such data must be considered tentative at best and confirmed for accuracy as soon as possible.**

**4.5.2 Source Data on Operational Systems.** The analyst should accumulate the following types of data, many of which will be important inputs for MTI&A on operational systems:

- a. **Maintenance Manuals, Parts Breakdowns — Organizational, Intermediate, or Depot level maintenance manuals, Illustrated Parts Breakdowns (IPBs), Repair Parts and Special Tools Lists, including changes or revisions to basic manuals. (Data in Depot level manuals can be useful even though MTI&A is intended for Organizational or Intermediate maintenance levels.)**
- b. **Time Compliance Technical Orders (TCTOs) — Direction and instructions on how to implement system or equipment changes, perform inspections, or install new equipment.**
- c. **Performance Data — Historical data relating to maintainability, reliability, and supportability of systems, subsystems, and components.**
- d. **Inspection Workcards, Work Unit Code Manuals, and Maintenance Checklists — Technical instructions for maintenance personnel.**
- e. **AFTO Form 22's (Technical Order System Improvement Reports) — Or similar forms, which are intended to reveal improvements or corrections to technical manuals recommended by field users.**
- f. **Test Equipment and Ground Support Equipment Manuals — Explaining operation and maintenance of support equipment required in performing maintenance on the subject system.**
- g. **Standard Operating Procedures (SOPs) — Detailed procedures which augment formal technical instructions.**
- h. **Parts Utilization Summaries — History of parts usage in the field.**
- i. **Engineering Reports — Providing information on need for design improvements, etc.**
- j. **Field Engineering Bulletins — Providing field personnel with necessary instructions on changes or techniques before they become part of more formal documentation, such as TCTOs, and manuals.**
- k. **Interviews — With engineers, maintenance supervisors, and technicians experienced in maintenance problems, techniques, etc.**
- l. **Observations of Maintenance in Progress — For better understanding of maintenance processes, problems, and techniques.**

**4.5.3 Configuration Control of Data.** System hardware undergoes frequent modification during its design life and operational and maintenance concepts and techniques also change. The analyst must be certain that the data used for MTI&A are valid, up-to-date, and reflect the most advanced approach to maintenance.

Plans for MTI&A should include a well-defined system of control and identification of all data collected. Identify the source of each type of data collected so that there is an audit trail from the start of MTI&A. As mentioned earlier, task analysis data must be continuously marked up to record technical changes and generally be kept current even after the development of a JPA or manual is in progress. Plan this effort by developing a form, such as shown in Figure 2, with sufficient range to list all types of data (including interviews, photos, etc.), when they were obtained, and when they were changed, improved, or deleted. Annotate and identify each source document with its title and number, the original issue and revision date, page number, and any other helpful information. Annotate LSAR data with the LSAR control number, output summary title and page number, date and revision codes, etc., as applicable. Also identify equipments used for development or validation of analysis products. Record the nomenclature, part or model numbers, serial numbers, modification status, and configuration of each equipment. For verbal data, record the names of personnel interviewed, their organization and title, and the date.

**4.5.4 Assessing and Validating Source Data.** Task analysts are frequently impressed by the magnitude and depth of detailed data they have assembled. Quite often, though, the information is partly incorrect or outdated, or covers a similar but different model of equipment. Task identification should not begin until the analyst feels certain that the assembled data are valid. Some of the most important methods for certifying the integrity of collected data are:

- a. **Document Reviews.** Relevant documents and data sources are compared with the latest engineering drawings, bills of materials, and the actual hardware.
- b. **Observation and Interview.** The task analyst should take advantage of the availability of experienced maintenance technicians and their supervisors. Observing and interrogating them while they are performing work activities is a practical method for verifying maintenance techniques and getting current, detailed job performance requirements especially for tasks for which no documentation exists.
- c. **Subject Matter Expert (SME) Review.** Frequent reviews by SMEs such as system design personnel so they are aware of the data being used for analysis helps assure that the data are current and complete.

Task Analyst \_\_\_\_\_  
 Date \_\_\_\_\_  
 Model No. \_\_\_\_\_  
 Serial No. \_\_\_\_\_

(SYSTEM/EQPMT./ASSEMBLY NAME)

A. DATA SOURCE (Cross Out Unused Items)		Basic		First Revision		Second Revision		Third Revision		Fourth Revision		Final to JPA	
		Revision Level	Date	Revision Level	Date	Revision Level	Date	Revision Level	Date	Revision Level	Date	Revision Level	Date
LSAR Data Sheets: (Show Control Number)	A												
	B												
	C												
	D												
	E												
	G												
Parts Breakdown	BOM												
	IPB												
	PPB												
	RPSTL												
	Other												
Eng. Test Spec													
Eng. Test Report													
Maintenance Plan													
Photographs (Date Taken)													
Eng. Dwg.													
Military Documentation	TM's												
	T.O.'s												
	TCTOs												
	WUCM												
	PMTWC												
AFTO -22's													
Commercial Manuals	End Rems												
	Test EQ												
B. HANDS-ON EQPMT. ANALYSIS (Identify Eqmt. or Configuration)		Initials	Date Performed	Initials	Date Performed	Initials	Date Performed	Initials	Date Performed	Initials	Date Performed	Initials	Date Performed
C. SUBJ. MATTER EXPERT INTERVIEWS (Include SME Initials)		Initials	Date Performed	Initials	Date Performed	Initials	Date Performed	Initials	Date Performed	Initials	Date Performed	Initials	Date Performed
D. VALIDATION		Initials	Date Performed	Initials	Date Performed	Initials	Date Performed	Initials	Date Performed	Initials	Date Performed	Initials	Date Performed
		TDM											
		SEG											
		TAW											
		AT's											

FIGURE 2. MTI&A configuration control form (sample).



**4.6 Quality Assurance of Task Analysis.** To ensure an effective MTI&A organization, the contractor should necessarily include a QA function tuned to the complex disciplines of task analysis and one that starts to perform its mission at the outset of the program.

In the development of the various task analysis products for technically complex equipment, the level and amount of detail are much greater and more prone to error than in conventional technical documentation. This is largely due to the greater detail requirements in the final maintenance aid to be produced from the MTI&A. As the analyst constructs a task identification matrix or the logic of an action tree for example, a simple misconception may have a "ripple effect" on many tasks and have serious effects later. A competent quality assurance organization will catch these errors and prevent their propagation into other products. Quality assurance personnel must also eliminate quality deficiencies during the entire task analysis program. A dedicated quality assurance (QA) program for MTI&A must also establish the standards against which the quality of each product will be measured as it is being developed. For example, the program must address and define:

- a. The various kinds of inspections to be accomplished
- b. The responsibilities for evaluating quality and accuracy
- c. Means of recording and controlling quality control procedures
- d. Means for solving problems of deficiencies in MTI&A quality.

Merely being able to point out unacceptable data does not accomplish quality assurance. There must also exist an ongoing organizational approach to correcting the procedural deficiencies that create unacceptable task data. The contractor's Quality Assurance Plan must be designed to ensure both quality and accuracy in the finished product. Later in this handbook, the organization, procedures, and personnel necessary to monitor the planning, development, inspection, review, validation, verification, and final production stages of a project are discussed. It is therefore vital that the contractor's quality assurance organization is adequately staffed with personnel who understand MTI&A and its importance to the ultimate product as well as to the technician in the field.

**4.7 Schedules and Budget.** It is not within the scope of this handbook to provide advice on scheduling and budgets for the overall task analysis. It is appropriate, however, to point out that in planning an effective MTI&A capability, these two factors are of great importance. Developers who are planning task analysis for the first time should understand that the process is not merely a data gathering and outline stage for the JPA or manual. To consider it as such would be to allocate too little time and budget for a particularly complex function. Instead, the contractor should understand that a well organized and carefully considered

maintenance task identification and analysis program will provide the foundation that will ensure that the JPA development will be predictable, efficient, orderly, and cost effective. In order to lay this firm foundation, MTI&A must be scheduled and budgeted to allow for careful and complete development with full attention devoted to review, quality control, validation, and delivery. Some high priority items the contractor should consider are (1) Task analysis for troubleshooting is more costly and time-consuming than for nontroubleshooting tasks and therefore should be given adequate time for total research; (2) The timely scheduling of subject matter experts to support the task analysis effort will reduce false starts and guesswork on the part of analysts; and (3) Scheduling the timely coordination of LSAR analysis functions to coincide with MTI&A efforts will eliminate duplicate costs and efforts of these functions.

**4.8 Analysis and Analysis Products.** The MTI&A Specification focuses on two elements: analysis and analysis products. Although it is important to discuss the approach to effective preparation of products, it is the analysis itself that is the substance of MTI&A while the products are the recording of the substance. Some contractors have felt that it is the preparation and delivery of a task analysis product such as a TIM or a Fault Symptom List that is important because it is contract deliverable. To emphasize the paperwork over the careful research needed to thoroughly identify and analyze the tasks for maintenance as required in the specification is to run the risk of producing a set of output documents that may not be accurate or complete. If they are not, validation will not succeed and the analysis will have to be redeveloped at extra expense. When the following important ingredients of MTI&A are applied to the program, the analytical process will succeed, enabling cost-effective development of products and, most important, ensure that the ultimate JPA will be of maximum use to the government and user.

- a. Qualified task analysis personnel
- b. Management attention to MTI&A
- c. Subject matter expert (SME) availability
- d. Good source data
- e. Dedication of actual equipment time for analyst's needs
- f. Careful planning, scheduling, and funding.

## **5. DEVELOPING MTI&A WITH THE AID OF AN LSA DATA BASE**

The specification requires that the contractor coordinate the MTI&A and LSA functions when both are incorporated by contract. This ensures that maximum use will be made of LSA data, that there will be no significant data differences resulting from logistics support analysis and task analysis, and that MTI&A is

developed as cost effectively as possible. MIL-STD-1388-2 defines the standard data elements that must be satisfied by the contractor. Various input data sheets described in this section are required to be filled out by the cognizant contractor activity and are usually input to a master computer file (although they can also be manually developed) for accessing by various functions. These data are available for use during their development and as a completed master file, and this section describes how the analyst can most effectively use the data for each analysis function.

**5.1 Judicious Use of LSA Data.** Experienced task analysts will realize that LSAR data can be a most important asset to the MTI&A process. Analysts may also be aware that the quality and technical integrity of LSAR data varies considerably from one program to another. Those LSAR data bases that are required in full by the contract and completely implemented by the contractor, with a continuously updated data base, are of maximum value to the task analyst and should be fully employed. Frequently, however, a limited LSA is procured and is only performed during the engineering concept and development model phases. In such cases, LSAR data are limited and do not remain current because of changes occurring during the final design and production phase. Some LSA efforts are terminated after the first analysis and development of LSARs, and it is difficult for the analyst to track the impact of engineering changes on maintenance procedures in a timely manner. This increases MTI&A costs unless there is a dedicated effort by the contractor and analysts to carry on those LSA elements that are vital to MTI&A integrity. Those programs in which only part of the LSAR requirements are involved or in which the available data are late, incomplete, or limited to one or two updates, will produce an unreliable data base.

The analyst may find, however, that in the latter case of questionable technical integrity, the LSAR data base is at least a good starting point. Consider keeping such data current as a purely MTI&A activity. As long as there was an initial logistic activity that developed an early data base, the analyst can use that base as the vehicle for complete MTI&A, so long as it is understood that no one but the analyst will keep it current.

Logistics Support Analysis (LSA), as defined by MIL-STD-1388, identifies the support requirements of a system or equipment including maintenance planning, support and test equipment, technical data, facilities, personnel, and training, among others. LSA outputs are in the form of a report (LSAR) summary document such as shown in Figure 3 containing quantitative and qualitative data identifying and describing such items as personnel requirements by skill, type and number; support and test equipment; spares and repair parts, reliability and maintainability predictions, and facilities. Without the results of the LSA, the analyst must rely on creating and acquiring data and guidelines with limited assistance, as described in Section 6.

LSA-05 LOGISTICS SUPPORT ANALYSIS RECORD DATE 11/10/76 PAGE 004  
 SUPPORT ITEM UTILIZATION SUMMARY  
 END ITEM ACRONYM LSA CONTROL NUMBER REF PART NUMBER ITEM NAME SERVICE DESIGNATION ITEM CATEGORY CODES SELECTED  
 TESTDA 1 8M-1234 WEAPON SYSTEM R,J,L

SUPPORT ITEM PART NUMBER C56-3 ITEM NAME SCREWDRIVER ITEM CATEGORY CODE R

MAINT LSA CONTROL LEVEL NUMBER	ITEM NAME	TASK CODE	TASK IDENTIFICATION	TASK PREQ	ELAP TIME	MAN-HOURS	QTY PER TASK
00C 10210	PRE-AMP	MGOFFAA	REMOVE AND REPLACE THE PRE-AMPLIFIER	.50	.25	.25	1.0
10220	MAIN AMP	MGOFFAA	REMOVE AND REPLACE THE MAIN AMPLIFIER	2.00	1.50	1.50	1.0
103	SYSTEM-3	MGOFFAA	REMOVE AND REPLACE SYSTEM-3	1.00	2.50	5.00	1.0
		JG0FFAA	REPLACE LEAKY GASKET	1.00	3.00	6.00	1.0
		JG0FFAB	REPLACE LEAKY SEAL	1.00	.50	.50	1.0
1031C	PUMP ASSEMBLY	MG0FFAA	REMOVE AND REPLACE THE PUMP ASSEMBLY	1.50	2.00	2.00	1.0
		JG0FFAA	REPLACE LEAKY PUMP ASSEMBLY GASKET	.50	2.50	2.50	1.0
10320	ACTUATOR ASSEMBLY	MG0FFAA	REMOVE AND REPLACE ACTUATOR ASSEMBLY	1.50	2.00	2.00	1.0
		JG0FFAR	REPLACE ACTUATOR ASSEMBLY GASKET	2.00	3.00	4.50	1.0
					42.13		24.50
					92.11		30.25

\*\*\*\* ANNUAL REQUIREMENTS FOR MAINT LEVEL \*\*\*\*  
 \*\*\*\* ANNUAL REQUIREMENTS FOR ALL MAINT LEVELS \*\*\*\*

SUPPORT ITEM PART NUMBER C56-6 ITEM NAME MULTIMETER ITEM CATEGORY CODE L

MAINT LSA CONTROL LEVEL NUMBER	ITEM NAME	TASK CODE	TASK IDENTIFICATION	TASK PREQ	ELAP TIME	MAN-HOURS	QTY PER TASK
U-5. 10216Z	BOARD-1	MGFMHYA	REMOVE AND REPLACE CIRCUIT BOARD-1	.25	.10	.10	1.0
102103	BOARD-2	MGFMHYA	REMOVE AND REPLACE CIRCUIT BOARD-2	.25	.10	.10	1.0
10224Z	RACE-1	MGFMHYA	REMOVE AND REPLACE MAIN-AMP RACE-1	1.50	.30	.30	1.0
102203	RACE-2	MGFMHYA	REMOVE AND REPLACE MAIN-AMP RACE-2	.50	.30	.30	1.0
					.05		2.50

\*\*\*\* ANNUAL REQUIREMENTS FOR MAINT LEVEL \*\*\*\*

FIGURE 3. Typical LSAR printout.

A variety of LSA "data sheets" are used to record analysis data. They are designated Data Sheets A through H. (This alphabetical sequence does not denote the sequence in which they are prepared.) The LSA program is fully automated and produces output summaries in the form of computer printouts that will be of vital interest to the MTI&A task analysts. Input data sheets E, F, and G, however, are not usually entered into the computer data base. They contain descriptive rather than quantitative data and are therefore very important to the analyst in their original form. A brief description of all of the pertinent data sheets and output summary reports follows.

5.1.1 Data Sheets B, E, F, and G. The analyst should review these sheets to see if they contain data pertinent to MTI&A on the particular program. Data sheet B, in addition to other system data, includes Failure Analysis data, item function, and the maintenance concept. It contains data on hardware failure modes, frequency of failures, and failure effects and is therefore an important input to the troubleshooting task analysis.

Data sheet E identifies requirements for special support and test equipment and new training aids. Data sheet F specifies requirements for any new facilities or facilities modification to support the program. Data sheet G identifies the need for new skills or training requirements for personnel to support the system.

The analyst may be able to examine these three data sheets for general background data before proceeding to other LSAR data.

5.1.2 Data Sheets A, C, H, and D. Data sheet D is the core of the MTI&A process because it can provide the analyst with the following:

1. Item (equipment, system, component) to be worked on
2. Task to be performed (for all tasks in the system)
3. Maintenance level (e.g., O or I)
4. Descriptive instructions on how to accomplish the task
5. Personnel and training requirements for the task (who performs the task)
6. Identifies tools and test equipment required
7. Time required to perform the task.

The other data sheets A, C, and H contain information that becomes part of outputs of the LSA process, reports (LSAR) or summaries. These data sheets are coded for computer entry and are of limited use to the analyst. However, the summaries that result from these data are of great importance to the analyst and are therefore discussed in the following paragraphs.

**5.1.3 Output Summary Reports.** The data entered into the LSAR automated system will be stored and used to produce reports that are tailored to the particular system/equipment end use. The MTI&A analyst should therefore examine the contract CDRL and related Data Item Descriptions (DIDs) to determine which summaries are required and available.

Some of the LSAR summaries that the MTI&A analyst will need, if they are available, are:

1. **Direct Annual Maintenance Manhours by Skill Specialty Code and Level of Maintenance.** This report summarizes the manpower required to support one system for a year. It defines the Air Force Specialty Code (AFSC) or Military Occupational Specialty (MOS) levels required for staffing at each level of maintenance.

2. **Personnel and Skill Summary.** This report is an expansion of the Summary just described. It defines the detail concerning each task performed by each type of technician.

3. **Reliability and Maintenance Summary.** This report lists the unscheduled maintenance tasks and the 10 most important scheduled maintenance tasks both by frequency and annual manhours consumed.

4. **Maintenance Allocation Summary.** This report summarizes data sheet inputs related to (a) the maintenance plan and concept, (b) repair parts list, (c) tool and test equipment allocations, (d) the available technician skills and manpower allocation, (e) the maintenance levels (e.g., O, I, or Depot) for each maintenance task. This summary printout explains, therefore, the responsibility for the performance of each maintenance function on each component of the system.

5. **Support and Test Equipment Utilization Summary.** This summary lists each item of support equipment by type. It gives the part number and name of the support and test equipment and then lists every task on which it is used.

6. **System Ten High Report.** This summary reports those maintenance actions that have high failure rates, high manhour consumption, and high repair times.

7. **Repair Parts Summary.** A listing of repair parts by each maintenance level (e.g., O, I, or Depot), or by a combination of Maintenance levels.

8. **Failure and Effects Summary.** This summary reflects Failure Mode and Effects Analysis (FMEA) data performed under LSA and is a primary source of data for the troubleshooting task analysis because it identifies corrective and preventive maintenance tasks.

**5.2 Optimum Use of LSAR.** A coordinated MTI&A/LSA effort, in which contractor logistic support engineers and maintenance task analysts pool their efforts and knowledge, can have the following good effects:

- a. Interaction between the two contractor functions will provide the best data possible. Each will benefit from knowing and serving the contract and user requirements of the other.
- b. There will be minimal duplication of effort.
- c. There will be minimal conflict in the data used throughout the project.
- d. Data processing can, if properly planned, satisfy all requirements from the same data base.
- e. The MTI&A analyst can utilize LSAR data sheets by neatly annotating them, as appropriate. The specification permits handwritten entries on output summaries, added or deleted columns, etc., as approved by the Acquisition agency. Samples of proposed printouts with proposed annotations and notes must be submitted as part of the MTI&A/LSA Coordination Plan. The requirements for the plan are listed in 3.5.1.1 of the specification.

**5.3 Performing Task Identification.** Task identification is the process by which the contractor defines all hardware items and related tasks necessary for carrying out the system maintenance concept and for providing complete procedural data for technicians at either O or I level, or both. The results of the task identification process are recorded on the Task Identification Matrix (TIM) form. On LSAR-based MTI&A, the analyst should consider using the existing LSAR summaries for the TIM. Although all data, including LSAR, must be checked carefully by the analyst before it is used, the information in 5.3.1 provides an excellent starting point for the analyst.

**5.3.1 Gathering Source Data for the TIM.** The analyst should consult a variety of LSAR data to aid development of the TIM. LSAR data sheets A, B, E, and G provide important planning and background information for the analyst. Formal name and part number for each item can be found on data sheet H, which is prepared for each numbered part in the system along with data to identify the item reference designator. Data sheet D should contain a narrative description of each task required for each maintenance significant O&I item, (e.g., replace brake assembly).

The analyst, however, will get more use from output summary reports of these data sheets than the data sheets themselves. If the summaries are available, the analyst can regard most of the data sheets only as reference material except for sheets D, E, and G.

**5.3.2 Filling Out the TIM form.** Ideally, the analyst can request from LSAR specialists or programmers an actual TIM printout such as shown in Figure 4, instead of adapting or modifying printouts for TIM use. This approach has the economical benefit of eliminating all depot parts, producing a much smaller TIM document. If such TIM printouts are not practical however, a Repair Parts Summary (Figure 5), Maintenance Allocation Summary (Figure 6), or a provisioning document output (Figure 7) can be adapted. This is done by adding or pasting down, a blank preprinted maintenance function matrix to the appropriate LSAR summary printout (as shown in Figure 8) that provides the best O and I equipment breakdown.

The maintenance functions that should ordinarily be covered in the matrix columns, to the extent they are appropriate, are adjust, align, calibrate, checkout/troubleshoot, clean, disassemble/assemble, replace, lubricate, remove/install, repair, service. Maintenance functions can also be coded as shown in Figure 4. If the system requires particular maintenance functions such as "inspect," or "diagnostic," to indicate that the component is checked or diagnosed by a diagnostic program as in Figure 4, the analyst should add it to the columns.

The column headings across the top of the matrix are: (1) Codes column for equipment breakdown (e.g., FGC Codes); (2) Description column in which the item (subsystem, assembly, subassembly, or part) is identified; (3) the Part Number column, where the item part number is recorded; and (4) the various "functions" columns for each of the maintenance functions. Depending on the LSA document used as a TIM base, these columns may be in another sequence on the TIM, than listed here. The analyst may find it beneficial to add a "Reference Designator" column for heavily electronic systems. For many systems, reference designators are set forth in schematic diagrams to identify each equipment item in terms of its location and function within the system.

The intersection of each item or part listing in the part column of the TIM form with a "Maintenance Function" column is called a "cell." Each cell defines a theoretically possible task. The entries to be made in each cell indicate the actual tasks, if any, to be performed on each hardware item, and the maintenance level at which each is to be performed.

**5.3.2.1 Code and Description Columns.** The Code columns of the TIM are intended to show the relationship and subordination of each system, assembly, subassembly and part that is maintainable at the O or I level. In most LSA-based programs, an adequate system coding such as Functional Group Codes (FGC codes) will be readily available to the analyst, either as part of the LSA Repair Parts summary or provisioning document. If no such system is available to satisfy the specification requirements, consult Section 6 of this handbook.





FOR ALL LEVELS OF MAINTENANCE

GROUP CODE	ILLUSTRATION FIGURE NO.	LSA CONTROL NUMBER	MFR PART NUMBER	FSCM	ITEM NAME	SERVICE DESIGNATION	USABLE ON CODE	QTY PER U/M ASSY
10110A1	5	PAFFF	9999-00-111-9996	MS-4	X1234	MUT		4
10110A1	6	PAFFF	9999-00-111-9996	MS-4	X1234	MUT		4
10110A2	5	PAFFF	9999-00-111-9995	MS-5	X1234	WASHER		4
10110A3	4	PAFMM		GB-1	X1234	TO-GEAR BOX		1
10110A3	4	PAFMM		R-1	X1234	RING		1
10110A3	5	PAFMM		G-1	X1234	GEAR-1		1
10110A3	6	PAFMM	5555-00-555-6111	G-2	X1234	GEAR-2		1
10110A3	7	PAFMM	5555-00-555-6112	G-2	X1234	GEAR-2		1
10110A4	4	PAFMM	7777-00-233-8111	M-1	X1234	HOUSING		1
10110B	5	PAFMM	8888-00-222-9112	IDA-2	X1234	TO-ASSEMBLY-2		1
10110B	7	PAFMM	8888-00-222-9112	IDA-2	X1234	TO-ASSEMBLY-2		1
10110B	7	PAFMM	9999-00-111-9996	MS-4	X1234	MUT		4
10110B1	5	PAFFF	9999-00-111-9996	MS-4	X1234	MUT		4
10110B1	7	PAFFF	9999-00-111-9996	MS-4	X1234	MUT		4
10110B2	5	PAFFF	9999-00-111-9995	MS-5	X1234	WASHER		4
10110B2	7	PAFFF	9999-00-111-9995	MS-5	X1234	WASHER		4
10110B3	5	PAFFF	9999-00-111-9996	MS-6	X1234	BOLT		4
10110B3	7	PAFFF	9999-00-111-9996	MS-6	X1234	BOLT		4
10110B4	7	PAFMM	1114-00-444-1411	P-1	X1234	PLATE		1
10110B5	7	PAFMM		R-1	X1234	RING		1
10110B5	7	PAFMM	5555-00-555-6114	G-4	X1234	GEAR-4		1
10110B6	7	PAFMM	5555-00-555-6115	G-5	X1234	GEAR-5		1
10110B7	7	PAFMM	1112-00-222-1312	UMBR	X1234	MID-DRIVE		1
10120	3	PAFFF		MID-DRIVE-PART-M	X1234	MID-DRIVE		1
10120	4	PAUFF	1112-00-222-1312	UMBR	X1234	MID-DRIVE		1
10120	8	PAUFF	1112-00-222-1312	UMBR	X1234	MID-DRIVE		1
101201	3	PAUZZ	9999-00-111-9998	MS-1	X1234	MUT	PAA	2
101201	4	PAUZZ	9999-00-111-9998	MS-1	X1234	MUT	PAA	2
101201	6	PAUZZ	9999-00-111-9998	MS-1	X1234	MUT	PAA	2
101202	3	PAUCC	9999-00-111-9993	MS-3	X1234	BOLT	PCC	2
101202	4	PAUCC	9999-00-111-9993	MS-3	X1234	BOLT	PCC	2
101202	8	PAUCC	9999-00-111-9993	MS-3	X1234	BOLT	PCC	2
101203	8	PAFFF	1114-00-444-1412	P-2	X1234	PLATE		1
101204	8	PAFFF		R-2	X1234	RING		1
101205	8	PAFFF	5555-00-555-6114	G-4	X1234	GEAR-4		1

FIGURE 5. Sample of repair parts summary for TIM development.

END ITEM ACRONYM	LSA CONTROL NUMBER	MFR PART NUMBER	FSCM	ITEM NAME	SERVICE DESIGNATION			
11510A	1	M-1234	M1234	WEAPON SYSTEM				
GROUP NUMBER	COMPONENT/ASSEMBLY	MAINTENANCE FUNCTION	C	M	P	H	D	TOOLS AND EQUIPMENT
1	WEAPON SYSTEM	INSPECT	.40	4.00	.00	.00	.00	.00 001 002 003
		SERVICE	.25	.00	.00	.00	.00	.00 001 002
		OVERHAUL	.00	.00	.00	.00	110.00	.00 001 002 003 006 007 008 009
		MISSION PROFILE CHANGE	.00	3.00	.00	.00	.00	.00 001 002
101	SYSTEM-1	REMOVE/REPLACE	.00	.50	.00	.00	.00	.00 001 002
		REPAIR	.60	1.00	.00	.00	.00	.00 001 002
10110	INPUT DRIVE	ADJUST	.00	.50	.00	.00	.00	.00 003 005 007 008
		REMOVE/REPLACE	.00	2.00	.00	.00	.00	.00 001 002 003 006
10110A	10-ASSEMBLY-1	REMOVE/REPLACE	.00	.00	1.00	.00	.00	.00 001 002
		REPAIR	.00	.00	1.00	.00	.00	.00 001 002
10110A:	10-GEAR BOX	REMOVE/REPLACE	.60	.60	.00	1.00	.00	.00 001 002 003
		REPAIR	.00	.00	.00	2.00	.00	.00 001 002 007 008 010
10110B	10-ASSEMBLY-2	REMOVE/REPLACE	.00	.00	3.00	.00	.00	.00 001 002
		REPAIR	.00	.00	.00	2.50	.00	.00 001 002 007 008 010
102L	MID-DRIVE	REMOVE/REPLACE	.00	4.00	.00	.00	.00	.00 001 002
		REPAIR	.00	.00	3.00	.00	.00	.00 001 002 008 010
1013A	INPUT CALIB	ADJUST	.00	.50	.00	.00	.00	.00 003 005 007 008
		REMOVE/REPLACE	.00	3.00	.00	.00	.00	.00 001 002
		REPAIR	.00	.00	3.00	.00	.00	.00 001 002 010
102	SYSTEM-2	REMOVE/REPLACE	.00	2.00	.00	.00	.00	.00 001 002 003
		REPAIR	.00	3.00	.00	.00	.00	.00 001 002 003

FIGURE 6. Sample maintenance allocation summary for TIM development.

PARTS PROVISIONING LIST

A	G704P	E	,1349 01349 5970	MIL-1-7798 .750 IN. X .010 THK	A B	2 3	INSULATION TAPE		AR	REF	IN	1 A 02 A 1 B 01 D 01 E	
B			G704A 3155-2TYQ14-501				0000 G683Q	1					
C													
D													
E	J704Q	E	71643 5970	TYPE MS350 1-2W		3 3	INSULATION TAPE		AR	REF	EA	1 A 1 B 01 D 01 E	
			G704A 3155-2TYQ14-501				0000 G683R	1					
	G704R	E	50464 9A619 9A619 5935 A2W317P303 G704A 3155-2TYQ14-501	7717383-2 00-0026-075-000- 403	A B	1 3	CONNECTOR		1	3	EA	1 A 02 A 01 B 01 C 01 D 01 E	
							0000	1					
	G704S	E	49671 5940 G704A 3155-2TYQ14-501	2377276		3 1	SHIELD, TERMINATION		AR	REF	EA	1 A 1 B 01 D 01 E	
							0000 G682R	1					
	G704T	E	9A619 9A619 5940 G704A 3155-2TYQ14-501	60-0216-0313-000 -343	A B		CONTACT, ELECTRICAL		36	REF	EA	1 A 02 A 1 B 01 L 01 E	
							0000 F686Z	1					
	G704F	E	96906 5340 G704A 3155-2TYQ14-501	MS33681-1-08		2 1	STRAP, CABLE		1	1	EA	1 A 01 B 01 L 01 E	
								1					
	G704G	E	96906 5340 G704A 3155-2TYQ14-501	MS33671-9		2 1	STRAP, CABLE		5	21	EA	1 A 01 B 01 D 01 E	
								1					
	G704H	E	96906 5940 G704A 3155-2TYQ14-501	MS25311-130		2 1	FERRULE		1	20	76	EA	1 A 01 B 01 D 01 E
								1					
	G704J	E	,1349 01349 5970 G704A 3155-2TYQ14-501	MIL-1-23053/5 .250 DIA, CL1, BLK	A B	2 3	INSULATION SLEEVING		10	10	IN	1 A 02 A 01 B 01 C 01 D 01 E	
							0000 E	1					
	G704K	E	,1349 01349 5970 G704A 3155-2TYQ14-501	MIL-1-23053/5 .375 DIA, CL1, BLK	A B	2 3	INSULATION SLEEVING		50	50	EA	1 A 02 A 01 B 01 C 01 D 01 E	
							0000 E	1					
	G704A	D	50464 5995 A2W325 0329 M 3155-2TYQ14-501	7717250-1		3 1	CABLE ASSEMBLY		1	1	EA	1 A 01 B 01 C 01 D 01 E	
							A						
	G704B	E	49671 0145 G704A 3155-2TYQ14-501	2359057		3 1	WIRE, ELECTRICAL		AR	REF	IN	1 A 1 B 01 M 01 E	
							G682D	1					
	G704C	E	92196 0145 G704A 3155-2TYQ14-501	5053		3 1	WIRE, ELECTRICAL		AR	AR	IN	1 A 01 B 01 D 01 E	
								1					
	G704D	E	10016 5970 G704A 3155-2TYQ14-501	RT1150-1		3 1	INSULATION SLEEVING		AR	AR	IN	1 A 01 B 01 D 01 E	
								1					

FIGURE 7. Typical provisioning document output.

(1) SMR CODE	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION Reference Number & Mfr. Code      Unable On Code	(4) UNIT OF MEAS	(5) QTY IN UNIT	Align/Adjust	Lockout/Troubleshoot	Disassemble/Assemble	Clean	Lubricate	Replace	Remove/Install	Repair	Service	NOTES
P H	5905-060-247C	RESISTOR, FIXED 1 MEG, ± 1%, .25 WATT R-6021004F (81349)	EA	4	%			%	%		%			Ref doc# 15672
P H	6615-617-9020	CIRCUIT BOARD, PRINTED FIBREBOARD, 5-3/8 IN. LG, 2-11/16 IN. W, 6 MTC HOLES .112 IN. DIA 6490-60686-101 (78286)	LA	1	%			%	%		%			
P H	5905-988-2307	RESISTOR, FIXED 100000 OHM, ± 1%, .25 WATT R-6021003F (81349)	LA	4	%		%	%		%			1/5	
P H	5962-449-4335	AMPLIFIER, OPERATIONAL INTEGRATED CIRCUIT SILICON 369237-01 (19645)	LA	4	%		%			%			1/5	
P H	5961-087-6047	SEMICONDUCTOR DEVICE, DIODE SILICON, .125 IN. DIA J4411-645 (81349)	EA	12	%		%			%			1/5	
P H	5905-051-8007	RESISTOR, FIXED 27400 OHM, ± 1%, .25 WATT R-6021742F (81349)	EA	8	%			%		%			1/5	
P H	5905-988-2317	RESISTOR, FIXED 1000 OHM ± 1%, .25 WATT R-6021001F (81349)	EA	8	%			%		%			1/5	
P F	5961-043-1390	DIODE SILICON, .250 IN. DIA L2808 (12969)	LA	4	%				1/5			1/5		
P F	5961-068-1985	TRANSISTOR SILICON, .370 IN. DIA 24436 (92735)	EA	4	%		%			1/5				
P H	5905-052-2395	RESISTOR, FIXED 49900 OHM ± 1%, .25 WATT R-6021002F (81349)	EA	6	%		1/5							
P H	5961-177-3359	TRANSISTOR SILICON, .460 IN. DIA J4422700A (81349)	EA	6	%		1/5							1/5
P H	5905-079-3431	RESISTOR, FIXED 4990 OHM ± 1%, .25 WATT R-6021001F (81349)	LA	6	%		1/5							

FIGURE 8. LSAR printout used as TIM.

5.3.2.2 TIM Cells. When complete LSA data are available, many of the analyst's decisions for TIM cell entries will have been decided by LSA specialists. TIM data may therefore exist if the following LSA data are available.

a. If a current Maintenance Allocation Summary exists, it will provide the analyst with answers to the questions:

- Can a maintenance function be performed on this item?
- At what level of maintenance, O or I or both, will the task be performed?

The only major decisions left for the analyst on task identification would be to determine where the task should be documented by answering these questions:

- Is the task too simple to be included in a manual? (Leave a blank in right portion of cell.)
- Is the task a fixed procedure; one that involves no checkout or troubleshooting by the user? (Enter a J for JGM in the cell.)
- Is the task one that requires checking and trouble diagnosis? (Enter an L for LTTA in the cell.)

b. If no current Maintenance Allocation Summary exists, the analyst should use a Repair Parts Summary or a Provisioning List summary report as the foundation for the TIM. Either document should provide the answers to the following task identification questions:

- What is the item name and description?
- At what level of maintenance should it be repaired or replaced?
- What is the FGC code?
- What is the item part number?

With such a complete part breakdown, the analyst may need only to add the maintenance function matrix to printout sheets, as in Figure 8, or have these columns printed by the computer, as in Figure 4. In any case, the analyst will find most of the data needed to identify all tasks on the following LSA data sheets:

Data Sheet D — This sheet is entitled Maintenance and Operator Task Analysis. It provides the following answers to complete the data needs of the MTI&A analyst. (See Figure 9.)

- What task is to be performed on each item and at what maintenance level?



- How must the task be performed?
- What type of personnel can perform the task?
- What support and test equipment is required for the task?

Data Sheet G - This sheet is entitled "Skill Evaluation and Justification" (Figure 10). It answers the following questions concerning maintenance personnel to support the system.

- Are there any physical or mental requirements?
- Are there peculiar educational requirements (such as specific subjects, degrees, or licenses?)
- Is there additional training required? What does it consist of?

At each cell (i.e., the intersection of a TIM equipment item and a maintenance function column), the analyst must decide from all of this available data, including subject matter expert interviews, if a maintenance task is to be performed on this item and if so, what type, and what level? The codes to be entered in each cell must be drawn from the list shown in Figure 11.

**5.3.2.3 Ensuring TIM Completeness.** Omission of any hardware item from the TIM can result in omission of one or more tasks from the data base, and hence from the JPAs. It is therefore critical that the analyst prepare and check the list of hardware items with great care, and see that it is thoroughly reviewed for completeness by a subject matter expert (SME).

**5.3.2.4 Checking the LSA Task Identification.** The LSA summaries and data sheets reveal most of the tasks associated with a system or equipment. If there are equipment items, however, for which the LSA data have not supplied the decision on task identification, the analyst must make task decisions from other data. Where cells contain no task decisions, the analyst must identify them through existing equipment descriptions or task descriptive data, or from experience with similar equipment items by the subject matter expert, or the analyst. Section 6 discusses in more detail the task identification process for those situations where there is no satisfactory LSA data base.

**5.3.2.5 Assigning Each Task to a Manual.** Once the analyst has identified basic tasks with O or I entries or blanks for nontasks, the right part of each cell identified for tasks must be annotated to identify the expected application for the task (i.e., in what manual will the task be described). If the task is for fixed, nontroubleshooting procedures, enter "J" for JGM in the cell. If it is for a checkout or troubleshooting procedure, enter "L" for LTTA in the cell. If the





<input type="checkbox"/> O <input type="checkbox"/> J	Organizational level task to be included in a JGM
<input type="checkbox"/> I <input type="checkbox"/> J	Intermediate level task to be included in a JGM
<input type="checkbox"/> O <input type="checkbox"/> L	Organizational level task to be included in a LTTA
<input type="checkbox"/> I <input type="checkbox"/> L	Intermediate level task to be included in a LTTA
<input type="checkbox"/> O <input type="checkbox"/>	Organizational level task not to be included in a JGM or LTTA
<input type="checkbox"/> I <input type="checkbox"/>	Intermediate level task not to be included in a JGM or LTTA
<input type="checkbox"/> B <input type="checkbox"/> J	Task to be included in both Organizational and Intermediate level JGMs, but method of accomplishment/procedure differs for each
<input type="checkbox"/> B <input type="checkbox"/> L	Task to be included in both Organizational and Intermediate level LTTAs, but method of accomplishment/procedure differs for each
<input type="checkbox"/> O <input type="checkbox"/> A	Organizational level task performed by automatic self-test equipment (BITE)
<input type="checkbox"/> I <input type="checkbox"/> A	Intermediate level task performed by automatic test equipment (ATE)
<input type="checkbox"/> <input type="checkbox"/>	No such task required at O or I level
<input type="checkbox"/> ? <input type="checkbox"/>	A decision is needed - "Is there such a task?" "At what level?" (Interim code)
<input type="checkbox"/> O <input type="checkbox"/> ?	Organizational level task - A decision on JGM or LTTA inclusion is needed (Interim code)
<input type="checkbox"/> I <input type="checkbox"/> ?	Intermediate level task - A decision on JGM or LTTA inclusion is needed (Interim code)
<input type="checkbox"/> ? <input type="checkbox"/> J	Task to be included in a JGM - A decision as to maintenance level is needed (Interim code)
<input type="checkbox"/> ? <input type="checkbox"/> L	Task to be included in a LTTA - A decision as to maintenance level is needed (Interim code)

FIGURE 11. Basic TIM codes.

task will be satisfactorily performed by automatic test equipment including Built-in Test Equipment or BITE, as determined by LSA data, the second entry is "A." If the analyst determines that the task is too simple or unimportant to require coverage in a manual, leave the second entry in the cell blank.

5.3.2.6 Notes Column. The analyst should consider the Notes column as a convenient way to record significant facts, or data generated or gathered during TIM development for later use. Information such as pertinent LSAR revision levels, or deficiencies in the LSA data, interrelationships between tasks, reasons for further resolution (?) entries, special information such as techniques or problems unearthed during research, can be of significant value during later analyses efforts.

5.3.2.7 Expanded TIM. The specification defines expansion of the Basic TIM to accommodate special information about the identified tasks where the Acquisition agency has designated a requirement. From a complete LSAR data base, the analyst can request numerous types of data edits information through computer programming. When expansion is required, the analyst should develop the TIM form to allow for additional columns of summary printout or manually entered data or a separate form to be attached to the TIM if the data does not lend itself to additional columns. The TIM can be expanded, for example, to include data such as:

- Depot level breakdown of items
- Task performance times
- Tasks to be considered for special skills training
- Task Frequency (e.g., on preventive maintenance tasks).

5.4 Performing a User Analysis. A complete LSA data base contains all of the information required in User Analysis. The analyst should analyze Data sheet C and the printout called Personnel and Skill Summary and develop the MTI&A User Profile accordingly.

5.4.1 Data Sheet C. This sheet lists the estimated user characteristics and answers the following questions that are important in performing a User Analysis. See Figure 12 for pertinent columns.

- What is the skill level of personnel required to accomplish each task? Data sheet C, for example, supplies the answer in directing that the task must be accomplished by persons with Basic skills (i.e., usually for personnel in pay grades E-4 and lower), or Intermediate skills (i.e., usually for E-5 personnel), or Advanced skills (i.e., usually for E-6 and above).



- What is the skill specialty necessary to accomplish the task? Skill specialties are coded for each military agency. For example, Air Force skill specialties found in the Data sheet C listings are derived from AFR 36-1, Officer Classification Manual and AFR 39-1, Airman Classification Manual.
- Is the selected skill specialty inadequate and is additional training therefore required? This is particularly important to the analyst who must accommodate this skill deficiency by adding sufficient procedural detail in the MTI&A data base to overcome the deficiency. Additional data on these deficiencies, which must be pointed out in the user profile, can be found on Data sheet G.

5.4.2 Data Sheet G. This data sheet (see Figure 13) defines and justifies the need for any new skills beyond the capability of the appropriate skill specialty listed on sheet C. When the "SS Eval" column of sheet C is checked, the analyst should go to sheet G to determine the requirements for additional training. An A in the SS Eval indicates that the skill specialty is adequate, an M indicates that modification (additional training) is needed, and an E indicates that there is no appropriate skill specialty and a new one must be established. Of particular importance to the analyst in developing the Definitized User Profile are those parts of sheet G which answer the following questions about the user:

- Are there any unique physical or mental attributes required of personnel before they are qualified to perform the task?
- Are there any particular educational requirements that personnel must satisfy before they can acquire the skill to perform the task or attain the Skill Specialty code?
- If there are requirements for additional training, what does it consist of (type of course, length and site of course, and student prerequisites)?

5.4.3 Personnel and Skill Summary. This report summarizes the data from the Data sheet C. The analyst will find that this summary (see Figure 14), if available, will form the foundation of the user analysis. Analyze the skill specialty codes required for maintenance by consulting AFR 36-1 or AFR 39-1 and consult the LSA analyst to determine whether the skill specialty is adequate. If not, explain in the user profile the extent to which this inadequacy must be supported by additional tasks or task detail.

5.4.4 Using the Preliminary User Profile. In the early stages of a contract, before Personnel and Skills data have emerged from the LSA system, the analyst must depend on a Preliminary User Profile supplied by the Acquisition agency. It will define the general background and training of apprentice and



PERSONNEL AND SKILL SUMMARY

END ITEM ACRONYM LSA CONTROL NUMBER MFR PART NUMBER FSCM ITEM NAME SERVICE DESIGNATION  
 TESTDA 1 14-1234 X1234 WEAPON SYSTEM

OPTIONS EMPLOYED: 1. SKILL SPECIALTY EVALUATION SELECTED - ALL SKILLS  
 2. NUMBER OF SYSTEMS SUPPORTED BY MAINTENANCE LEVEL 1  
 OPERATOR/CREW - 1  
 ORGANIZATIONAL/AVUM - 1  
 INTERMEDIATE/D.S./AVIM/AFLOAT - 1  
 INTERMEDIATE/G.S./ASHORE - 1  
 INTERMEDIATE/ASHORE AND AFLOAT (NAVY) - 1  
 DEPTOY/SHIPYARDS/SPECIALIZED REPAIR ACTIVITY - 1

SKILL SPECIALTY CODE	LSA CONTROL NUMBER	TASK CODE	TASK IDENTIFICATION	TASK FREQ	SKILL SPEC EVAL	SKILL NUM OF MEN	TRNG EQP REQD	MAN-HRS PER TASK	MMS TYPE CODE	ANNUAL MAN-HRS PER ITEM	TOTAL ANNUAL MAN-HRS
35A40	102201 BOARD-11	HGHDDYA	REMOVE AND REPLACE C IRCUT BOARD-11	1.00	E	1	Y	.20	P	.2000	.2000
	102202	HGHDDYA	REMOVE AND REPLACE C IRCUT BOARD-2,MM AM	.50	E	1	Y	.30	P	.3500	.1500
		BGHDDYA	TEST CIRCUIT BOARD-2	.50	E	1	Y	.10	M	.0500	.0500
		JGHDDYA	REPAIR CIRCUIT BOARD -2	.40	E	1	Y	1.25	M	.5000	.5000
	102203	JGHDDYB	REPAIR RACK-2,REMOVE /REPLACE CARD-2	.25	E	1	Y	.80	P	.2000	.2000
		JGHDDYA	REPAIR RACK-2, REMOVE E/REPLACE CARD-1	.25	E	1	Y	.80	P	.2000	.2000
63C20	1 WEAPON SYSTEM	HGUFFAA	END ITEM MISSION PRO FILE CHANGE	1.00	A	2		3.00	M	3.0000	3.0000
		ALOFFBA	PERIODIC END ITEM IN SPECTION	4.00	A	2		4.00	P	16.0000	16.0000
	101	JGOFFAA	REMOVE AND REPLACE L EKV GASKFF	1.00	M	2		1.00	M	1.0000	1.0000

FIGURE 14. Personnel and skill summary for use in user profile.

experienced technicians who will be responsible for maintenance of the system. It will provide the analyst with data on which to base MTI&A planning, such as the user technician's reading level, training school courses and other educational background, a skills inventory, expected normal work conditions, and the level of supervision. Later, in coordination with the LSA specialists, the analyst shall develop a more comprehensive Definitized User Profile which will be used by the JPA developer.

**5.4.5 Developing the Definitized User Profile.** The Definitized User Profile is developed from data accumulated and studied by the analyst during User Analysis. It therefore will be developed from the LSA personnel and skills data. The MTI&A analyst shall develop this detailed profile for review and assurance by all contractor subject matter experts and the Acquisition agency personnel, that the definition of the actual maintenance technician user(s) culled from LSA information is accurate and complete.

If the analyst determines that the Definitized User Profile establishes a user that is different from that described by the Acquisition agency, the contractor should convene a conference to explain and receive concurrence in the intended changes. This conference will clarify the definition of the individuals who will be using the task details in the JPA including improved training requirements. The contractor may find it extremely helpful to observe government-defined users in their training setting or in actual performance of their maintenance duties, so as to verify that their skills and knowledge equate with the profiled user. The product of this conference is an approved, final, Definitized User Profile, which will guide the further task analysis process and the JPA developers.

**5.5 Performing the Support Equipment Analysis.** The contractor must perform a detailed analysis of all common and special-purpose test equipment, special tools, and ground support equipment that is necessary to maintain the system or equipment at O or I level. This research will include understanding the functions and operation of all support equipment and consolidating this data for later use by the analyst and the JPA developer. The analyst must be quite certain in this analysis that the support equipment list is complete and accurate because the list will determine level of task detail and affect the number and level of tasks to be developed for the user. Note that, as used in the specification, support equipment includes special tools, metrology and calibration equipment, performance monitoring and fault isolation equipment, maintenance stands, and handling devices required for maintenance of the system. LSAR Data sheet E and resulting summary reports provide the source data for this analysis.

**5.5.1 Data Sheet E.** This sheet (Figure 15) describes and justifies the requirements for support and test equipment necessary to operate or maintain the system.





Data sheet E will provide the analyst with answers to the following questions which are necessary to perform a complete Support Equipment Analysis.

- What testing, measuring, diagnostic tools, and test equipment are required? (These are identified by name, model number, part number, and physical size.)
- What functions will the item perform (e.g., the type, accuracy, and range of readouts)?
- What additional skills or training must be provided before the technician can use it properly? For example, it may indicate that special contractor training school must be completed before the operating skills of the technician will be adequate.

5.5.2 Support Item Summaries. The analyst will use one or more of the following printout reports summarizing support and test equipment data as a data source for developing the Support Equipment Guide.

a. Support and Test Equipment Utilization Summary. This summary shows the analyst how each item is used — by maintenance level. In addition to providing the MTI&A analyst with an excellent data source for the Support Equipment Analysis, this summary also provides the data to check the accuracy and completeness of the TIM. As shown in Figure 16, for each tool or support equipment item, there is a description of each maintenance task for which the item is required and the maintenance level at which the task is performed.

b. Tool and Equipment Requirements Summary. This report provides a listing of all tools and test equipment as they are used at either or both O or I maintenance level.

5.5.3 Developing the Support Equipment Guide. The analyst should follow these steps to produce an acceptable Support Equipment Guide:

- a. Assemble and study all of the LSA data on support equipment.
- b. On each page of the guide, record the title of the system or equipment, the date the guide was developed, and the task analyst's name (see Figure 17).
- c. For each item, list all of the functions for which it is used. Consult commercial manuals that describe each special tool and test equipment and the LSAR data for its uses.
- d. Indicate the name and number of each item of test equipment or special tool used. Identify the item by AN designation, if assigned, or by the manufacturer's designation. Common types such as voltmeters, signal generators, etc.,



RADIO SET AN/GRC - XXX  
SUPPORT EQUIPMENT GUIDE

Date 3-3-79  
Analyst J. Gault

FUNCTIONS	EQUIPMENT IDENTIFICATION	PERSONNEL ASSUMPTIONS	STANDARD STATEMENTS
Measure DC Voltage	Multimeter AW/PSM-6B	<ol style="list-style-type: none"> <li>1. Recognizes meter forms in making DC voltage measurements.</li> <li>2. Knows how to make function and range settings.</li> <li>3. Knows how to read meter scales.</li> <li>4. Is aware of safety precautions.</li> <li>5. Knows what to connect leads to meter and how to take actual readings.</li> </ol>	<p>"Connect multimeter leads between _____ and _____". Check that meter indicator + VDC" (or: "more than _____ VDC"; or "less than _____ VDC"; or "between _____ and _____ VDC")</p>
Remove/replace Connector Pins	Extractor/Insertion Tool KS-12	<ol style="list-style-type: none"> <li>1. Recognizes tool by name and sight.</li> <li>2. Knows how to use tool to remove and replace connector pins.</li> </ol>	<p>"Using Extractor/insertion Tool KS-12, remove (insert) pin(A) _____ from (in) connector _____".</p>

FIGURE 17. Example of support equipment guide.

must be listed. A special tool is any tool not normally found in a mechanic's tool kit.

e. In the personnel assumptions column, explain clearly the assumptions to be made regarding the behavioral skills and knowledge the user must possess to perform the function. Also explain the information and directions that will have to be provided in the JPA procedures using the item.

f. In the standard statements column, the analyst must list all of the exact statements to be made in the Task Steps portion of the Task Analysis Worksheets and the JPAs each time the function is needed. The statement should consist of as many of the actual words to be used when a certain category of data is to be used in the tasks. Take care that wording is consistent between similar or identical MTI&A task data. In determining standard statement wording, use the Definitized User Profile and consider user knowledge, skills, and technical difficulty in operating the item.

**5.6 Performing the Level of Detail Analysis.** If the capabilities of the users are over-estimated, they will not be able to follow the instructions in the JPA. If the instructions merely state "Check the waveform at Pin 21001," and the technicians do not know where Pin 21001 is, what the waveform should be, how to check it, or what the equipment state should be before making this check, they cannot perform this task. Too much detail, on the other hand, slows down task performance and can also increase errors in performance because users may tend to avoid using the JPA if it forces them to wade through more detail than needed. Arriving at the proper level of detail for task analysis is important. The analyst must determine from the Definitized User Profile and its LSA data sources (Data sheets C and G and Personnel and Skill Summary) the level of instructions that are appropriate to the JPA reader. The Level of Detail Analysis should be performed in conjunction with or immediately following the User Analysis because the information concerning user skills, capabilities, training deficiencies, technical experience that it provides are the same criteria from which to develop the Level of Detail Guide. For example, if the Definitized User Profile dictates that the user has the knowledge and skills to use an oscilloscope, then the Level of Detail Guide will reflect that capability by excluding details of oscilloscope operation. Conversely, if the User Profile shows that the user will not have knowledge or experience in the use of a piston ring groove wear gage, then the Level of Detail Guide will require specific in-text detail each time the gage is used in a task.

**5.6.1 Developing the Level of Detail Guide.** The Level of Detail Guide is a statement of how detailed the information must be, based upon what is known about the skills of maintenance personnel and about the equipment systems. The analyst shall develop the Guide in accordance with the specification with additional

explanation supplied below. The questions below are only suggestive of the ones that should be answered in the Level of Detail Guide. Additional questions will need to be answered for most systems, and some suggested questions may not apply to a given system. After answering such questions, and analyst must explain the directives in a form similar to Figure 18.

5.6.1.1 Discriminations and Perceptions. The Guide must define the level of detail by answering questions such as:

a. Observing Gross Indications. If a technician must respond to a gross indication such as a light being on or a meter being out of an acceptable range of values, will the task step merely name the indicator or meter and state the value to be observed or should there be an illustration that shows the indicator in the "on" state or the meter in an out-of-tolerance condition?

b. Reading Quantitative Values. When a technician must respond to a precise value on a meter (plus or minus some tolerance), will the meter face always be illustrated? Which meters will be treated differently? Will some meters require special instructions on how they are to be read (e.g., how to make interpretations)?

c. Noting Relative Motion. Will instruments be used to detect relative motion between components? How much will have to be said concerning the use of these instruments? If instruments are not used, how much should be said about the technician's point of observation? Will the illustrations indicate the direction of motion?

d. Reading or Interpreting Oscilloscope Patterns and Waveforms. How will standards for comparison be presented? What dimensions of the waveforms will be specified? How much will be said about the appropriate methods for determining amplitude, frequency, and shape of the waveforms?

e. Noting Visually Detectable Physical Defects. Will standards for comparison be presented or will it be assumed that these judgments will be mastered in training? Will illustrations show only obviously acceptable and obviously unacceptable conditions, or will various degrees of marginally acceptable conditions be shown and evaluated?

f. Detecting Presence or Absence of Sounds and Vibrations. Will the sounds or vibrations be characterized in words, or will they merely be named? Will detection of vibrations be by feel?

Date 5/10/78  
Analyst R. M. H.

AIR COMBAT FIGHTER XF-12

LEVEL OF DETAIL GUIDE

1. DISCRIMINATIONS AND PERCEPTIONS CRITICAL TO SUCCESSFUL TASK PERFORMANCE

a. Observing Gross Indications. The task step will name the indicator and will state the condition to be observed (for example, a light on or off; a motor running or not running). The illustration will depict the indicator's location; wherever practical and necessary to communicate an instruction, the illustration will also show the state of the indicator.

b. Reading Quantitative Values. The task step will state a range of acceptable values by naming the inclusive limits of the range. The location of the indicator (scale, counter) will be illustrated (with the exception of some common pieces of test equipment see the Support Equipment Guide). Counter readings will not be illustrated. Necessary scale reading and interpolation skills are assumed to be present in the user.

c. Noting Relative Motion. When relative motion is an important cue, the task step will describe the relevant dimensions of motion (direction and/or rate) of objects with respect to one another, and will include a statement of the observer's position relative to the objects whenever position is necessary for correct interpretation of the text (e.g., a fan rotating clockwise when viewed from the front). Illustration of the moving components will indicate the direction of motion with the use of an arrow pointing from each object along its path of motion.

d. Reading or Interpreting Oscilloscope Patterns or Waveforms. The task step text will require the technician to compare display with a standard provided in the illustration. The illustration will be a line drawing or rendering of the nominal expected display, with the frequency, amplitude, and/or shape tolerance range indicated with dimension lines, and a statement of the tolerance (e.g., "greater than 10 divisions").

FIGURE 18. Example of level of detail guide.

g. **Discrimination of Pitch or Other Characteristics of a Sound.** In what term will pitch be described? In what terms will other characteristics of sound be described?

h. **Discrimination of Odors.** How will significant odors be described?

5.6.1.2 **Problem Solving and Decision Making.** The Guide must define the level of detail by answering questions such as:

a. **Selection of Appropriate Next Step or Task.** Will guidance be provided for each decision that arises? In what situations will the next step or task not be specified?

b. **Performing Calculations.** What sorts of calculations will be explained in detail? In what cases will tables or nomographs be substituted for each calculation?

c. **Exercising Judgment.** Will the technician be required to make judgments without the aid of the JPA? When?

d. **Conversion of Data from One Form to Another.** Will conversions (e.g., binary to decimal or Fahrenheit to Centigrade) be aided by tables or graphs? Will complete instructions and examples accompany any tables or graphs that are presented?

5.6.1.3 **Motor Actions.** The Guide must define level of detail by answering questions such as:

a. **Activating Switches.** Will the desired setting for the switch be illustrated as well as being specified in the text? Will the location of the switch be illustrated, described in the text, or neither?

b. **Adjusting Continuous and Multiposition Controls.** Will the desired setting for the switch be illustrated as well as being specified in the text? Will the location of the switch be illustrated, described in the text, or neither? Will the direction of operation be specified (e.g., clockwise, to the left)?

c. **Performing Coordinated Gross Body Movements.** Will the movements required for moving and positioning hardware items be described or merely named?

d. **Performing Actions Requiring Fine Coordination.** Will guidance be provided for performing actions requiring fine coordination?



**5.7 Performing the Task Detail Analysis.** The Level of Detail Analysis described in Section 5.6 provides the rules for "how much detail" the JPA developer must provide in the task steps. The Task Detail Analysis discussed here will consider those rules in establishing for each specific task "what must be done." Note that this analysis will not communicate "how" to do it — that is left to the JPA developer to analyze from a behavioral approach and then to communicate "how to" to the user. To illustrate, in Figure 19, Sheets 2 and 3, the analyst has determined the task details that must be covered by the JPA developer in Removing and Installing Fuselage Tank Units. In Sheet 3 of the figure, the analyst describes the task details necessary for Follow-On Maintenance after the tank units have been installed. In the second item of that follow-on maintenance, the task detail analysis has determined that:

a. The access panels must be installed after the tank units. Presume that the analyst knows from the Definitized User Profile that the technician will not be experienced in this installation and the Level of Detail Analysis indicates that the JPA must always give detailed, well-illustrated reassembly procedures. The Level of Detail Guide, for example, would have prescribed:

Disassembly and Reassembly. For disassembly and reassembly (or removal and installation) the task step will always provide step-by-step reassembly procedures and illustrations of attaching panels, hardware, etc., to show all parts as seen from the installer's position relative to the equipment. Assume that the technician is familiar with use of the torque wrench.

b. The analyst has indicated what tasks are to be performed (i.e., "Engage access panel screws" and later "Perform leak test of fuel tanks"). The JPA developer will illustrate and explain these tasks to the extent that the task analyst has directed in the Level of Detail Guide. The analyst must make certain that every non-troubleshooting task identified in the TIM for inclusion in a JGM has been analyzed to determine the cues for each task step, the preconditions for task performance, the steps that are necessary for successful task completion (including performance standards and keyed locator illustrations), identification of follow-on tasks, and other data that is important for the JGM developer to know. Most of the task step detail analysis is in the actual writing of task step details, discussed in the following paragraphs.

**5.7.1 Writing Task Analysis Worksheets.** The contractor shall record the results of the analysis of each task on Task Analysis Worksheets, one set for each task. The worksheets must contain all of the information required by the specification and the general format of the worksheets must be similar to that in Figure 19. Legibility, completeness, and accuracy are the primary requirements for an acceptable task analysis worksheet. The first step in preparing a

TASK ANALYSIS WORKSHEET									
② FUNCTION TITLE: <i>Removal &amp; Installation of Fuselage Tank Units</i> ③ EQUIPT NOMENCLATURE & APPLICABILITY: <i>Tank, Encl 236462-001,003-006</i> <i>Air Combat Fighter XF-72 Serial 001-010</i> ④ TASK INTERVAL: <i>N/A</i> ⑥ ANALYST: <i>T. Fredericks</i>	① SHEET <u>1</u> OF <u>4</u> ⑤ DATE COMPLETED: <i>2-15-78</i> <i>Rev: 5-3-78</i>								
<u>INPUT CONDITIONS</u>									
⑦ REQUIRED CONDITIONS: <i>Aircraft safe for maintenance (see Worksheet 012)</i> <i>Aircraft defueled (see Worksheet 035)</i> <i>Aircraft drained and purged (see Worksheets 101 and 102)</i> <i>Access panels 2413, 3406, 3417 thru 3429 removed (see Worksheet 114)</i>									
⑧ PERSONNEL REQUIRED: <i>Two</i> <i>Person A - remove and install fuel tank units (at unit access)</i> <i>Person B - act as safety guard and be available for fire extinguisher duty (inc position of quick access to both Person A and extinguisher)</i>									
⑨ SUPPORT EQUIPMENT: <i>Fire extinguishers (Two)</i> <i>Maintenance platform, Type 43J6, P/N 12B1302</i>									
⑩ SUPPLIES: <table style="width: 100%; border-collapse: collapse; margin-top: 5px;"> <thead> <tr> <th style="text-align: left; border-bottom: 1px solid black; padding: 2px;"><u>NOMENCLATURE</u></th> <th style="text-align: left; border-bottom: 1px solid black; padding: 2px;"><u>SPECIFICATION</u></th> <th style="text-align: left; border-bottom: 1px solid black; padding: 2px;"><u>PART NO.</u></th> <th style="text-align: left; border-bottom: 1px solid black; padding: 2px;"><u>Quantity</u></th> </tr> </thead> <tbody> <tr> <td style="padding: 2px;"><i>Protective Rain</i></td> <td style="padding: 2px;"><i>MIL-C-5501</i></td> <td style="padding: 2px;"><i>—</i></td> <td style="padding: 2px;"><i>AR</i></td> </tr> </tbody> </table>		<u>NOMENCLATURE</u>	<u>SPECIFICATION</u>	<u>PART NO.</u>	<u>Quantity</u>	<i>Protective Rain</i>	<i>MIL-C-5501</i>	<i>—</i>	<i>AR</i>
<u>NOMENCLATURE</u>	<u>SPECIFICATION</u>	<u>PART NO.</u>	<u>Quantity</u>						
<i>Protective Rain</i>	<i>MIL-C-5501</i>	<i>—</i>	<i>AR</i>						
⑪ SAFETY CONDITIONS: <p style="text-align: center; margin: 5px 0;"><u>WARNING</u></p> <i>The removal and installation of the fuselage tank units require that work be accomplished inside the fuel tanks. To prevent</i>									

FIGURE 19. Example of task analysis worksheets (sheet 1 of 4).

TASK ANALYSIS WORKSHEET

SHEET 2 OF 4

possible injury to personnel, all safety precautions outlined in T.O. 1-1-3 shall be followed

CAUTION

The quantity of bolts, nuts and washers must be noted both before and after removal and installation to guard against leaving loose parts in the tank.

NOTE

Removal of access panels depends upon the tank unit or units to which access is required. All access panels may not require removal to perform a specific task.

TASK STEPS

(12) PRELIMINARY TASKS: None

(13) SUBTASKS:

Removal of Tank Units  
Installation of Tank Units

(14) STEP DESCRIPTIONS:

Removal of Tank Units

(All steps performed by Person A)

1. Remove screws to disconnect electrical connections.
2. Loosen screws in strain relief clamps and remove ferrules.
3. Remove bolt, nut and washer from two clamps holding the tank units to structure.
4. Carefully remove tank unit.

FIGURE 19. Example of task analysis worksheets (sheet 2 of 4).

TASK ANALYSIS WORKSHEET

SHEET 3 OF 4

Installation of Tank Units

(All steps performed by Person A)

1. Position tank unit in place; connect clamps with bolts, nuts, and washers and torque to 12-25 inch pounds.
2. Thread each wire through strain relief clamps and position strain relief ferrules under clamp. Ensure wire is in groove provided in clamp.
3. Connect wires to proper terminals.
4. Adjust ferrules so that wires are straight but under no strain, and tighten clamp screws.

FOLLOW-ON MAINTENANCE

- Engage <sup>(access panel)</sup> screws. Tighten as required to clamp up and fair-in panel to match adjacent structure.
- Install applicable access panels and secure as follows:  
3406 with 34 screws. Maximum torque 60 inch-lb  
3417 with 19 screws. " " 35 " "  
3421 thru 3428 with 19 screws. " " 60 " "
- Refuel aircraft (Worksheet 034). Press TEST button on fuel quantity select panel and check for proper indication on fuel quantity indicator.
- Perform leak test of fuel tanks (wet). (Worksheet 067).

FIGURE 19. Example of task analysis worksheets (sheet 3 of 4).

TASK ANALYSIS WORKSHEET

SHEET 4 OF 4

NOTES

*Drawing refs for procedures:*

12D4302 rev. D  
24E2260 rev. B  
20E6622 rev. B  
23D1401 rev. C  
16C3512 rev. A  
16C4220 rev. F

*See attached sketches (S1 thru S4) and photos  
(P1 thru P3) for location and position refs.*

*Procedure checked OK on aircraft no. 002 (5/5/78).*

FIGURE 19. Example of task analysis worksheets (sheet 4 of 4).

worksheet is to fill in all of the identifying and administrative data (circled item numbers 1 to 6 on Figure 19) and Input Conditions information (items 7 to 11), as indicated on the form.

The analyst can determine the Required Conditions, item 7, for the task by learning the interrelationships between tasks from SMEs and from early development of typical or preliminary tasks. Early in the MTI&A process, the analyst will begin to find common or typical tasks that will be required as preliminary to or part of other tasks. To the extent possible, the analyst should try to determine early in the analysis, which are the common, often used tasks. Generating the worksheets for common tasks early and knowing their content will simplify the organization and development of the Required Conditions entries for all other worksheets. For example, if the "Removal of the Left and Right Main Landing Gear Actuator Valves" is a procedure that must precede many other maintenance tasks, it is very helpful to complete the worksheet on that task early so that the analyst knows where it begins and ends when considering other tasks.

The analyst should refer to LSAR Data sheet C or D, to find the number of persons required in performance of the task (worksheet item 8). When using such input data, the analyst must verify that the task, as performed on the real equipment, can be performed with the personnel indicated on the data sheets. The analyst should note the importance of communication and coordination between members of a team performing a task.

The analyst should refer to Data sheet E or to the Support and Equipment Summary for a listing of the items of support and test equipment required (worksheet item 9) and Supplies (item 10), for each task. The contractor should make certain that the support equipment listed in the task analysis worksheet agrees with the LSAR data, including part numbers, description, etc. Much of the data in the worksheets may be invalid if the wrong model or type of support equipment has been used in task step details.

The analyst should ensure that all conditions which may affect the safety of personnel or equipment have been considered and listed under item 11 of the worksheet. Overall notes, cautions, and warnings shall be included under this item, even though they will also be repeated just preceding the task step to which they apply. To ensure that all such data are included, the analyst should consult subject matter experts who may be responsible under the contract for hazard identification if MIL-STD-882, System Safety Program Requirements, is invoked. Evaluation of component fault hazards, their causes, and hazardous effects is important data that must be investigated and included in the worksheets. The analyst should examine LSAR Data sheet D for the safety hazard level code. If no formal safety requirements are included in the contract, the analyst should seek out such information from subject matter experts.

The heart of the task analysis process is in the writing of task step details for worksheet items 12, 13, and 14 by the MTI&A analyst. The description of each step must communicate enough detail and guidance so that the JPA developer will understand the behaviors, cues, and technical information the user needs to perform the task successfully.

Each task must be analyzed to define in precise terms what the users will see or detect (behavioral cues) and what their responses must be to accomplish the task objectives. To ensure a precise understanding of all the task conditions, cues, responses, and objectives, the analysts must put themselves in the role of the technician trying to perform the task. The analysts' aim is to determine the optimum way to perform each task step and to ensure that all of the cues to which the user must respond have been communicated.

A cue is simply a signal for action by the technician. It can be a condition ("If the alarm light is on"), an event or situation ("When the system is ready"), or the completion of the preceding task step. The analyst, then, must organize the cues in optimum sequence that will start the task, proceed through the necessary performance steps, and then end the task. In analyzing the technical detail in conjunction with behavioral cues and responses the analyst should ask:

a. What conditions exist that make it possible for the procedure to start (initiating cues)? For example:

1. Is removal of the aircraft fuel tanks a task that can be performed at Intermediate maintenance level safely?
2. Is the aircraft safe for maintenance?
3. Has the aircraft been defueled?
4. Has it been drained and purged?
5. Have preparatory tasks (from other procedures) been performed (e.g., removal of access panels)?

b. What are the various technician responses that trigger the next cue? Usually the completion of the preceding step triggers the next, in a chain of task steps. In the body of task steps, the analyst must consider the behavioral discriminations and perceptions, problem solving and decisions, and motor actions, described in paragraphs 5.6.1.1, 5.6.1.2, and 5.6.1.3. Each of those questions must be analyzed to ensure the task steps are complete. In addition to these discriminations and perceptions, the analyst must determine through inquisitive research whether there is a better technique or a special trick that will help the user. For example, "Would loosening the access plate for the clutch assembly give the technician better access to the gear train?" or "Would the use of a printed circuit board extractor eliminate steps d and e?"

c. What cues signal the end of the task? A common problem in MTI&A is to miss or omit final wrapup steps because they are so obvious (e.g., "Disconnect test equipment," or "Tighten panel screws"). Because these ending steps are often critical, the analyst must ensure that accurate cues are provided to the JPA developer.

It is important to reiterate the need for validation of task steps through performance by the analyst or by observation of performance by a typical user. The analyst should ensure the validity and completeness of LSA information by actual testing with such typical questions as:

- a. Is there any cue or action that must precede this step?
- b. Are there too many cues in the task step?
- c. Is that step always performed this way?
- d. Is there an alternative to this step?
- e. Is the observed behavior of the tested user more typical than assumed in the LSA data?
- f. Is this the quickest sequence of task steps possible?
- g. Have all available support equipment been fully utilized in task steps?

As described in 5.1.2, LSAR Data sheet D provides a narrative description of each maintenance task (e.g., replace tank cover gasket), as well as description of the steps necessary to accomplish the task. If the analyst verifies the cues and behavioral responses described in sheet D, its data provides an excellent input to task analysis, as well as the descriptions of the actual steps necessary to accomplish the task, for example:

- a. Remove gasket from around tank cover mounting surface.
- b. Use knife to lift gasket from groove.
- c. Remove old adhesive using cleaning solvent and clean.

The data may not be in perfect form and the analyst may wish to improve or modify the task step wording, as appropriate. For example, investigation may indicate that step b should precede step a and that another tool would be safer and more effective than a knife. The analyst must also consider data from technical manuals and other sources, as a check on questionable LSA task step information. If, however, the LSAR data are found to be technically complete and accurate, the analyst can significantly cut the MTI&A effort by depending on it.



5.7.1.1 Hands-on Equipment Analysis. The equipment is the only completely reliable source of information about itself. As the development of task steps and step description for the worksheets progresses, the analyst must gain regular hands-on access to the system or equipment. The surest way to ensure accuracy and completeness is to eliminate theorizing and guesswork by actually performing tasks such as making checks with the actual test equipment, disassembling a hard-to-reach assembly, or going through all the steps of a complex alignment. The hands-on effort gives the analyst confident familiarity with the equipment, which usually is reflected in better task analysis and decreased development time for MTI&A. Later in the analysis process, of course, the analyst must validate all of the worksheet data and other MTI&A products on the actual equipment. The analyst will find validation a much simpler process if the task worksheet data have been tried out on the equipment all during development.

5.7.1.2 Level of Detail in Step Descriptions. The analyst should ensure that for each task and subtask the worksheet includes only the simplest, briefest, and most straightforward and efficient step descriptions. The level of detail of the worksheet step descriptions shall be consistent with the level recommended in Figure 19, Sheet 2 Item 14. If it is too brief, it will require the JPA developer to re-examine the data thereby repeating the research efforts of the task analyst. If it is more detailed than the sample, the analyst will have, in effect, written the JPA procedures and that is not the purpose of the MTI&A process or the function of an analyst. The data called for in the worksheet is the keystone of the MTI&A. Step descriptions must include all elements of the procedure and identify all of the cues available to the user and all of the responses the user must make. Given this information, the JPA developer can prepare procedures which focus on the cues available to the technician and explain the responses which must be made. The task analyst's job is to make certain that all of the information required to write the procedure in accordance with the specification is in the data base. The analyst must imagine how the technician will perceive the real equipment and relate to it using the JPA. In writing step descriptions, the analyst must mentally assume the place of the maintenance technician who will perform the task in the field. The analyst must visualize performance of the task, conceptualize the JPA that will be prepared to meet the stated requirements, and then judge whether the needed data are in the data base. It is much better to err in favor of providing more data than the JPA developer needs than the costly problem that would develop if there were not enough data. Finally, any missing information must be obtained and included to complete the task data base.

5.7.1.3 Illustrations. The analyst must attach to each worksheet, any and all illustrative data such as engineering drawings, diagrams, sketches, photographs, copies of pages from commercial manuals, or combinations of these that were used in compiling the task detail analysis and worksheets. The analyst should

provide sketches of settings, physical locations, etc., that are important in understanding the step description. The analyst should annotate each item with callouts, lines, notes, sketches, etc., as appropriate. Such data may be applied by hand, as long as it is neat and legible. Each worksheet illustration package should be preceded by a listing of illustrations that the analyst has compiled to support the task. Most are normal outgrowths of engineering documentation except for analyst's sketches and are an excellent asset to the analyst to communicate technical information and graphic detail to the JPA developer. Most equipment manufacturers can be expected to produce as a part of their design and fabrication process, a complete set of drawings for use in developing a prototype. Typically an engineering drawing package, which will be available to the analyst, will consist of the following:

a. **Installation Drawings.** An installation assembly drawing, Figure 20, illustrates the installed or assembled portion of an item or items relative to its supporting structure or to associated items. An installation control drawing, Figure 21, supplies information on the item in terms of area, weight, access clearances and any attachments required for installation or proper operation of the item. The analyst is using the sample installation drawings to show the JPA developer the position of the Printer in the trailer with notations about its final position. The analyst has also included the installation control drawing to portray installation details and physical mounting information for use in future creation of JPA artwork on the unit. Note the neat, handwritten notes by the analyst to indicate important features of the drawings. Such installation drawings are normal outputs of the contractor's system engineering or facility design function. The analyst need only add important task notes and attach to the Task Analysis Worksheet. These two installation drawings may be copied and used over and over again (each time with notations peculiar to the specific task). Do not refer to such drawings from one Worksheet to another because it creates total confusion to the analyst, to government reviewers, contractor SMEs and to the JPA developer.

b. **Interface Control Drawings.** Interface control drawings such as that shown in Figure 22 illustrate physical and functional interface requirements of an item which will affect the design or operation of associated or connecting items. The analyst should review this type of drawing and use it where appropriate to convey any of the physical information it depicts. Note that the analyst is not using the drawing to show interface requirements of connecting items but rather as an available type of data, which when clearly annotated with large, legible notes is a vehicle for transmitting data.

c. **Schematic Drawings.** Schematic drawings such as that shown in Figure 23 enable the analyst to illustrate by means of notations on an existing functional diagram information pertinent to the particular task. The analyst has used the



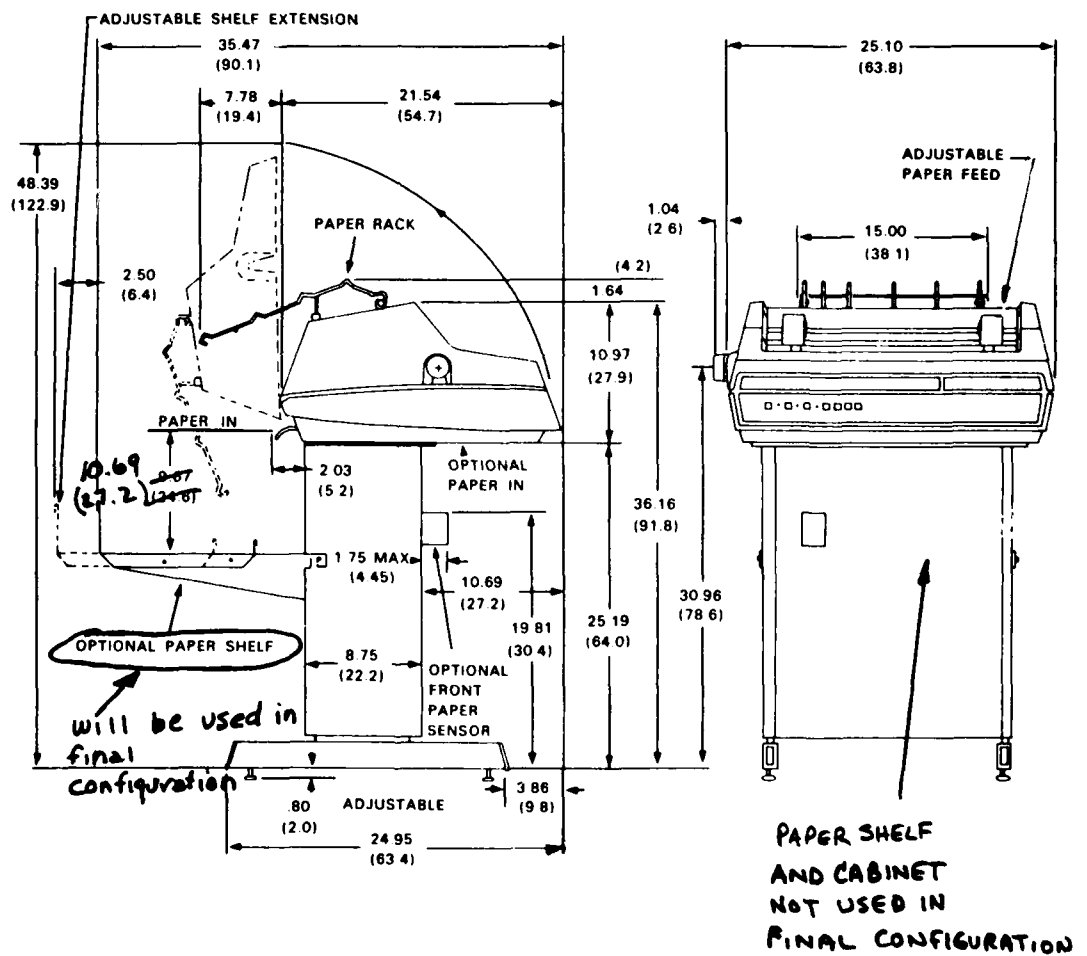
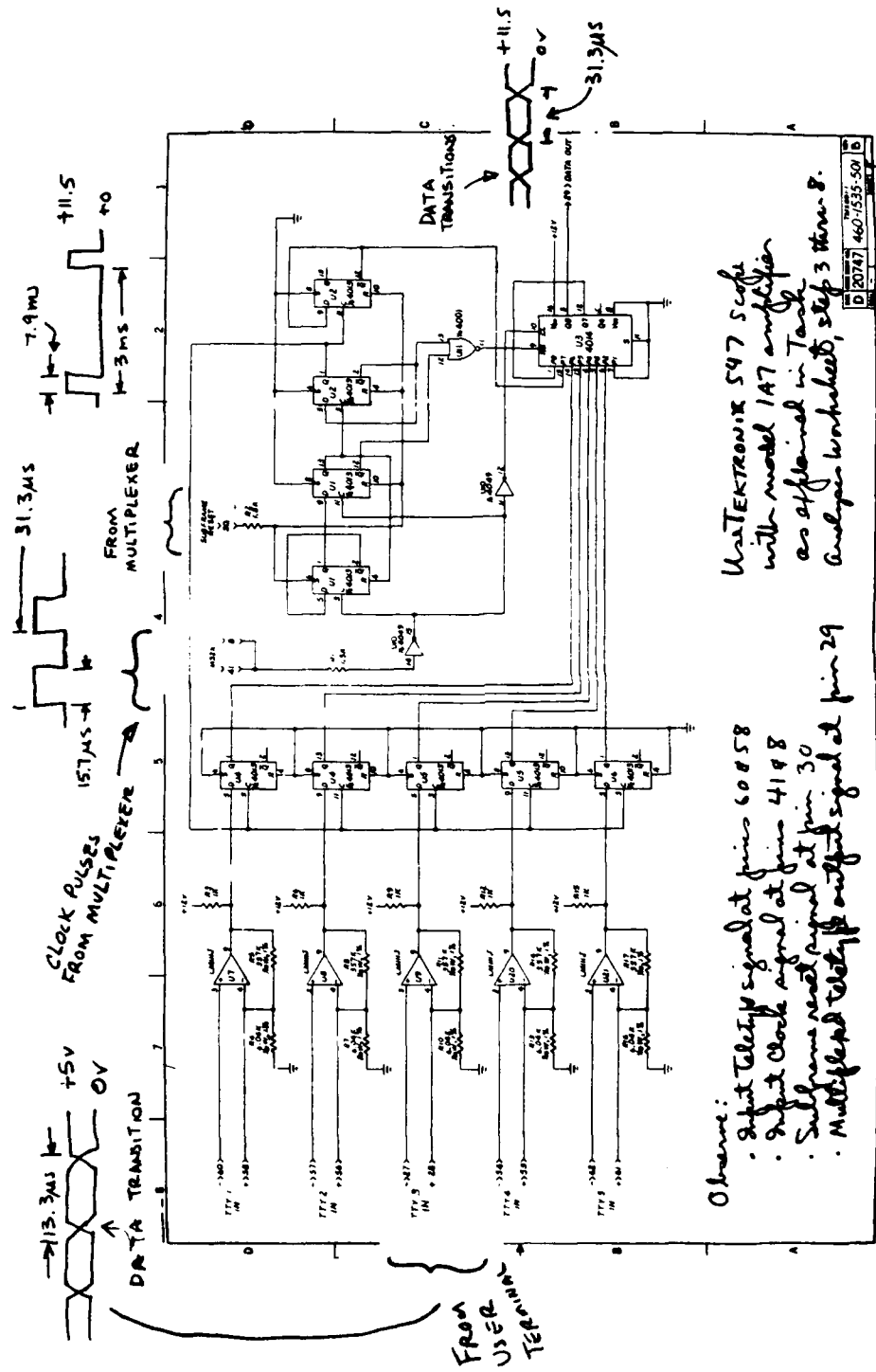


FIGURE 21. Sample installation control drawing.





Observe:  
 • Input Teletype signal at pins 60 & 58  
 • Input Clock signal at pins 41 & 48  
 • Subframe reset signal at pin 30  
 • Multiplexed Teletype output signal at pin 29

UnitEKTRONIX 547 Scope  
 with model 1A7 amplifier  
 as specified in Task  
 Analyzer worksheets, step 3 thru 8.

D 07A7 460-1535-S01 B

FIGURE 23. Sample schematic diagram.

hybrid logic schematic in the sample as a vehicle to show various input and output test data which will support a task step. The type of data shown in this sample is most effectively used in troubleshooting analysis described later. It also makes available to the JPA developer data concerning physical test points (e.g., for checking the various input and output voltages with an oscilloscope). In the sample, the analyst has provided additional data, at the bottom of the drawing, on what to test at various pins. The analyst should supply and annotate only those schematics which are necessary to support the maintenance tasks. The analyst should make certain that all pertinent input or output waveforms and voltage and resistance measurements are listed at connectors and terminal boards. Also all test point locations and test equipment connection points should be included on drawings where available (the analyst should add such data to preliminary schematics if necessary).

d. Interconnection and Wiring Diagrams. Interconnection diagrams, Figure 24, or wiring diagrams, Figure 25, are typical engineering development drawings which can be used by the analyst to illustrate internal and external electrical connections or as a vehicle for other data, as in Figure 25. The analyst should show specific test points, and input and output voltage and waveform measurements and make sure all component parts are properly identified by reference designation, unit or group symbol numbers or location.

e. Logic Diagrams. Logic diagrams shown in Figure 26, are usually used by the analyst in troubleshooting analysis, described later. In Performance Analysis, the analyst can use these diagrams to show pertinent input and output test points and values. Associated timing diagrams should be supplied when they aid in the performance analysis and checkout summary. Notations should be made as neatly and legibly as shown in the sample.

f. Mechanical Schematic. Mechanical schematics shown in Figure 27, illustrate the operational sequence or arrangement of mechanical device(s). The analyst can use this type of existing engineering drawing to show all mechanical parts of an assembly and to properly identify them by name or function. (Make certain that all gear ratios and rotational directions are clearly shown, when it is pertinent to the task.)

g. Elevation Drawings. Elevation drawings, Figure 28, depict vertical projections of structures or profiles of equipment such as aircraft or electronics systems. They show configuration, shapes and sizes of features, compartments, location and arrangement of machinery or fixed equipment. They are therefore a valuable aid to the analyst in identifying equipment or assembly geography.





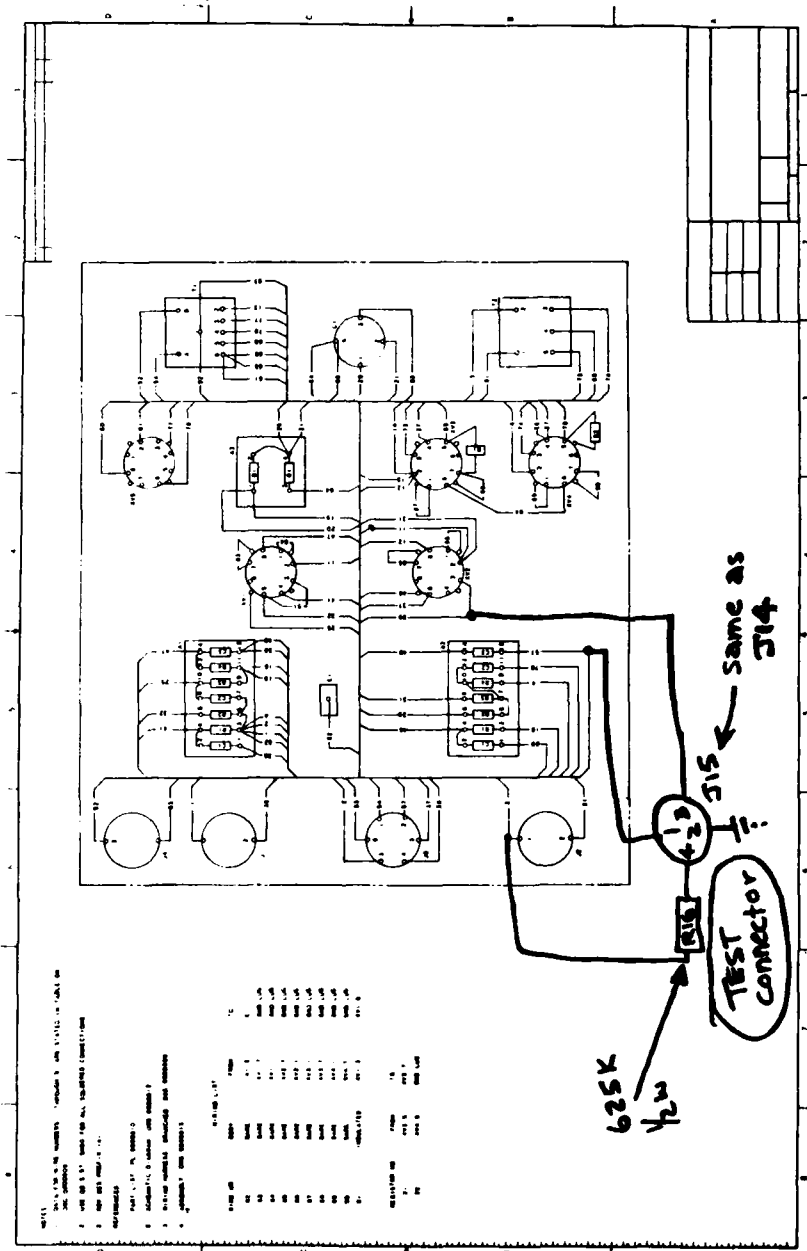


FIGURE 25. Sample connection or wiring diagram.

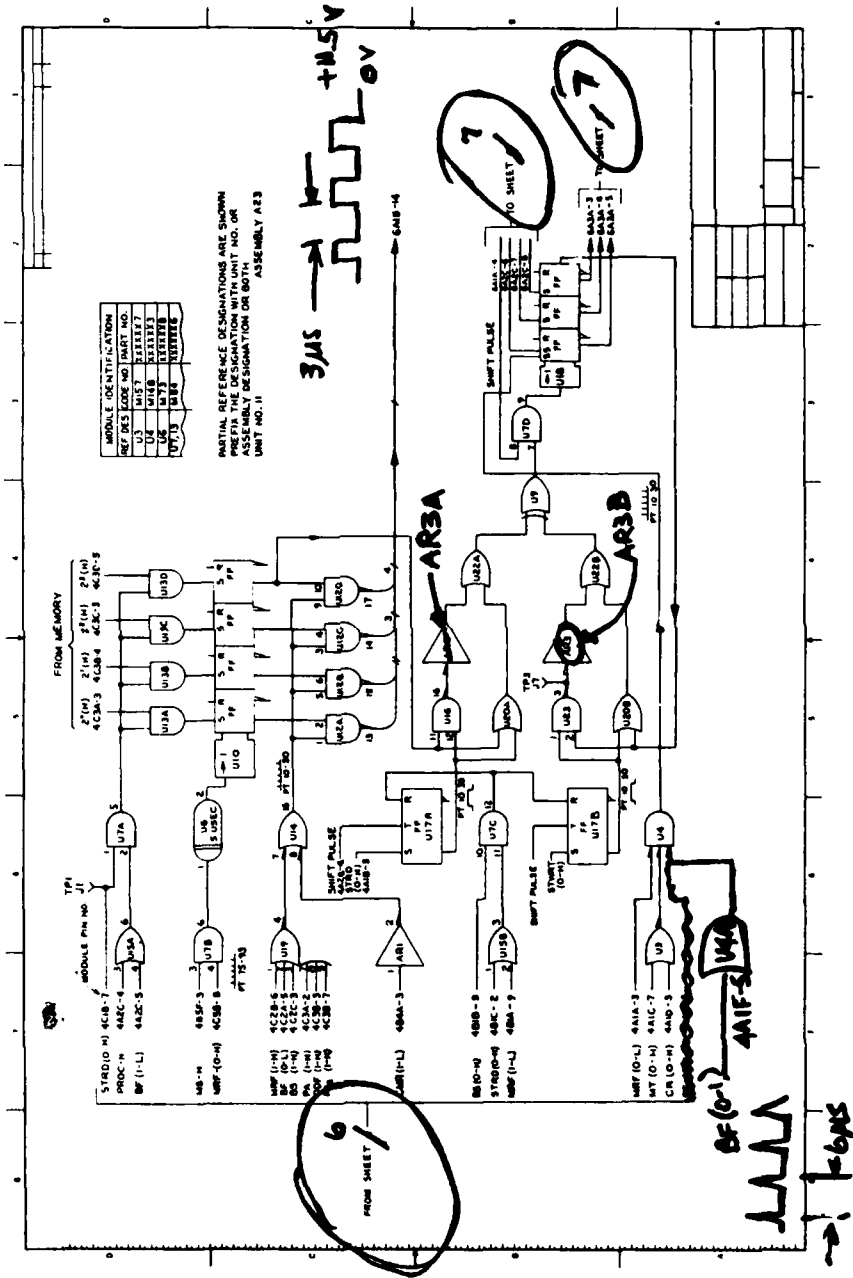


FIGURE E 26. Sample logic diagram.



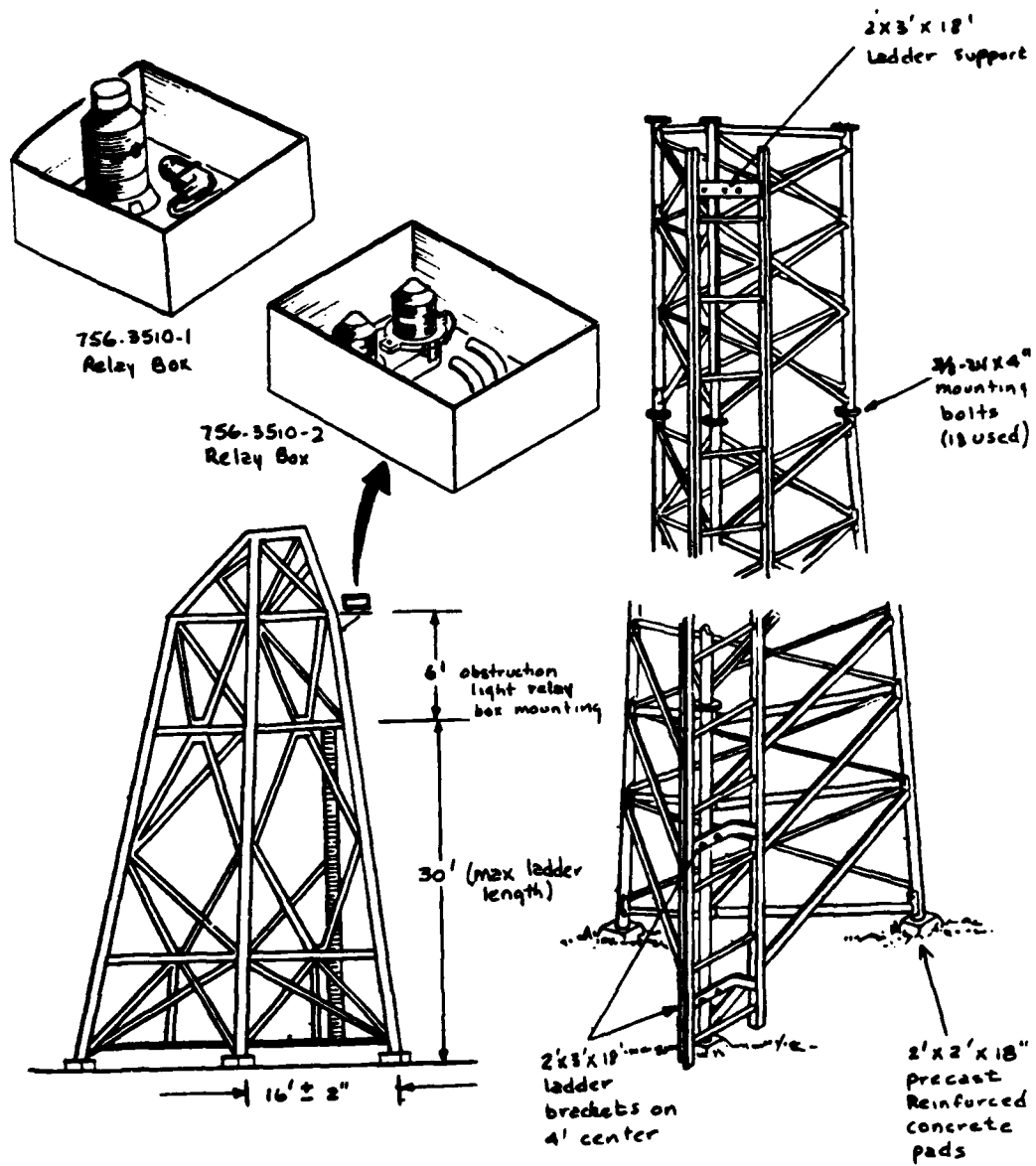


FIGURE 28. Sample elevation drawing.

h. **Assembly Drawings.** Assembly drawings, such as shown in Figure 29, illustrate the assembled relationship of two or more parts, a combination of parts and subassemblies, or a group of assemblies required to form an assembly of higher order. Assembly drawings can be presented in orthographic drawing form, photo-assembly form using halftone (screened) photographs, or in exploded assembly form utilizing either isometric or perspective drawing techniques. The analyst should use assembly drawings only if they contain sufficient detail or detailed views to show proper relationships between subordinate assemblies and/or parts that support Worksheet details.

i. **Component Part Drawing.** Component part drawings are engineering drawings that define an item and assign a part or control number to identify its configuration. Although at O and I levels, analysts may not need to use part drawings, many show details that are helpful to the JPA developer.

j. **Miscellaneous Drawings.** Figures 30 and 31 illustrate other types of engineering drawings which will augment the Task Analysis Worksheet package. The analyst should review all available drawings of this type and annotate those that illustrate pertinent data with notes, callouts, part numbers, descriptive data, etc., if it will improve the understandability of the worksheet package.

k. **Descriptive and Supplemental Data.** When a suitable engineering drawing package is not available or when the illustrative data package does not fully support the task worksheet, the analyst must supplement or provide the data in other forms. This supplemental data can be in the form of Polaroid or 35 mm photographs of suitable size and quality that, when properly annotated, suitably portray the equipment. Rough, hand-drawn sketches, similar to that illustrated in Figure 32, can be prepared inexpensively by the analyst or with some illustrator support. Care should be taken in preparing such sketches to ensure that all details are clearly defined, that the sketches are prepared in proper perspective for maximum usability, and that the line weight of drawings is heavy enough to produce clear, legible copies when reproduced with standard office type copiers. Additional data to support the worksheet can be obtained from commercial handbooks, brochures, and catalogues. A typical illustrative package supplied with the Task Analysis Worksheet to illustrate an engine fuel control assembly for the JPA developer is shown in Figure 33. Note that in Figure 33, the analyst has provided the JPA developer with a trail through a number of related photographs and illustrations culled from various sources with arrows and references (detail A, detail B, etc.).

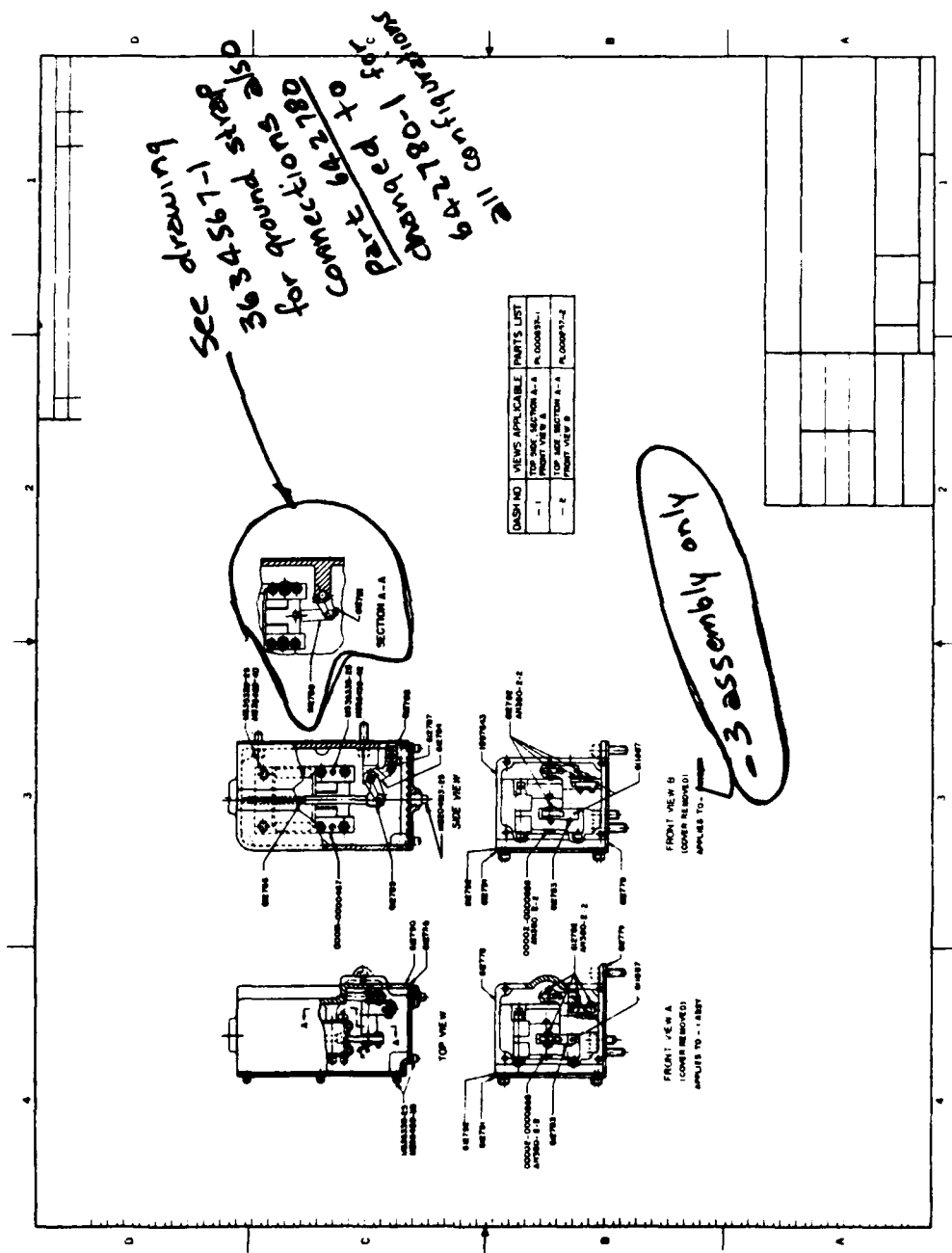


FIGURE 29. Sample assembly drawing.

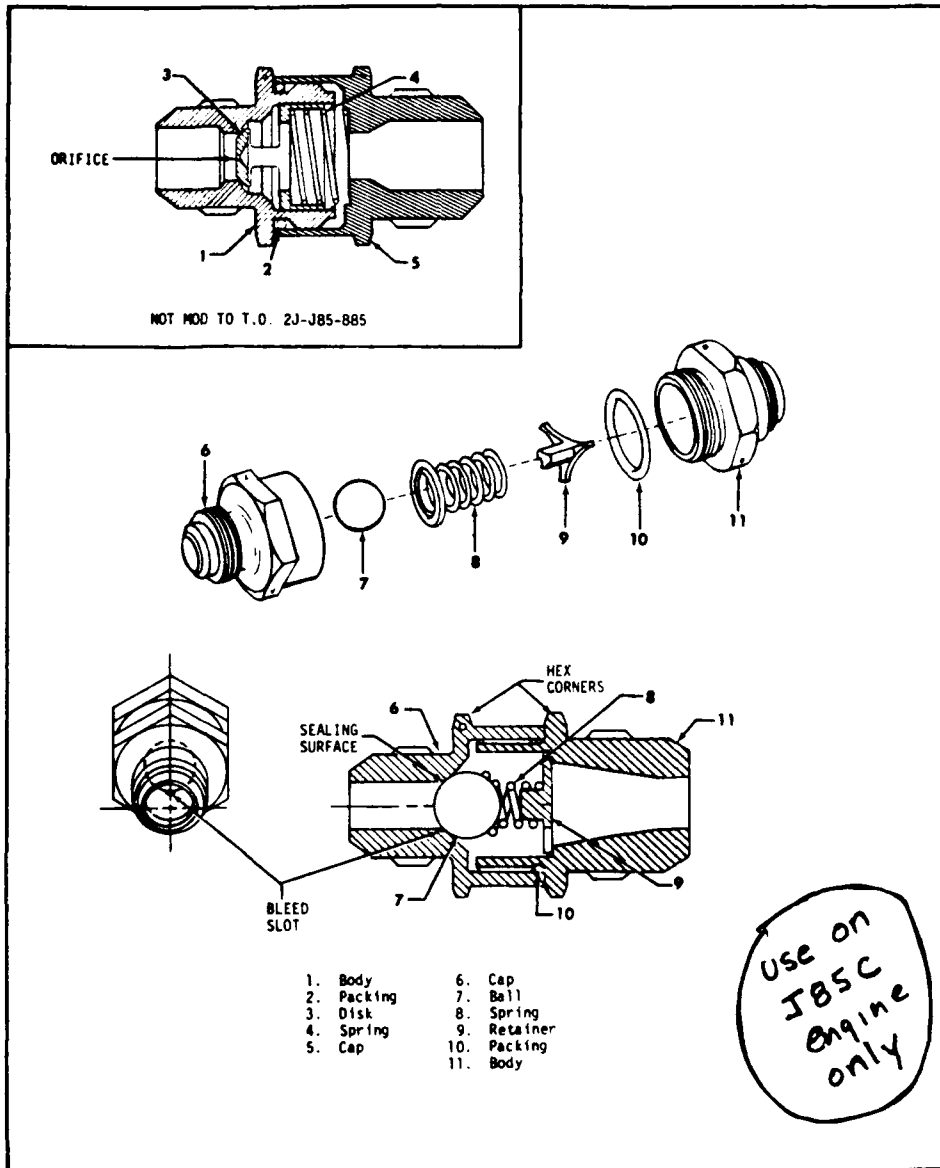


FIGURE 30. Sample illustrated assembly drawing.

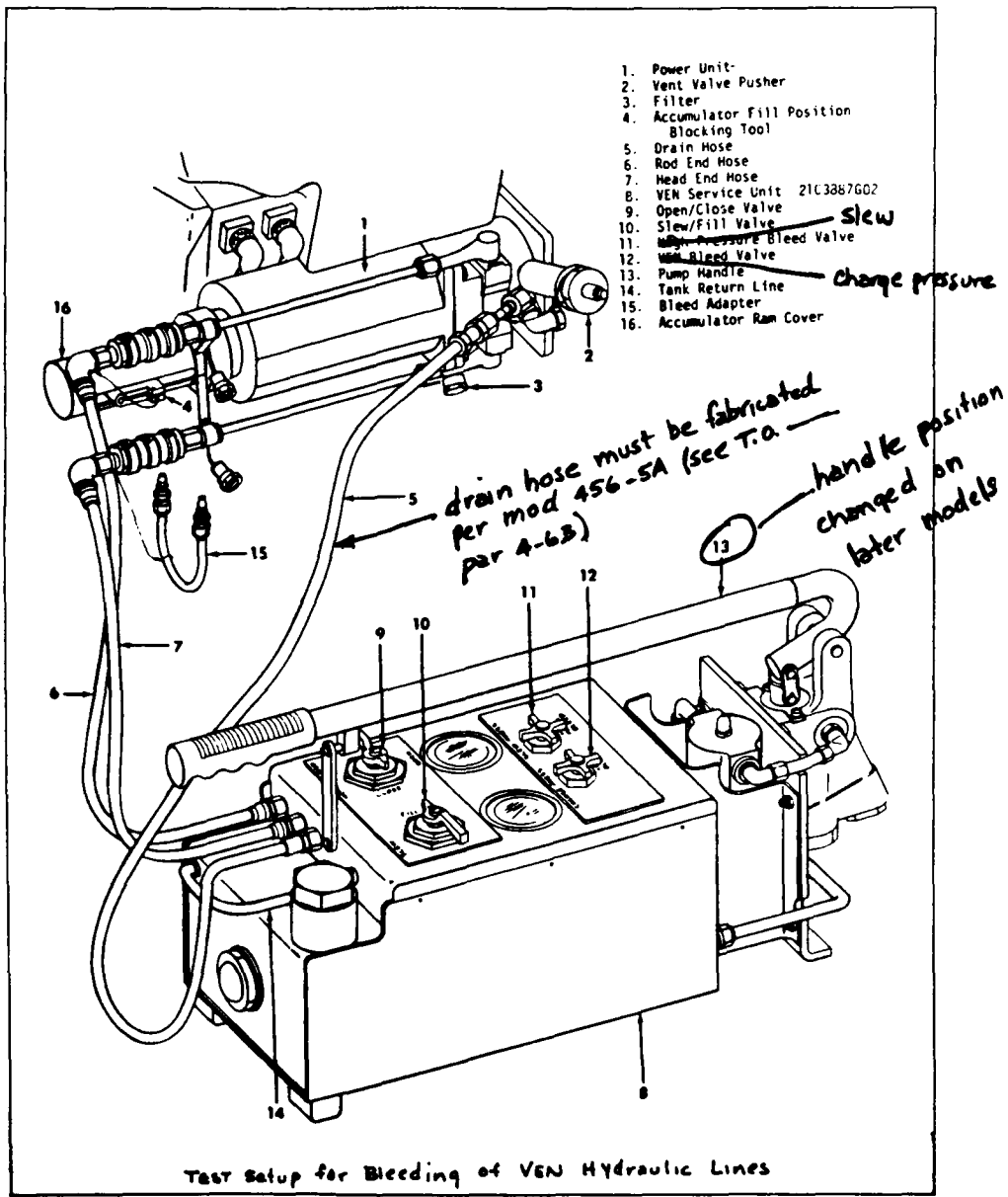


FIGURE 31. Sample test setup diagram.



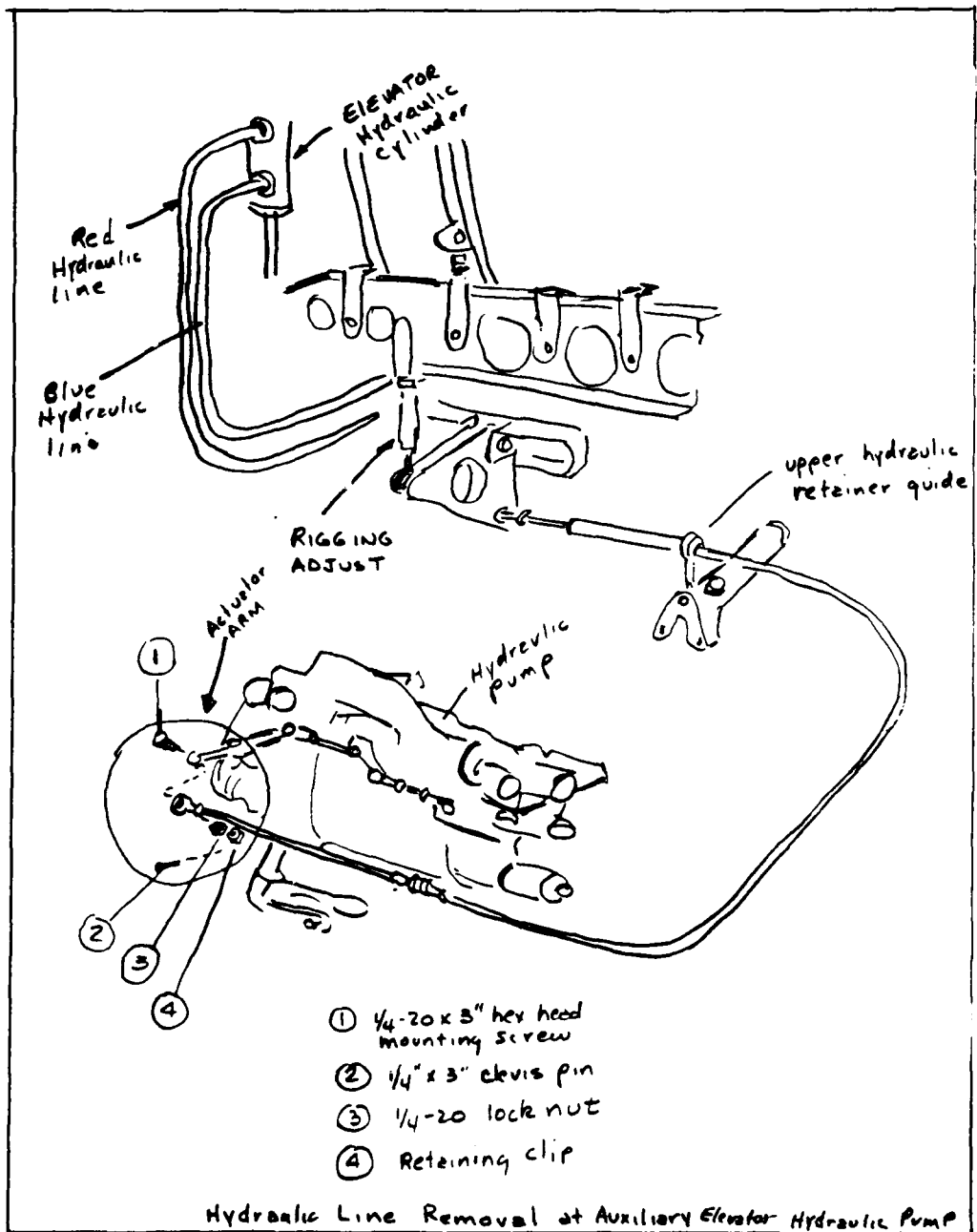


FIGURE 32. Sample analyst rough sketch.

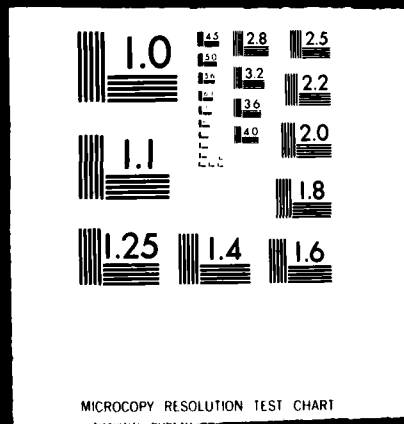




2 OF 3

ADA

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Each illustration, data sheet, or procedure should have a unique task analysis worksheet identification with the number noted on the worksheet. Below is a typical checklist of guidelines to aid the analyst in preparing and checking on the completeness and suitability of the illustrations being supplied as part of the illustrative package.

	YES	NO	N/A
1. Subject matter clearly and correctly portrayed.			
2. Subject matter is in proper relation to other assemblies and viewed from angle and perspective of the technician.			
3. Official nomenclatures and reference designators agree with the source data.			
4. Illustration depicts the correct maintenance technique and operation of the assembly under test.			
5. If halftones are used, they are clear enough for an illustrator to develop a detailed view of the assembly or component.			
6. No diagrams are included that are not of use in JPA development.			
7. All parts required for JPA development are included and identified properly.			
8. All analyst annotations are legible.			
9. All drawings included with the worksheet package have been annotated to explain their usefulness to the JPA developer.			

**5.7.1.4 Follow-on Maintenance.** The analyst must identify all maintenance actions which must be performed after the subject task. Some tasks are not complete work units in themselves. When the goal of the task is achieved, the tasks required to return the system/equipment to operational readiness or safe condition after completion of the task shall be listed in this item.

**5.8 Troubleshooting Task Analysis.** Since this phase of task analysis is the most demanding, it requires the most qualified people (analysts) and dedicated support to the analysts (subject matter experts, equipment availability, management support, etc.). Properly planned, supported, and carried out, this phase can produce a cost-efficient, complete, and accurate troubleshooting data base that will provide the user with useful, effective Logic Tree Troubleshooting Aid JPAs or other type manuals, as appropriate. Aided by LSAR data, and previously developed MTI&A products, the TIM, the Definitized User Profile, the

Support Equipment Guide, and the Level of Detail Guide the analyst must perform a Performance Analysis and a Failure Mode and Fault Symptom Analysis. The products of these troubleshooting analyses are as follows:

- a. Checkout Summary
- b. Fault Symptom List
- c. Action Trees

**5.8.1 Overview.** The analyst begins the analysis and definition of checkout and troubleshooting tasks by examining the TIM for all cells coded as OL, IL, or BL. These codes indicate that checkout and troubleshoot tasks have been identified for the equipment component and it is a candidate for checkout or troubleshooting at O or I level, or at both levels (B). The letter L indicates that the checkout or troubleshooting task will be developed for the LTTA manual. In the Performance Analysis, the analyst must identify all of the design functions of the subsystems and equipment, and establish the checks that can determine if these functions are performing normally. The performance analysis also establishes the measurable parameters associated with each function and each component that contributes to that function. Performance parameters are the range of acceptable values that, when measured, indicate whether or not the component (subsystem, equipment, assembly, part) is operating satisfactorily. The results of this analysis are recorded on a Checkout Summary, Figure 34, which becomes the basis for later development of checkout procedures by LTTA preparers. (Checkout procedures in the LTTA are used to test whether the components of the system are functioning properly or, if not, are causing fault symptoms.) Next, with the aid of Data sheet B, the analyst performs a failure mode and fault symptom analysis on each component of the system identified in the TIM for checkout and troubleshooting tasks. The fault symptom analysis identifies the ways in which each component or function can fail (its failure modes) and cause a fault and a related fault symptom. This analysis produces a list of fault symptoms for each failure mode. The final phase of troubleshooting task analysis is the development of an Action Tree (AT) for each of the fault symptoms on the list.

#### **5.8.2 Accomplishing Performance Analysis**

**5.8.2.1 Source Data.** The analyst will depend on a number of data sources for troubleshooting task analysis, but few are as important as solid understanding of the theory of operation of the system, at and above the pertinent level of repair. The data sources for performance analysis will focus on those that permit the analyst to learn the functional interrelationships of system components, such as theory of operation descriptions and diagrams in the following.

DATE: 4/18/78  
ANALYST: D. Hayslett

CHECKOUT SUMMARY  
GUIDANCE AND CONTROL SYSTEM MB-1

CHECKS	PERFORMANCE PARAMETERS
<b>DETECTION SUBSYSTEM</b>	
<b>STARTUP CHECK</b> 1. Control position 2. DC power input 3. Gyro erection 4. Ready for operation	1. STANDBY light on 2. 24 VDC $\pm$ 1.2 VDC 3. Vertical within .005 deg. within 15 $\pm$ .25 minutes 4. READY light on.
<b>WIDE SCAN MODE CHECK</b> 1. Control position 2. Antenna scan position 3. Indicator presentation	1. WIDE light on 2. 85 $\pm$ 1.5 degrees (resolution output) 3a. horizontal scan 5 $\pm$ .15 in. b. vertical scan 4 $\pm$ .10 in. c. transmitter pulse present d. target/clutter video present
<b>NARROW SCAN MODE CHECK</b> 1. Control position 2. Antenna scan position 3. Indicator presentation	1. NARROW light on 2. 12 $\pm$ 0.5 degrees (resolution output) 3a. horiz. scan - same as WIDE b. vert. scan - " " " c. transmitter pulse present d. target/clutter video present (expanded)
<b>SHUTDOWN CHECK</b> 1. Control position	1. STANDBY light on

FIGURE 34. Example of checkout summary.

a. Existing Technical Literature — Contractor SME (engineers, LSA specialists, etc.) should be able to provide such technical literature in the form of commercial operation and maintenance manuals, or if the equipment has been previously procured for military use, Air Force Technical Orders, Army Technical Manuals, etc. If the system employs equipment or major assemblies manufactured by other companies, commercial manuals are usually packed with each unit shipped to the prime contractor. If not, the analyst should request the contractor purchasing agent to request or purchase commercial manuals. MIL-spec manuals often provide the analyst with greater detail, so it is helpful to query the manufacturer to determine if a military manual has been developed on the component. If so, it can be ordered through your contracting office or technical library.

b. Functional Block and Schematic Diagrams — If the system/equipment is under development and no technical literature exists, the analyst should obtain electronic and mechanical block diagrams that show the organization and interrelationships of units from the design engineering personnel or from the manufacturer. Start with diagrams used in catalogs, data sheets, proposals, etc. For example, many technical proposals contain such drawings showing the system components and their inputs and outputs. Engineering design usually begins with sketched block diagrams and schematics outlining the equipment hierarchy. Figure 35 is a sample of the system hierarchy portrayed in a functional block diagram.

c. Other Data — The analyst will also need more detailed information in order to understand the system, such as mechanical layout diagrams, wiring lists, written functional descriptions, circuit descriptions, and similar data describing signal flow, interdependencies, operation, and performance parameters. Most of this information is generated in some form by engineers to explain to other supporting departments (logistics, manufacturing, etc.) the makeup of the hardware. Consult, for example, functional descriptions in purchasing specifications that are written to procure vendor equipments or assemblies. Many purchased items such as printed circuit boards, power supplies, and mechanical assemblies are selected from company catalogs that contain descriptions, diagrams, and test data.

**5.8.2.2 Learning the System Functional Operation.** The analyst must become familiar with all of the source data and quickly determine weaknesses and data gaps, if there are any. If the data are inadequate or unreliable, or if the analyst is doing performance analysis on a developing system with little formal data, it will be necessary to learn the system or equipment functions by other means. If technical data exist on hardware that has similar functions or components, the analyst should assemble data on and study those parts that are like the subject equipment and develop the functional interrelationships for analysis purposes by





assembling and studying engineering drawings or sketches on new, undocumented hardware. After that, the analyst must complete the learning phase by interview and consultations with subject matter experts and so gain the knowledge to prepare a complete Checkout Summary, a Fault Symptom List, and complete Action Trees.

**5.8.2.3 The Performance Analysis Process.** The performance analysis is developed from the energy flow diagrams, functional block diagrams, schematics, and other collected source data that depict the functional, organizational hierarchy of the system and the interrelationships among all components. The analyst should assemble all such drawings until all maintenance significant components (significant at Organizational or Intermediate level, as appropriate) in the entire system or equipment are represented. Make certain by checking off each TIM component to show that there is coverage for that item at the pertinent functional level. If you have each assembly on the block diagram checked against the TIM, you are certain of a complete functional picture. At each new level of subdivision, all parts or assemblies must be accounted for on the drawings and checked against the TIM. Make certain that all the components related to cells of the TIM that are marked for OL, IL, or BL can be identified on the assembled drawings. For each such TIM component, annotate the drawing to show the measurable performance parameter for that component (such as 24 Vdc;  $\pm 1.2$  Vdc, or horizontal scan = 5 inches ( $\pm .15$  inch)). Figure 23 is a diagram that the analyst has researched and neatly annotated to show the performance parameters of each functional block.

The analyst checks the accuracy of these annotated performance parameters by testing them with appropriate test equipment on the actual system hardware or by visualizing, etc., as the check requires. After each is tested and if necessary corrected, the analyst has a complete set of source data drawings which contain, for each TIM cell marked for Checkout/Troubleshoot, a measurable or observable parameter consisting of input or output measurements, observable indications, panel readings, etc. The analyst should include in the annotations information concerning test equipment to be used or other methods of observation. These drawings will be used as follows:

- a. To develop the Checkout Summary
- b. To aid the analyst in AT preparation
- c. To be retained throughout the program and carefully updated with every change
- d. To be made available to the government during in-process review, validation, etc.
- e. To aid the JPA developer in checkout and logic tree preparation.

These drawings will provide a detailed record of the performance analysis for troubleshooting and an audit trail for government reviewers. For these reasons the drawing annotations must be neat and legible as exemplified in Figure 26.

**5.8.3 Checkout Summary.** The analyst shall develop a summary of all observable performance parameters on the diagrams in a Checkout Summary as shown in Figure 34. One or more separate Checkout Summaries should be developed for each diagram annotated during performance analysis. Enter the name of the component (e.g., Detection Subsystem) and include the reference designator from the TIM, if the item has one.

**5.8.3.1 Checks Column.** Using the information annotated on the drawings, prepare a list of checks that must be made to test performance of each component listed for Checkout on the TIM, including any data to be used in the check. As each check is entered on the Checkout Summary, mark the appropriate TIM cell to indicate that the Checkout entry has been satisfied. A completely checked-off TIM is assurance that the Checkout Summary is complete.

**5.8.3.2 Performance Parameters Column.** This column must include parameters for each mode of operation in which observations or tests can be made and the range over which they can safely vary. The parameters to be listed should include all indicators of performance that are necessary to be tested. For example, in Figure 34, the second check that is listed for the Detection Subsystem is a check to see that the Wide Scan Mode checks out acceptably. To do so, the user must satisfy the following:

- a. Check that the Control position is okay (by checking that WIDE light is on).
- b. Check that the Antenna Scan position is okay (by checking that the resolver output reading is  $85 (\pm 1.5)$  degrees).
- c. Check that the Indicator presentation is okay by testing that:
  - (1) The horizontal scan is  $5 (\pm .15)$  inches
  - (2) The vertical scan is  $4 (\pm .1)$  inches
  - (3) There is a transmitter pulse present
  - (4) There is target/clutter video present.

As suggested in the specification, the Checkout Summary need not be typed but, if it is not, it should be neatly handwritten and kept up to date throughout MTI&A.

#### **5.8.4 Failure Mode and Fault Symptom Analysis**

**5.8.4.1 Source Data.** The LSA data source for the Failure Mode and Fault Symptom Analysis is Data sheet B, Item Reliability and Maintainability Characteristics. As shown in Figure 36, sheet B contains four types of information needed by the analyst:

- a. Item name and part number
- b. Component failure data including failure modes and symptoms, failure effects and their criticality
- c. The maintenance concept for the particular item
- d. Estimated repair time for each failure and the code for the tasks required for repair.

**5.8.4.2 The Analysis Process.** The analyst should correlate all of the B data sheets with the TIM. Check off each TIM item for which there is a Data sheet B. Confirm that the cell listing for that item has a notation for Checkout/Troubleshooting. Remember that since Data sheet B reflects Reliability Maintainability data of system design, it is frequently in a state of change and the analyst should be on distribution for all Data sheet B changes.

When the analyst is satisfied that Data sheet B and the TIM are in agreement, the diagrams annotated during performance analysis can be checked for agreement of failure mode and symptoms with each Data sheet B. In the Failure Mode and Fault Symptom Analysis, the analyst will determine the ways in which each component can fail by checking each against sheet B information. For example, if LSA sheet B shows that a processor control unit can fail (failure mode) when there is no communication between the PCU and the computer (see Figure 36), the performance analysis drawings should show (a) where and how that communication link can be checked for failure (e.g., pin 7, terminal board 07), (b) what operating parameters must be tested to determine if it is abnormal (e.g., 15.2  $\mu$ sec pulses, +11.5 volts), (c) and what are the failure symptoms (e.g., no indications on the PCU control panel).

**5.8.5 Fault Symptom List.** The analyst must develop from the failure mode and fault symptom analysis, a list of Fault Symptoms appropriate to the system (an example is shown in Figure 37), which will include the symptoms of each failure mode of each component in the Checkout Summary. This list must also agree with the LSA sheet B symptoms. However, sheet B may not include testing or checking details, such as meter readings, sounds, or other cues from the Checkout Summary. These details must be added by the analyst from the information accumulated from the Checkout Summary and from the Performance analysis drawings. Whenever possible, the analyst should create the failure mode on the system by inserting faults, observing and listing each symptom.



**Fault Symptoms  
for  
Teletype Interface Card**

1. No data received at either terminal.
2. Garbled data received on only one TTY unit (at rear terminal)
3. Garbled data received on only one TTY (at far terminal)
4. Garbled data received on only one TTY (at far terminal)
  - a. Units 1, 2, 3, 4, 5 not functioning
  - b. Units 6, 7, 8, 9, 10 not functioning
5. Garbled data simultaneously received on five related TTY units (at far terminal)
  - a. BER alarm not active

**FIGURE 37. Sample fault symptoms list.**

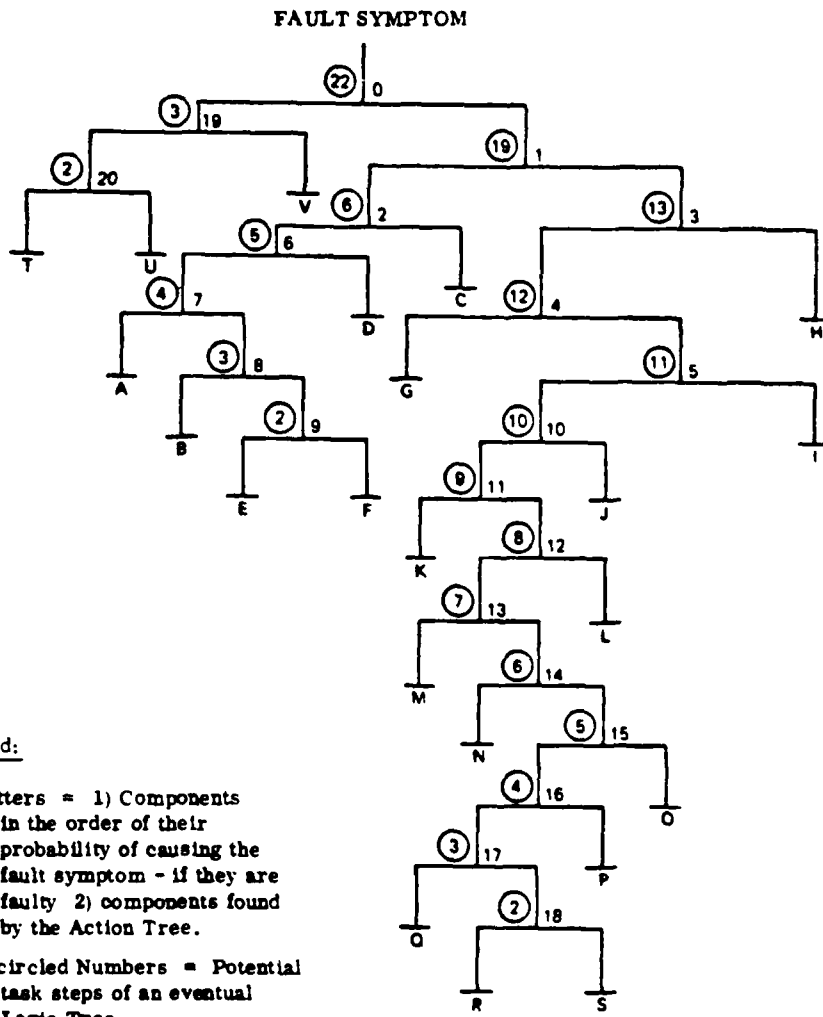
The analyst must prepare a separate Fault Symptom List for each operational mode of the system or equipment, where each mode creates different fault symptoms.

**5.8.6 Action Trees.** An action tree (AT) shall be developed for each fault symptom identified on the Fault Symptom List. An action tree is a branching tree outline, or block diagram, of the components, assemblies, or equipments that can cause the fault symptom, together with procedural information necessary for later use by the LTТА developer in explaining diagnostic procedures. The title of the AT is the fault symptom it addresses and diagnoses.

**5.8.6.1 Developing the Troubleshooting Logic.** The analyst should construct the action tree from those components in the TIM that can contribute to the fault symptom involved. The AT must be prepared from a basic knowledge of the logical hierarchy of components as in Figures 38 and 39, together with a modified half-split fault isolation technique. The AT procedure must optimize the following technician considerations to ensure that minimum fault isolation time has been achieved:

- a. Time to gain access to the component
- b. Time to test the component
- c. Reliability of parts involved and of replacement parts
- d. Requirements of tools and test equipment to be used
- e. Modified half-split troubleshooting logic (explained below).

Action trees should contain a synopsis of all essential and pertinent information that will be needed by the JPA developer to prepare a LTТА from the AT and other MTI&A products. This includes warnings, cautions, notes, power turn-on procedures, pre-checkout procedures, reference diagrams, initial switch settings, etc. Each AT should be prepared assuming only one malfunction at a time is being addressed and the arrangement of components must be in the order of their importance as most probable causes of the fault. Selection of support equipment must be limited to those items found in the Support Equipment Guide. The first step in developing the logic of the AT is to develop a schematic representation of the functional relationships among components in the system, a block diagram that depicts the relationships among all of the components listed as possible causes of the fault symptom for which the AT will be prepared. Components that cannot contribute to the fault should be eliminated from the diagram so as to keep the troubleshooting logic as simple as possible. From this hierarchy of components, the tree branches can be developed by choosing test instrument, type of test, and location of test, and diagnostic tests which will determine the



**Legend:**

- Letters = 1) Components in the order of their probability of causing the fault symptom - if they are faulty 2) components found by the Action Tree.
- Uncircled Numbers = Potential task steps of an eventual Logic Tree.
- Circled Numbers = Number of components isolated downstream of each step in the action tree.

FIGURE 38. Sample outline of an action tree for a complex fault symptom (without component names and procedural information).



NO SLIDE PROJECTIONS ON PLASMA DISPLAY PANEL

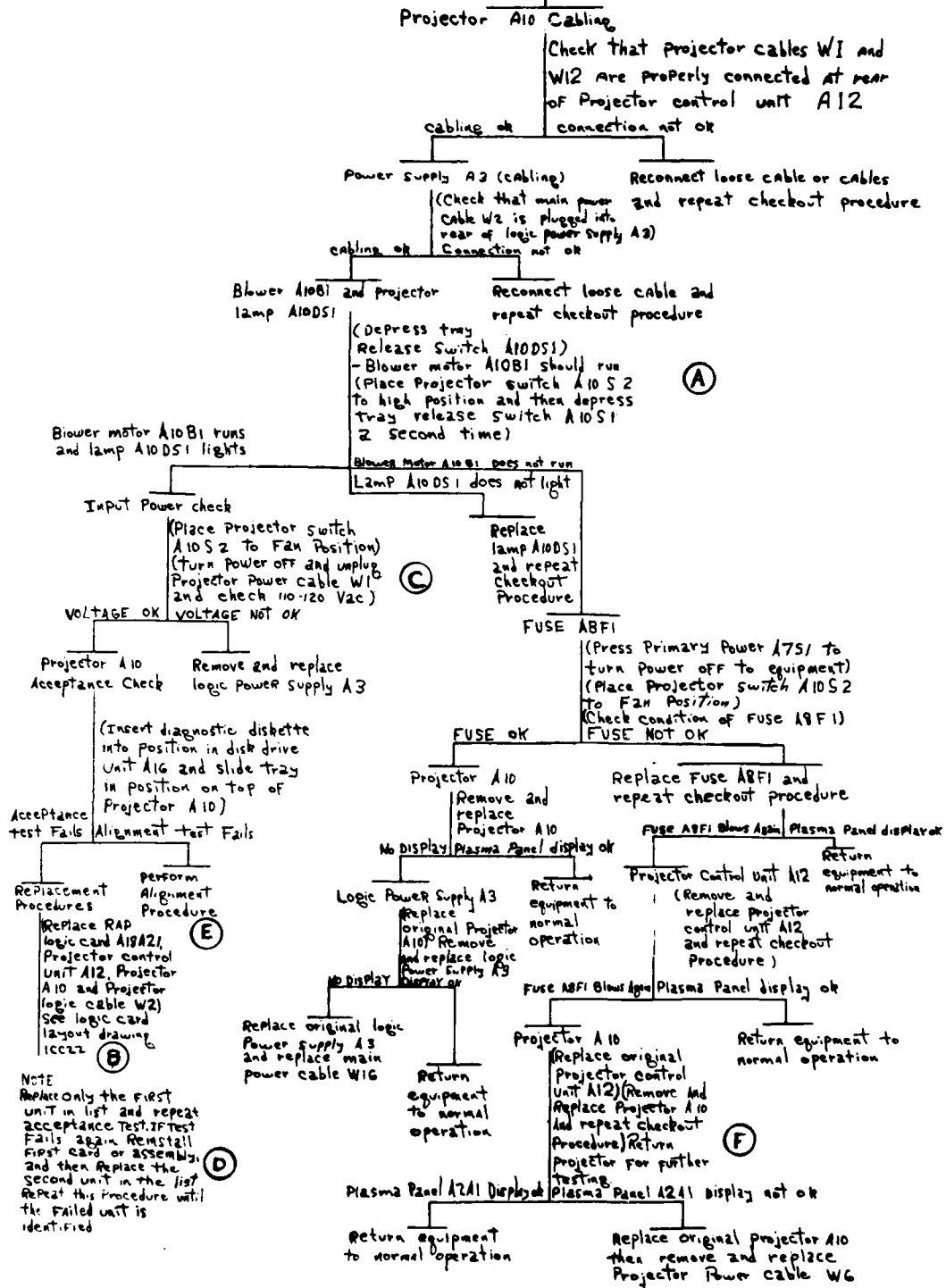
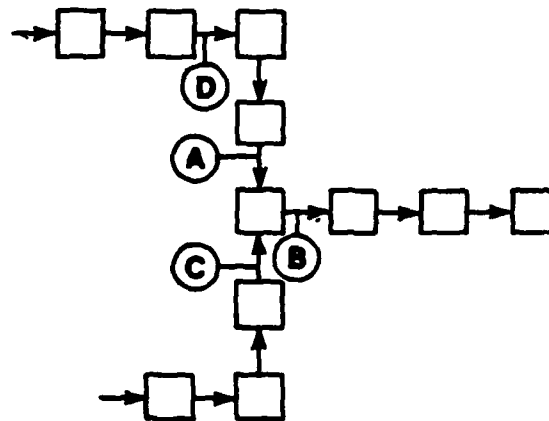


FIGURE 39. Sample action tree.

best branch of the tree to follow, the possible outcome of each test, and the action to be taken as a result of each test. In summary, develop the AT so that it provides a synopsis of the most logical, orderly troubleshooting sequence that provides the fastest route to fault diagnosis.

The analyst should use Data sheet B information discussed earlier to aid in establishing the AT logic. The Failure Analysis portion of sheet B will aid in AT construction and also as a check on the completeness of the AT.

5.8.6.2 Modified Half-Split Troubleshooting Strategy<sup>1</sup>. Selection of the best branch to perform a troubleshooting test is of primary importance. Test branches should be selected in such a way as to divide all of the suspect components for the fault symptom on the block diagram into two equal groups (as nearly as possible). For the component block diagram shown below, if all components have equal failure probability and are equally accessible, the first test location would be at point A since the choice permits dividing the components most nearly in half. No other test point permits better than an 8-3 split. If a "good" indication is found at A, the second test should be at B or C. If a "bad" indication is found at A, the second test should be at D. Each check eliminates about half of the components from consideration. These components are known to be "good." The choice of test location between the suspect components should be such that the check be made at the mid-point of the chain, and each succeeding check be made at the mid-point of the remaining portion of the chain. Thus, assuming each component has an equal probability of failure, the branching proceeds by halving the probabilities that the malfunctioning component lies on one side or the other of the check. This strategy defines the half-split technique of troubleshooting.



<sup>1</sup>Joyce, R. P., Chenzoff, A. P., Mulligan, J. F., and Mallory, W. J. Fully proceduralized job performance aids: Handbook for JPA developers. AFHRL-TR-73-43(II), AD-775 705. Wright Patterson AFB, OH: Advanced Systems Division Air Force Human Resources Laboratory, December 1973.

The pure half-split technique just described is seldom the most economical for 100 percent of the checks, because of practical constraints. The half-split strategy should be modified by introducing the following considerations:

- a. **Reliability.** Checks for items with high failure rates should precede checks for items with lower failure rates.
- b. **Accessibility.** Checks that are "quick and easy" should precede checks that involve extensive or time-consuming disassembly. Remember that the best AT from a user's standpoint is one that finds the trouble in the shortest time.
- c. **Probability of Malfunction Introduction.** Those checks which involve activities with high probability of accidental malfunction introduction should be deferred toward the end of the procedure. Whenever a static check (power off) and a dynamic check can reveal roughly the same diagnostic information, the static check is preferred.
- d. **Location of the Technician.** Other things being equal, the sequence of checks should minimize the movement of the technician from one location to another.
- e. **Test Equipment Setup.** An unusually time-consuming test equipment setup should be weighed against the information it can provide to consider whether its use should be presented earlier or later in the check sequence.

The analyst must include procedural step data in the AT where changes in equipment condition are required to permit a check, when method of access must be specified, or when test equipment settings must be specified.

Include a corrective action step at the end of each branch of the AT, and identify any follow-on or related tasks (e.g., return to checkout) that the LTTA developer should know.

**5.8.6.3 Action Tree Data.** Action trees shall contain the following information:

- a. **Brief procedural steps that will provide the LTTA developer with technical guidelines on developing the checkout and logic tree troubleshooting for operations where no decision is required, such as in Figure 39. In the statement "Check condition of fuse A8F1," the analyst provides data for the LTTA developer to use as source data in preparing detailed Logic Tree test/decision boxes.**
- b. **Repair or replacement steps, which direct the repair or replacement of a faulty component. The component to be repaired or replaced should be identified by the same nomenclature or reference designator, as listed in the TIM.**

- c. **Decision branches in the tree should identify the diagnostic tests to be made, the possible outcomes, and the action to be taken as a result of each outcome. Make certain that the following data are included:**

- (1) **Name and model number of test instrument (if any)**
- (2) **Type of reading (e.g., pressure, voltage)**
- (3) **Location of test points**
- (4) **Range of acceptable values for the reading**
- (5) **Action to take as a result of each possible outcome of the check.**

**5.8.6.4 Action Tree Development Rules. The analyst shall develop each AT according to the following rules and strategies: (Refer to Figure 39 for application of these rules.)**

- a. **Only one fault symptom is observable at a time and only one fault exists in the system at a time.**
- b. **Each point of test shall be selected to obtain the greatest amount of fault isolation information for the action taken (i.e., the modified half-split strategy). Instructions for performing the test shall be concise, simply worded, and arranged in specific steps (see A). The analyst shall make reference from the test steps to an attached drawing or other reference, for physical identification and location of components involved.**
- c. **When a test result shows that the fault does not lie in a specified section of the system, the branch of the tree representing that section should not be accessible for later trouble isolation tests (i.e., no further testing is permitted in that section of the system) (see B).**
- d. **The first tests to be done will normally be those that use meters, switches, annunciators, warning lights, and other built-in test equipment. The human senses for sight, sound, and touch should also be used to advantage in the testing process.**
- e. **Tests that must be done with external test equipment will normally appear later in the testing process.**
- f. **Two or more tests shall not cause a closed loop in the strategy (i.e., a situation wherein one fault is isolated from two branches of the action tree.**

- g. No test shall result in a dead end (i. e. , a situation in which the LTТА developer is left to devise a strategy for continuing the trouble isolation procedure).
- h. Every test must yield a reliable result compatible with a yes or no question. There shall be no possibility of a third ambiguous result.
- i. A serial (nonbranching) sequence in which one item after another is checked for a pass/fail condition until the fault is found (as in doing a Checkout) is permissible only where it is the only possible sequence for testing.
- j. The tests in each branch shall result in accomplishing one of the following, as applicable to the respective maintenance level and authorized maintenance procedures:
  - (1) Determine which one of two components is faulty.
  - (2) Determine that a component is faulty or that an additional test must be made.
  - (3) Determine that further checkout or test must be made.
- k. Each AT test instruction shall provide the LTТА developer with enough information to develop complete logic tree instructions (see C).
- l. Corrective action instructions at the ends of the branches shall include both the corrective action to be taken and follow-on to be done (see D).
- m. Corrective action instructions shall include one of the following, as required actions:
  - (1) Repair, replacement, adjustment, or alignment of a specific unit, part, or piece (see E).
  - (2) Further testing of the assembly or subassembly to further isolate the fault (see F).

**5.8.6.5 Action Tree Format.** The specification permits any format that permits a well organized AT structure and is logical, legible, and complete. The sample AT in Figure 39 would be acceptable in handwritten or typed format.

## **6. DEVELOPING MTI&A WITHOUT THE AID OF AN LSA DATA BASE**

The contractor is required to perform a thorough MTI&A whether or not LSA data are available. This section provides guidance for contractor analysts to perform effective task analysis when no LSA data base exists.

**6.1 Performing Task Identification.** Task identification is the process by which the contractor defines all hardware items and related tasks necessary in order to carry out the system maintenance concept and provide a complete procedural data base for JPA developers and for technicians at either Organizational or Intermediate level, or both. The results of the task identification process are recorded on the Task Identification Matrix (TIM) form. The analyst should use the most formal equipment breakdowns available as the basis for TIM preparation.

**6.1.1 Gathering Source Data for the TIM.** The analyst should consult a variety of source data to aid development of the TIM and ensure that the most thorough, accurate, and current parts information is being used as the cornerstone of the MTI&A process, the TIM. As a minimum, the document selected from the types listed in Section 4.5 must contain the formal name and part number for each item repairable or replaceable at O or I level. The analyst may have more than one document from which to select the best equipment breakdown for the TIM, and the available data may be different for new or developing systems than for fielded or operational systems.

Because of varying contractual considerations, schedules, system environments, and the like, there is no ironclad rule for the "best" document to use. The list below, therefore, is only a suggested sequence by which the analyst should consider each available document. The analyst must judge, with the aid of subject matter experts, which is the most complete and current document. Note that the task identification and analysis process is greatly simplified if the equipment breakdown can be purged of all Depot level maintenance parts.

### **6.1.1.1 New Systems**

- a. Provisioning Parts List
- b. Existing Illustrated Parts Breakdowns (IPBs), Repair Parts and Special Tools Lists (RPSTLs), T.O.s, and T.M.s
- c. Parts lists in commercial literature
- d. Bills of material on engineering documentation.

### 6.1.1.2 Operational Systems

- a. Provisioning Parts List
- b. Existing IPBs or RPSTLs
- c. Work Unit Code Manuals
- d. T.C.T.O.s
- e. Parts Utilization Summaries
- f. AFTO Form 22's (for parts changes).

6.1.2 Filling Out the TIM Form. The analyst must prepare a TIM form that will, when correctly filled out, provide task identification data as required by the specification. Develop, copy, or modify, if necessary, a TIM form such as shown in Figure 40, with enough copies to incorporate all O and I level parts in the system. If an up-to-date, complete IPB, Repair Parts and Special Tools List, Provisioning List, or commercial manual parts breakdown is available, the specification permits the analyst to develop the TIM by adding or pasting down a blank, preprinted maintenance function matrix to the equipment breakdown such as shown in Figure 8.

The maintenance functions that should ordinarily be covered in the matrix columns, to the extent they are appropriate, are: adjust, align, calibrate, checkout/troubleshoot, clean, disassemble/assemble, replace, lubricate, remove/install, repair, service. Maintenance functions can also be coded as shown in Figure 4. If the system requires particular maintenance functions, such as inspect, or diagnostic, to indicate that the component is checked or diagnosed by a diagnostic program as in Figure 4, the analyst should add it to the columns.

The column headings across the top of the matrix are: (a) Codes column for equipment breakdown (e.g., FGC Codes); (b) Description column in which the item (subsystem, assembly, subassembly, or part) is identified; (c) the Part Number column, where the item part number is recorded; and (d) the various "functions" columns for each of the maintenance functions. If desired, these columns may be in another sequence on the TIM, than listed here. The analyst may find it beneficial to add a "Reference Designator" column for heavily electronic systems. For many systems, reference designators are set forth in schematic diagrams to identify each equipment item in terms of its location and function within the system.

The intersection of each item or part listing in the part column of the TIM form with a "Maintenance Function" column is called a "cell." Each cell defines a theoretically possible task. The entries to be made in each cell indicate the actual tasks, if any, to be performed on each hardware item, and the maintenance level at which each is to be performed.

TASK IDENTIFICATION MATRIX - AIRCRAFT CANNON XG-88

CODE	DESCRIPTION	PART NO.	Align/Adjust	Calibrate	Checkout/Troubleshoot	Disassemble/Assemble	Clean	Lubricate	Replace	Remove/Install	Repair	Service	NOTES
1 2	20MM gun mounting/M64		0 J		0	1 J	0 J	0 J				0 J	Ref desig 100397 rev A
1 2 1	Mounting kit, bore sight	105456	0 J	1 J					0 J	0 J	1 J		
1 2 2	Chute Assy, section	184792				1 J	0 J	0 J			1 J	0 J	
1 2 2 1	Cor. m. chute, popper	846223							0 J	0 J			
1 2 2 2	Chute, food	84739	0 J						0 J	0 J			
1 2 3	Inventor, pump, late	445211	0 J	1 L					0 J	0 J	1 J		Ref desig 40012, rev C
1 2 4	Distributor, electrical	67709				1 J	0 J		0 J	0 J	1 J		
1 2 4 1	Switch Assy, igniter	663290	0 J						0 J				
1 2 4 2	Cable Assy, electrical	678035			0 L		0 J						
1 2 5	Mount, redundant	110228				1 J	0 J		0 J		1 J		
1 2 6	Meter, drive	105582			1 L	1 J	0 J		0 J	0 J	1 J	0 J	Ref desig 111007

FIGURE 40. Example of basic task identification matrix - manually prepared.



**6.1.2.1 Code and Description Columns.** The Code columns of the TIM are intended to show the relationship and subordination of each system, assembly, subassembly and part that is maintainable at the O or I levels. On some contracts, an adequate system coding, such as FGC codes will be readily available to the analyst, as part of a provisioning document. However, if no such system is available to satisfy the specification requirements, the analyst must develop a code for each equipment item. The level of coding to be assigned will be determined by the complexity of the equipment. On small, less complex equipments, the use of a four-level numerical coding may be sufficient, whereas on larger or more complex equipments, the use of additional levels of coding will be required. The assigned coding may be purely numerical such as:

CODE				DESCRIPTION
1	2			DMM gun mount assembly XM161
1	2	1		Mounting kit, boresight
1	2	2		Chute assembly, return
1	2	2	1	Corner, chute, upper
1	2	2	2	Chute, feed

or made up of a combination of alphabetical symbols and numerical numbers such as:

CODE		DESCRIPTION
AL	001	ENGINE INSTRUMENTATION
AM	002	ALCC SYSTEM INSTALLATION
AN	003	ALCC STAFF CONSOLE POSITIONS 1 AND 2
AP	004	TELETYPE SYSTEM - HIGH SPEED
AQ	005	SECURE DIGITAL COMMUNICATIONS INSTALLATION

Most important is that selected coding method is simple and provides a system by which the analyst can easily recognize the relationship of every item to its next higher assembly. Before any coding is assigned, the analyst must determine how the system is organized, with the aid of system functional drawings such as block diagrams, schematics, mechanical layout drawings, or from explanation by the SME. Once organized into a hierarchy of distinct subsystems, main groups, assemblies, subassemblies, etc., as the system organization dictates, codes can be assigned to each individual item. Since each coding position identifies a specific level of assembly, each system or equipment shall be broken down into the following categories.

a. **First Level Assembly.** First level assemblies are usually the major systems. They may be mechanical systems such as the hydraulic system, landing gear system, or fuel system or electronic systems such as the transmitting system, receiving system, or central data computer. This level is identified by the first one or two characters of the group coding.

b. **Second Level Assembly.** Second level assemblies are the subsystems within the major systems. They are identified by the second or third character of the group coding. For example, a major system such as a landing gear system may be comprised of a wheel assembly, hub assembly, and landing strut assembly. In this case, the wheel assembly, hub assembly, and landing strut assembly are each a subsystem of the overall landing gear system. Each performs a specific sub-function within the overall function of the major system.

c. **Third Level Assembly.** Third level assemblies are usually individual components within the end item. They are identified by the third or fourth character of the group coding. Components are the individual items such as wheels, hubs, or hydraulic cylinders.

d. **Additional Coding Levels.** On more complex equipment breakdowns additional (fifth and sixth) coding positions may be required to identify repairable subassemblies and detail parts within a component. On some contracts, the analyst may find complete reference designators or Work Unit Codes assigned to equipment breakdowns by Government or contractor personnel. These designations or codes will suffice for TIM coding because most maintenance significant components and detail parts are identified.

6.1.2.2 **TIM Cells.** The analyst must decide for each TIM cell whether or not a maintenance task will be required for that equipment item. If so, the analyst must then decide whether the maintenance task is to be done at O or at I level. Finally, the analyst decides where the task should be documented, in a JGM, or in a LTTA manual. In order to make these various decisions, the analyst must ask a number of questions as described below. The preferred way to fill in the TIM is to do it with an SME who can provide accurate answers to the analyst's questions with pertinent data (e.g., drawing numbers and data sources) which can be entered in the Notes column. This method has the advantage that the analyst can control the task identification process and use the SME's time most effectively.

Another way, if the analyst is familiar with the equipment and the maintenance concepts, is to fill in the cells from available data and then have the SME review the TIM, correcting and annotating it as portions of it are completed.

In any case, the analyst-SME team must "identify" and "analyze" by asking the following questions:

- Can a maintenance function be performed on this item by the types of technician user identified in the Government preliminary user profile?
- At what level of maintenance, O or I or both, will the task be performed?
- Is the technician described for O or I maintenance capable of performing it?
- Are there spares allocated for that item if a replacement, disassemble, or repair task has been identified?

The only major decisions left for the analyst on task identification would be to determine where the task should be documented by answering these questions:

- Is the task too simple to be included in a manual? (Leave a blank in right portion of cell.)
- Is the task a fixed procedure; one that involves no checkout or troubleshooting by the user? (Enter a J for JGM in the cell.)
- Is the task one that requires checking and trouble diagnosis? (Enter an L for LTTA in the cell.)

In developing the TIM the analyst will find it very helpful for later analyses to obtain answers to the following questions and note them in the Notes column.

- How much time does the task take?
- What support and test equipment is required for the task?
- Is there any special skill needed by maintenance personnel to perform this task? (This may necessitate modifying the preliminary user profile, and including more detail in the task description worksheets and level of detail guide.)

The codes to be entered in each cell must be drawn from the list shown in Figure 11.

**6.1.2.3 Ensuring TIM Completeness.** Omission of any hardware item from the TIM can result in omission of one or more tasks from the data base, and hence from the JPAs. It is therefore critical that the analyst prepare and check the list of hardware items with great care and that the list is thoroughly reviewed for completeness by an SME.

**6.1.2.4 Completing Task Identification.** If there are equipment items, however, for which all available data have not supplied the decision on task identification and if there are cells with "?", the analyst must make task decisions from other data. These decisions can be based on existing equipment descriptions or task descriptive data, or from experience with similar equipment items by the SME or by the analyst.

**6.1.2.5 Notes Column.** The analyst should consider the Notes column as a convenient way to record significant facts, or to record data generated or gathered during TIM development for later use. Information such as the following can be of significant value during later analyses efforts.

- a. Drawing revision levels
- b. Deficiencies in the data
- c. Interrelationships among tasks
- d. Reasons for further resolution (?) entries
- e. Special information such as techniques or problems unearthed during research
- f. Time to perform the task
- g. Number of people to perform the task
- h. Special skill required to perform the task
- i. Support or test equipment required to perform the task.

**6.1.2.6 Expanded TIM.** The specification AFHRL-TR-79-50 defines expansion of the Basic TIM to accommodate special information about the identified tasks where the Acquisition agency has designated a requirement. When expansion is required, the analyst should develop the TIM form to allow for additional columns of data or a separate form to be attached to the TIM if the data does not lend itself to additional columns. The TIM can be expanded, for example, to include data such as

1. Depot level breakdown of items
2. Task performance times
3. Tasks to be considered for special skills training
4. Task Frequency (e.g., on preventive maintenance tasks)
5. Special training requirements.

**6.2 Performing a User Analysis.** In order to analyze and define the user and develop a complete MTI&A User Profile, the analyst will depend primarily on the government-supplied Preliminary User Profile. If this profile indicates that maintenance personnel with similar training and skills are maintaining other systems or equipment in the field, the analyst should consider observing the user in action. By watching a technician perform tasks on similar equipment, the analyst may gain important insight into the practical skills required. For example, if called upon to develop MTI&A on aircraft systems for the first time, an analyst may learn more about the skills required of an O or I aircraft technician by the interviewing and observing typical users at their daily tasks than through any other method. During User Analysis, the analyst must seek and find answers to these questions:

1. What is the expected technical training and experience of the average technician who will perform Organizational maintenance tasks? Intermediate maintenance tasks?
2. Will this training and experience suffice for maintaining this system, or will additional training be required?
3. What additional training will be required? Must additional skills be developed? For example, must the user be trained in the use of complex test equipment?
4. Is the skill specialty described in the Preliminary User Profile adequate, or does the contractor recommend that some other skill specialty be utilized?
5. Are there special work conditions important to system repair that must be considered when defining the user?
6. If the government-selected skill specialty is inadequate, must the analyst accommodate this deficiency by providing additional procedures in the task worksheets? For example, if the target engine mechanic needs, but is not trained in the use of, an engine test set — must the task analysis worksheets, and therefore the JPA, contain instructions on the operation of the test set and how to interpret its outputs? If so, it is important that this skill deficiency be defined in the User Profile.
7. What is the lowest level of security clearance the user must possess to perform required tasks?

**6.2.1 Using the Preliminary User Profile.** In the early stages of a contract the analyst must depend on the Preliminary User Profile supplied by the Acquisition

agency. It will define the general background and training of apprentice and experienced technicians who will be responsible for maintenance of the system. It will provide the analyst with data on which to base MTI&A planning, such as the user technician's reading level, training school courses and other educational background, a skills inventory, expected normal work conditions, and the level of supervision. Later, in coordination with subject matter experts, the analyst develops a Definitized User Profile which may modify the Preliminary version to provide a more comprehensive description of the user.

**6.2.2 Developing the Definitized User Profile.** The Definitized User Profile is developed from data accumulated and studied by the analyst during User Analysis. It therefore will be developed from studies and recommendations made by the contractor task analysts and SMEs. The contractor may recommend modifications or refinements based on SME knowledge of peculiarities of system maintenance, such as when the complexity of system maintenance requires special test equipment, unusual skills, or new skill specialities. The MTI&A analyst shall develop this detailed profile for review and assurance by all contractor SMEs and the Acquisition agency personnel that the definition of the actual maintenance technician user(s) is accurate and complete.

If the analyst determines that the Definitized User Profile establishes a user that is different from that described by the Acquisition agency, the contractor should convene a conference to explain and receive concurrence in the intended changes. This conference will clarify the definition of the individuals who will be using the task details in the JPA, including improved training requirements. The product of this conference is an approved, final, Definitized User Profile, which will guide the further task analysis process and the JPA developers. The contractor may find it extremely helpful to observe government-defined users in their training setting or in actual performance of their maintenance duties, so as to verify that their skills and knowledge equate with the profiled user.

**6.3 Performing the Support Equipment Analysis.** The contractor must perform a detailed analysis of all common and special-purpose test equipment, special tools, and ground support equipment that is necessary to maintain the system or equipment at O or I level. This research will include understanding the functions and operation of all support equipment and consolidating this data for later use by the analyst and the JPA developer. The analyst must be quite certain in this analysis that the support equipment list is complete and accurate because the list will determine level of task detail and affect the number and level of tasks to be developed for the user. Note that, as used in the specification, support equipment includes special tools, metrology and calibration equipment, performance monitoring and fault isolation equipment, maintenance stands, and handling devices required for maintenance of the system. During this phase of MTI&A, the analyst must work closely with SMEs and system engineers to

ensure that plans for support and test equipment are closely coordinated. A change in test equipment can have a serious effect throughout the entire MTI&A process. If an engineer changes the type of diagnostic testing, say from automatic to manual, or changes the type of test equipment, all analyses and products may undergo a significant revision. Significant changes in maintenance support equipment or concepts has greater impact on task analysis than anything else, except for sweeping design changes. The analyst should remember to keep open communication lines with engineering personnel who are developing AGERDs, GSERDs, or other forms of test equipment and tool recommendations for Acquisition agency approval.

During Support Equipment Analysis, the analyst should answer the following questions:

1. What testing, measuring, diagnostic tools, and test equipment are required at Organizational level? At Intermediate level? Identify each by name, model number, part number, and physical size.
2. What functions will the item perform (e.g., the type, accuracy, and range of readouts)?
3. What additional skills or training must be provided before the profiled technician can use it properly? For example, must a special contractor training school be completed before the operating skills of the technician will be adequate?
4. What are the standard statements (see Figure 17) to be used to describe procedural steps using each equipment or tool?

**6.3.1 Gathering Source Data for the Support Equipment Analysis.** In order to answer the above questions on support equipment, the analyst should consult as many of the following data sources as available:

- Preliminary or Definitized User Profile (to determine if user can use this equipment)
- Technical manuals (operation and maintenance) on the support or test equipment (to learn its operation and functions)
- AGERDs or GSERDs explaining contractor-justification of need for the item (to learn how the equipment will be used in testing and troubleshooting)

- Procurement specifications explaining what the contractor expects the equipment to test, its size, etc., (to understand what the contractor's vendors are required to supply or design)
- Photographs or drawings of the item, if technical manuals are not available (to determine its physical size, controls, etc.).

Most support and test equipment is off-the-shelf and information is readily available to answer the analyst's questions. However, when peculiar or special test equipment is being recommended and designed, the analyst must depend on preliminary design data or similar equipment in the early development stages. The analyst must follow its development (sometimes by a vendor) as closely as the end item equipment, for it has so much impact on MTL&A.

**6.3.2 Developing the Support Equipment Guide.** The analyst should follow these steps to produce an acceptable Support Equipment Guide:

- a. Assemble and study all available source data on support equipment, including interviews with SMEs involved in support equipment development, planning or procurement.
- b. On each page of the guide, record the title of the system or equipment, the date the guide was developed, and the task analyst's name (see Figure 17).
- c. For each item, start a new page, indicating the name and number of each item of test equipment or special tool used. Identify the item by AN designation, if assigned, or by the manufacturer's designation. Common types such as voltmeters and signal generators must be listed. A special tool is any tool not normally found in a mechanic's tool kit.
- d. For each item, list all of the functions for which it is used. Consult commercial manuals that describe each special tool and test equipment for its uses.
- e. In the personnel assumptions column, explain clearly the assumptions to be made regarding the behavioral skills and knowledge the user must possess to perform the function. Also explain the information and directions that will have to be provided in the JPA procedures using the item.
- f. In the standard statements column, the analyst must list all of the exact statements to be made in the Task Steps portion of the Task Analysis Worksheets and the JPAs each time the function is needed. The statement should consist of as many of the actual words to be used when a certain category of data is to be used in the tasks. The wording must be consistent between similar or identical



MTI&A task data. Standard statement wording will depend on the Definitized User Profile, as well as user knowledge, skills, and technical difficulty in operating the item.

**6.4 Performing the Level of Detail Analysis.** If the capabilities of the users are over-estimated, they will not be able to follow the instructions in the JPA. If the instructions merely state "Check the waveform at Pin 21001," and the technician does not know where Pin 21001 is located, what the waveform should be or how to check it, or what the equipment state should be before making this check, then this task cannot be performed. Too much detail, on the other hand, slows down task performance. It can also increase errors in performance because the users may tend to avoid using the JPA if it forces them to wade through more detail than needed. Arriving at the proper level of detail for task analysis is important. The analyst must determine from the Definitized User Profile the level of instructions that are appropriate to the JPA reader. The Level of Detail Analysis should be performed in conjunction with or immediately following the User Analysis because the information concerning user skills, capabilities, training deficiencies, and technical experience that it provides are the same criteria used to develop the Level of Detail Guide. For example, if the Definitized User Profile dictates that the user has the knowledge and skills to use an oscilloscope, then the Level of Detail Guide will reflect that capability by excluding details of oscilloscope operation. Conversely, if the User Profile shows that the user will not have knowledge or experience in the use of a piston ring groove wear gage, then the Level of Detail Guide will require specific in-text detail each time the gage is used in a task.

**6.4.1 Developing the Level of Detail Guide.** The Level of Detail Guide is a statement of how detailed the information must be, based on what is known about the skills of maintenance personnel and about the equipment systems. The analyst shall develop the Guide in accordance with the specification with additional explanation supplied below. The questions in the following subsection are only suggestive of the ones that should be answered in the Level of Detail Guide. Additional questions will need to be answered for most systems, and some suggested questions may not apply to a given system. After answering such questions, the analyst must explain the directives in a form similar to Figure 6.

**6.4.1.1 Discriminations and Perceptions.** The Guide must define the level of detail by answering questions such as:

a. **Observing Gross Indications.** If a technician must respond to a gross indication such as a light being on or a meter being out of an acceptable range of values, will the task step merely name the indicator or meter and state the value to be observed or should there be an illustration that shows the indicator in the "on" state or the meter in an out-of-tolerance condition?

b. **Reading Quantitative Values.** When a technician must respond to a precise value on a meter (plus or minus some tolerance), will the meter face always be illustrated? Which meters will be treated differently? Will some meters require special instructions on how they are to be read (e.g., how to make interpretations)?

c. **Noting Relative Motion.** Will instruments be used to detect relative motion between components? How much will have to be said concerning the use of these instruments? If instruments are not used, how much should be said about the technician's point of observation? Will the illustrations indicate the direction of motion?

d. **Reading or Interpreting Oscilloscope Patterns and Waveforms.** How will standards for comparison be presented? What dimensions of the waveforms will be specified? How much will be said about the appropriate methods for determining amplitude, frequency, and shape of the waveforms?

e. **Noting Visually Detectable Physical Defects.** Will standards for comparison be presented or will it be assumed that these judgments will be mastered in training? Will illustrations show only obviously acceptable and obviously unacceptable conditions, or will various degrees of marginally acceptable conditions be shown and evaluated?

f. **Detecting Presence or Absence of Sounds and Vibrations.** Will the sounds or vibrations be characterized in words, or will they merely be named? Will detection of vibrations be by feel?

g. **Discrimination of Pitch or Other Characteristics of a Sound.** In what term will pitch be described? In what terms will other characteristics of sound be described?

h. **Discrimination of Odors.** How will significant odors be described?

**6.4.1.2 Problem Solving and Decision Making.** The Guide must define the level of detail by answering questions such as:

a. **Selection of Appropriate Next Step or Task.** Will guidance be provided for each decision that arises? In what situations will the next step or task not be specified?

b. **Performing Calculations.** What sorts of calculations will be explained in detail? In what cases will tables or nomographs be substituted for each calculation?

c. **Exercising Judgment.** Will the technician be required to make judgments without the aid of JPA? When?

d. **Conversion of Data from One Form to Another.** Will conversions (e.g., binary to decimal or Fahrenheit to Centigrade) be aided by tables or graphs? Will complete instructions and examples accompany any tables or graphs that are presented?

**6.4.1.3 Motor Actions.** The Guide must define level of detail by answering questions such as:

a. **Activating Switches.** Will the desired setting for the switch be illustrated as well as being specified in the text? Will the location of the switch be illustrated, described in the text, or neither?

b. **Adjusting Continuous and Multiposition Controls.** Will the desired setting for the switch be illustrated as well as being specified in the text? Will the location of the switch be illustrated, described in the text, or neither? Will the direction of operation be specified (e.g., clockwise, to the left)?

c. **Performing Coordinated Gross Body Movements.** Will the movements required for moving and positioning hardware items be described or merely named?

d. **Performing Actions Requiring Fine Coordination.** Will guidance be provided for performing actions requiring fine coordination?

**6.5 Performing the Task Detail Analysis.** The Level of Detail Analysis described in Section 6.4 provides the rules for "how much detail" the JPA developer must provide in the task steps. The Task Detail Analysis discussed here will consider those rules in establishing for each specific task "what must be done." Note that this analysis will not communicate "how" to do it — that is left to the JPA developer to analyze from a behavioral approach and then to communicate "how to" to the user. To illustrate, in Figure 19, the analyst has determined the task details that must be covered by the JPA developer in Removing and Installing Fuselage Tank Units. In Sheet 3 of Figure 19, the analyst describes the task details necessary for follow-on maintenance after the tank units have been installed. In the second item of that follow-on maintenance, the task detail analysis has determined that:

a. The access panels must be installed after the tank units. Presume that the analyst knows from the Definitized User Profile that the technician will not be experienced in this installation and the Level of Detail Analysis indicates that

the JPA must always give detailed, well-illustrated reassembly procedures. The Level of Detail Guide, for example, would have prescribed:

**Disassembly and Reassembly.** For disassembly and reassembly (or removal and installation) the task step will always provide step-by-step reassembly procedures and illustrations of attaching panels, hardware, etc., to show all parts as seen from the installer's position relative to the equipment. Assume that the technician is familiar with use of the torque wrench.

b. The analyst has indicated what tasks are to be performed (i.e., "Secure engine access panel screws" and later "Perform leak test of fuel tanks.") The JPA developer will illustrate and explain these tasks to the extent that the task analyst has directed in the Level of Detail Guide. The analyst must make certain that every non-troubleshooting task identified in the TIM for inclusion in a JGM has been analyzed to determine the cues for each task step, the preconditions for task performance, the steps that are necessary for successful task completion (including performance standards and keyed locator illustrations), identification of follow-on tasks, and other data that are important for the JGM developer to know. Most of the task detail analysis is in the actual writing of task step details, discussed in the following paragraph.

**6.5.1 Writing Task Analysis Worksheets.** The contractor shall record the results of the analysis of each task on Task Analysis Worksheets, one set for each task. The worksheets must contain all of the information required by the specification and the general format of the worksheets must be similar to that in Figure 19. Legibility, completeness, and accuracy are the primary requirements for an acceptable task analysis worksheet. The first step in preparing a worksheet is to fill in all of the identifying and administrative data (circled item numbers 1 to 6 on Figure 19), and Input Conditions information (items 7 to 11) as indicated on the form.

The analyst can determine the Required Conditions, item 7, for the task by learning the interrelationships between tasks from SMEs and from early development of typical or preliminary tasks. Early in the MTI&A process, the analyst will begin to find common or typical tasks that will be required as preliminary to or part of other tasks. To the extent possible, the analyst should try to determine early in the analysis, which are the common, often used tasks. Generating the worksheets for common tasks early and knowing their content will simplify the organization and development of the Required Conditions entries for all other worksheets. For example, if the "Removal of the Left and Right Main Landing Gear Actuator Valves" is a procedure that must precede many other maintenance tasks, it is very helpful to complete the worksheet on that task early so that the analyst knows where it begins and ends when considering other tasks.

Data for item 8, which identifies the number of persons required in performance of the task, is available from the User Profile and Support Equipment Guide. When using such input data, the analyst must verify that the task, as performed on the real equipment, can be performed with the personnel indicated on the data sheets. The analyst should note the importance of communication and coordination between members of a team performing a task.

The analyst should refer to the Support Equipment Guide for a listing of the items of support and test equipment, item 9, and supplies, item 10, required for each task. The contractor should make certain that the support equipment listed in the task analysis worksheet agrees with the AGERDs and GSERDs data, including part numbers, description, etc. Some or all of the data in the worksheet may be invalid if the wrong model or type of support equipment has been used in task step details.

The analyst should ensure that all conditions which may affect the safety of personnel or equipment have been considered and listed under item 11 of the worksheet. Overall notes, cautions, and warnings shall be included under this item, even though they will also be repeated just preceding the task step to which they apply. To ensure that all such data are included, the analyst should consult SMEs who may be responsible under the contract for hazard identification if MIL-STD-882, System Safety Program Requirements, is invoked. Evaluation of component fault hazards and their causes and hazardous effects is important data that must be investigated and included in the worksheets. If no formal safety requirements are included in the contract, the analyst should seek out such information from subject matter experts.

The heart of the task analysis process is in the writing of task step details for the worksheet items 12, 13 and 14 by the MTI&A analyst. The description of each step must communicate enough detail and guidance so that the JPA developer will understand the behaviors, cues, and technical information the user needs to perform the task successfully.

Each task must be analyzed to define in precise terms what the user sees or detects (behavioral cues), and what the responses must be to accomplish the task objectives. To ensure a precise understanding of all the task conditions, cues, responses, and objectives, the analysts must put themselves in the role of the technician trying to perform the task.

The analyst's aim is to determine the optimum way to perform each task step and to ensure that all of the cues to which the user must respond have been communicated.

A cue is simply a signal for action by the technician. It can be a condition ("If the alarm light is on"), an event or situation ("When the system is ready"), or

the completion of the preceding task step. The analyst, then, must organize the cues in optimum sequence that will start the task, proceed through the necessary performance steps, and then end the task. In analyzing the technical detail in conjunction with behavioral cues and responses the analyst should ask:

a. What conditions exist that make it possible for the procedure to start (initiating cues)? For example:

- (1) Is removal of the aircraft fuel tanks a task that can be performed at Intermediate maintenance level safely?
- (2) Is the aircraft safe for maintenance?
- (3) Has the aircraft been defueled?
- (4) Has it been drained and purged?
- (5) Have preparatory tasks (from other procedures) been performed (e.g., removal of access panels)?

b. What are the various technician responses that trigger the next cue? Usually the completion of the preceding step triggers the next, in a chain of task steps. In the body of task steps, the analyst must consider the behavioral discriminations and perceptions, problem solving and decisions, and motor actions, described in paragraphs 6.4.1.1, 6.4.1.2 and 6.4.1.3. Each of those questions must be analyzed to ensure the task steps are complete. In addition to these discriminations and perceptions, the analyst must determine through inquisitive research whether there is a better technique or a special trick that will help the user. For example, "Would loosening the access plate for the clutch assembly give the technician better access to the gear train?" or "Would the use of a printed circuit board extractor eliminate steps d and e?"

c. What cues signal the end of the task? A common problem in MTI&A is to miss or omit final wrapup steps because they are so obvious (e.g., "Disconnect test equipment," or "Tighten panel screws"). Because these ending steps are often critical, the analyst must ensure that accurate cues are provided to the JPA developer.

It is important to reiterate the need for validation of task steps through performance by the analyst or by observation of performance by a typical user. The analyst should ensure the validity and completeness of worksheet information by actual testing with such typical questions as:

1. Is there any cue or action that must precede this step?
2. Are there too many cues in the task step?
3. Is that step always performed this way?

4. Is there an alternative to this step?
5. Is the observed behavior of the tested user more typical than assumed in the step details?
6. Is this the quickest sequence of task steps possible?
7. Has all available support equipment been fully utilized in task steps?

The completed Task Analysis Worksheets provide a synopsis of technically accurate, logical steps which are the best way to perform the task. The JPA developer will amplify, refine and create final graphic aids from the complete data base developed via MTI&A.

**6.5.1.1 Hands-on Equipment Analysis.** The equipment is the only completely reliable source of information about itself. As the development of task steps and step description for the worksheets progresses, the analyst must gain regular hands-on access to the system or equipment. The surest way to ensure accuracy and completeness is to eliminate theorizing and guesswork by actually performing tasks such as making checks with the actual test equipment, disassembling a hard-to-reach assembly, or going through all the steps of a complex alignment. The hands-on effort gives the analysts confidence in their familiarity with the equipment, which is usually reflected in better task analysis and decreased development time for MTI&A. Later in the analysis process, of course, the analyst must validate all of the worksheet data and other MTI&A products on the actual equipment. The analysts will find validation a much simpler process if the task worksheet data have been tried out on the equipment throughout development.

**6.5.1.2 Level of Detail in Step Descriptions.** The analyst should ensure that for each task and subtask the worksheet includes only the simplest, briefest, and most straightforward and efficient step descriptions. The level of detail of the worksheet step descriptions shall be consistent with the level recommended in Figure 19, Sheet 2 Item 14. If it is too brief, it will require the JPA developer to re-examine the data thereby repeating the research efforts of the task analyst. If it is more detailed than the sample, the analyst will have, in effect, written the JPA procedures and that is not the purpose of the MTI&A process or the function of an analyst. The data called for in the worksheet is the keystone of the MTI&A. Step descriptions must include all elements of the procedure and identify all of the cues available to the user and all of the responses the user must make. Given this information, the JPA developer can prepare procedures which focus on the cues available to the technician and explain the responses which must be made. The task analyst's job is to make certain that all of the information required to write the procedure in accordance with the specification is in the data base. The analyst must imagine how the

technician will perceive the real equipment and relate to it using the JPA. In writing step descriptions, the analyst must mentally assume the place of the maintenance technician who will perform the task in the field. The analyst must visualize performance of the task, conceptualize the JPA that will be prepared to meet the stated requirements, and then judge whether the needed data are in the data base. It is much better to err in favor of providing more data than the JPA developer needs than the costly problem that would develop if there were not enough data. Finally, any missing information must be obtained and included to complete the task data base.

**6.5.1.3 Illustrations.** The analyst must attach to each worksheet, any and all illustrative data such as engineering drawings, diagrams, sketches, photographs, copies of pages from commercial manuals, or combinations of these that were used in compiling the task detail analysis and worksheets. The analyst should provide sketches of settings, physical locations, etc., that are important in understanding the step description. The analyst should annotate each item with callouts, lines, notes, sketches, etc., as appropriate. Such data may be applied by hand, as long as it is neat and legible. Section 5.7.1.3 provides guidelines for the analyst to observe when developing the illustration package that must accompany each Task Analysis Worksheet.

**6.5.1.4 Follow-on Maintenance.** The analyst must identify all maintenance actions which must be performed after the subject task. Some tasks are not complete work units in themselves. When the goal of the task is achieved, the tasks required to return the system/equipment to operational readiness or safe condition after completion of the task shall be listed in this item.

**6.6 Troubleshooting Task Analysis.** Since this phase of task analysis is the most demanding, it requires the best qualified people (analysts) and dedicated support to the analysis (SMEs, equipment availability, management support, etc.). Properly planned, supported, and carried out, this phase can produce a cost-efficient, complete, and accurate troubleshooting data base that will provide the user with useful, effective Logic Tree Troubleshooting Aid JPAs or other type manuals, as appropriate. Aided by previously developed MTI&A products, the TIM, the Definitized User Profile, the Support Equipment Guide, and the Level of Detail Guide, as well as system functional drawings, and a knowledge of the system, the analyst must perform a Performance Analysis and a Failure Mode and Fault Symptom Analysis. The products of these troubleshooting analyses are as follows:

- a. Checkout Summary
- b. Fault Symptom List
- c. Action Trees



**6.6.1 Overview.** The analyst begins the analysis and definition of checkout and troubleshooting tasks by examining the TIM for all cells coded as OL, IL, or BL. These codes indicate that a checkout and troubleshoot task has been identified for the equipment component and that it is a candidate for checkout or troubleshooting at O or I level, or at both levels (B). The letter L indicates that the checkout or troubleshooting task will be developed for the LTTA manual. In the Performance Analysis, the analyst must identify all of the design functions of the subsystems and equipment, and establish the checks that can determine if these functions are performing normally. The performance analysis also establishes the measurable parameters associated with each function and each component that contributes to that function. Performance parameters are the range of acceptable values that, when measured, indicate whether or not the component (subsystem, equipment, assembly, part) is operating satisfactorily. The results of this analysis are recorded on a Checkout Summary, Figure 34, which becomes the basis for later development of checkout procedures by LTTA preparers. (Checkout procedures in the LTTA are used to test whether the components of the system are functioning properly or, if not, are causing fault symptoms.) Next, the analyst performs a failure mode and fault symptom analysis on each component of the system identified in the TIM for checkout and troubleshooting. The fault symptom analysis identifies the ways in which each component function can fail (its failure modes) and cause a fault and a related fault symptom. This analysis produces a list of fault symptoms for each failure mode. The final phase of troubleshooting task analysis is the development of an AT for each of the fault symptoms on the list.

#### **6.6.2 Accomplishing Performance Analysis**

**6.6.2.1 Source Data.** The analyst will depend on a number of data sources for troubleshooting task analysis, but few are as important as solid understanding of the theory of operation of the system, at and above the pertinent level of repair. The data sources for performance analysis will focus on those that permit the analyst to learn the functional interrelationships of system components, such as theory of operation descriptions and diagrams in the following:

1. **Existing Technical Literature** — Contractor SMEs should be able to provide such technical literature in the form of commercial operation and maintenance manuals, or if the equipment has been previously procured for military use, then Air Force Technical Orders, Army Technical Manuals, etc., should be available. If the system employs equipment or major assemblies manufactured by other companies, commercial manuals are usually packed with each unit shipped to the prime contractor. If not, the analyst should request the contractor purchasing agent to request or purchase commercial manuals. MIL-spec manuals often provide the analyst with greater detail, so it is helpful to query the manufacturer to determine if a military manual has been developed on the component. If so, order it through your contracting office or technical library.

2. **Functional Block and Schematic Diagrams** — If the system/equipment is under development and no technical literature exists, the analyst should obtain electronic and mechanical block diagrams that show the organization and interrelationships of units from the design engineering personnel or from the manufacturer. Start with diagrams used in catalogs, data sheets, proposals, etc. For example, many technical proposals contain such drawings showing the system components and their inputs and outputs. Engineering design usually begins with sketched block diagrams and schematics outlining the equipment hierarchy. Figure 35 is a sample of the system hierarchy portrayed in a functional block diagram.

3. **Other Data** — The analyst will also need more detailed information in order to understand the system, such as mechanical layout diagrams, wiring lists, written functional descriptions, circuit descriptions, and similar data describing signal flow, interdependencies, operation, and performance parameters. Most of this information is generated in some form by engineers to explain to other supporting departments (logistics, manufacturing, etc.) the makeup of the hardware. Consult, for example, functional descriptions in purchasing specifications that are written to procure vendor equipments or assemblies. Many purchased items such as printed circuit boards, power supplies, and mechanical assemblies are selected from company catalogs that contain descriptions, diagrams, and test data.

6.6.2.2 **Learning the System Functional Operation.** The analyst must become familiar with all of the source data and quickly determine its weaknesses and data gaps, if there are any. If the data are inadequate or unreliable or if the analyst is doing performance analysis on a developing system with little formal data, it will be necessary to learn the system or equipment functions by other means. If technical data exist on hardware that has similar functions or components, the analyst should assemble data on and study those parts that are like the subject equipment. The analyst should then analyze the functional interrelationships of parts by assembling and studying engineering drawings or sketches on new, undocumented hardware. After that the analyst must complete the learning phase by interview and consultations with SMEs to obtain the knowledge necessary to prepare a complete Checkout Summary, a Fault Symptom List, and complete Action Trees.

6.6.2.3 The performance analysis is developed from the energy flow diagrams, functional flow block diagrams, schematics, other collected source data that depict the functional, organizational hierarchy of the system and the interrelationships among all components. The analyst should assemble all such drawings until all maintenance significant components (significant at Organizational or Intermediate level, as appropriate) in the entire system or equipment are represented. Figures 23, 26, 27, and 35 are samples of the types of engineering

drawings and data required for this task. Make certain by checking off each TIM component to show that there is coverage for that item at the pertinent functional level. If each assembly on the block diagram is checked against the TIM, a complete functional picture is assured. At each new level of subdivision, all parts or assemblies must be accounted for on the drawings and checked against the TIM. Make certain that all the components related to cells of the TIM that are marked for OL, IL, or BL can be identified on the assembled drawings. For each such TIM component, annotate the drawing to show the measurable performance parameters for that component (such as 24 Vdc;  $\pm 1.2$  Vdc; or horizontal scan = 5 ( $\pm .15$ ) inches. Figure 23 shows a diagram that the analyst has neatly annotated to show the performance parameters of important functional components. The waveforms and voltage levels were selected by the analyst during performance analysis because the TIM indicated that these components were appropriate for checkout and troubleshooting tasks. The analyst obtained the test data from an SME, and marked it on the functional flow diagram to indicate that if these readings and waveforms are tested as shown, they will indicate whether or not the unit is operating normally.

The analyst checks the accuracy of these annotated performance parameters by testing them with appropriate test equipment on the actual system hardware or by visualizing etc., as the check requires. After each is tested and if necessary corrected, the analyst has a complete set of source data drawings which contain, for each TIM cell marked for Checkout/Troubleshoot, a measurable or observable parameter consisting of input or output measurements, observable indications, panel readings, etc. The analyst should include in the annotations information concerning test equipment to be used, waveshapes, voltage levels, references to test diagrams or other observations. These drawings will be used as follows:

- a. To develop the Checkout Summary
- b. To aid the analyst in AT preparation
- c. To be retained throughout the program and carefully updated with every change
- d. To be made available to the government during in-process review, validation, etc.
- e. To aid the JPA developer in checkout and logic tree preparation.

These drawings will provide a detailed record of the performance analysis for troubleshooting and an audit trail for government reviewers. For these reasons the drawing annotations must be neat and legible as exemplified in Figures 23 and 25.

**6.6.3 Checkout Summary.** The analyst shall develop a summary of all observable performance parameters on the diagrams in a Checkout Summary as shown in Figure 34. One or more separate Checkout Summaries should be developed for each diagram annotated during performance analysis. Enter the name of the component (e.g., Detection Subsystem) and include the reference designator from the TIM, if the item has one.

**6.6.3.1 Checks Column.** Using the information annotated on the drawings, prepare a list of checks that must be made to test performance of each component listed for Checkout on the TIM, including any data to be used in the check. As each check is entered on the Checkout Summary, mark the appropriate TIM cell to indicate that the Checkout entry has been satisfied. A completely checked-off TIM is assurance that the Checkout Summary is complete.

**6.6.3.2 Performance Parameters Column.** This column must include parameters for each mode of operation in which observations or tests can be made and the range over which they can safely vary. The parameters to be listed should include all indicators of performance that are necessary to be tested. For example, in Figure 34, the second item listed for the Detection Subsystem is to see that the Wide Scan Mode checks out acceptably. To do so, the user must satisfy the following:

- a. Check that the Control position is okay (by checking that WIDE light is on).
- b. Check that the Antenna Scan position is okay (by checking that the resolver output reading is  $85 (\pm 1.5)$  degrees).
- c. Check that the Indicator presentation is okay by testing that:
  - (1) The horizontal scan is  $5 (\pm .15)$  inches
  - (2) The vertical scan is  $4 (\pm .1)$  inches
  - (3) There is a transmitter pulse present
  - (4) There is target/clutter video present.

As suggested in the specification, the Checkout Summary need not be typed, but if it is not, it should be neatly handwritten and kept up to date throughout MTI&A.

**6.6.4 Failure Mode and Fault Symptom Analysis.** For this analysis, the analyst should utilize the TIM, the Checkout Summary, and the drawings assembled for performance analysis. To develop the failure modes and fault symptoms, identify the ways (modes) in which each major function depicted on the performance analysis drawings can fail. Each of these failure modes can cause a fault and symptoms for that fault.

The analyst should check each item or component in the TIM that is coded for checkout and troubleshoot and make certain there is a related performance parameter that has been recorded on functional drawings. That is, ensure there is something to test for each component that is to be checked out or fault diagnosed.

For each component checked for Checkout or Troubleshoot task in the TIM, the analyst should ask questions such as the following to determine the component's failure modes and the characteristics of each:

1. How many ways can this component fail?
2. Will each level of failure have a distinct effect on documentation components?
3. What can happen when this component completely fails?
4. What can happen when it is operating but in a degraded condition?
5. What can happen if this component fails during operation mode a? During other modes?
6. Can this component fail intermittently?
7. What can happen during intermittent failures?

6.6.5 Fault Symptom List. The analyst must develop from the Failure Mode and Fault Symptom Analysis, a list of Fault Symptoms appropriate to the system (an example is shown in Figure 37). The list must include the symptoms of each failure mode of each component in the Checkout Summary including testing or checking details and such indications as meter readings, sounds, or other cues from the Checkout Summary Performance Analysis drawings. Whenever possible, the analyst should create the failure mode on the system by inserting faults, observing, and listing each symptom.

The analyst must prepare a separate Fault Symptom List for each operational mode of the system or equipment, where each mode creates different fault symptoms.

6.6.6 Action Trees. An Action Tree (AT) shall be developed for each fault symptom identified on the Fault Symptom List. An action tree is a branching tree outline, or block diagram, of the components, assemblies, or equipments that can cause the fault symptom, together with procedural information necessary for later use by the LTTA developer in explaining diagnostic procedures. The title of the AT is the fault symptom it addresses and diagnoses.

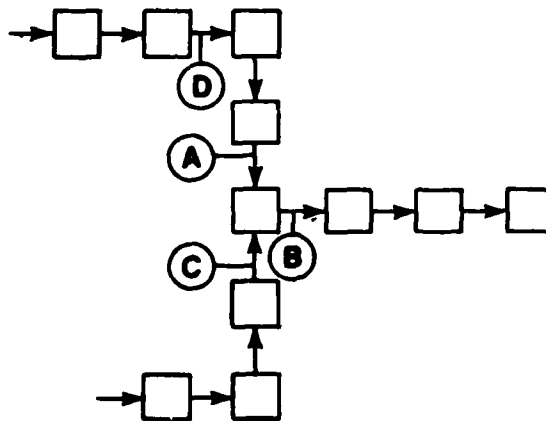
**6.6.6.1 Developing the Troubleshooting Logic.** The analyst should construct the action tree from those components in the TIM that can contribute to the fault symptom involved. The AT must be prepared from a basic knowledge of the logical hierarchy of components, as in Figures 38 and 39, together with a modified half-split fault isolation technique. The AT procedure must optimize the following technician considerations to ensure that minimum fault isolation time has been achieved:

- a. Time to gain access to the component
- b. Time to test the component
- c. Reliability of parts involved and of replacement parts
- d. Requirements of tools and test equipment to be used
- e. Modified half-split troubleshooting logic (explained below).

Action trees should contain a synopsis of all essential and pertinent information that will be needed by the JPA developer to prepare a LTTA from the AT and other MTI&A products. This includes warnings, cautions, notes, power turn-on procedures, pre-checkout procedures, reference diagrams, initial switch settings, etc. Each AT should be prepared assuming only one malfunction at a time is being addressed and the arrangement of components must be in the order of their importance as most probable causes of the fault. Selection of support equipment must be limited to those items found in the Support Equipment Guide. The first step in developing the logic of the AT is to develop a schematic representation of the functional relationships among components in the system, a block diagram that depicts the relationships among all of the components listed as possible causes of the fault symptom for which the AT will be prepared. Eliminate from the diagram, components that cannot contribute to the fault so as to keep the troubleshooting logic as simple as possible. From this hierarchy of components, develop the tree branches by choosing test instrument, type of test, and location of test, and diagnostic tests which will determine the best branch of the tree to follow, the possible outcome of each test, and the action to be taken as a result of each test. In summary, develop the AT so that it provides a synopsis of the most logical, orderly troubleshooting sequence that provides the fastest route to fault diagnosis.

**6.6.6.2 Modified Half-Split Troubleshooting Strategy.** Selection of the best branch to perform a troubleshooting test is of primary importance. Test branches should be selected in such a way as to divide all of the suspect components for the fault symptom on the block diagram into two equal groups (as nearly as possible). For the component block diagram shown below, if all components have equal failure probability and are equally accessible, the first test location would be at point A since the choice permits dividing the components most nearly

in half. No other test point permits better than an 8-3 split. If a "good" indication is found at A, the second test should be at B or C. If a "bad" indication is found at A, the second test should be at D. Each check eliminates about half of the components from consideration. These components are known to be "good." The choice of test location between the suspect components should be such that the check be made at the mid-point of the chain, and each succeeding check be made at the mid-point of the remaining portion of the chain. Thus, assuming each component has an equal probability of failure, the branching proceeds by halving the probabilities that the malfunctioning component lies on one side or the other of the check. This strategy defines the half-split technique of troubleshooting.



The pure half-split technique described above is seldom the most economical for 100 percent of the checks, because of practical constraints. The half-split strategy should be modified by introducing the following considerations:

- a. **Reliability.** Checks for items with high failure rates should precede checks for items with lower failure rates.
- b. **Accessibility.** Checks that are "quick and easy" should precede those that involve extensive or time-consuming disassembly. The best AT from a user's standpoint is one that finds the trouble in the shortest time.
- c. **Probability of Malfunction Introduction.** Those checks which involve activities with high probability of accidental malfunction introduction should be deferred toward the end of the procedure. Whenever a static check (power off) and a dynamic check can reveal roughly the same diagnostic information, the static check is preferred.

d. **Location of the Technician.** Other things being equal, the sequence of checks should minimize the movement of the technician from one location to another.

e. **Test Equipment Setup.** An unusually time-consuming test equipment setup should be weighed against the information it can provide to consider whether its use would be presented earlier or later in the check sequence.

The analyst must include procedural step data in the AT where changes in equipment condition are required to permit a check, when method of access must be specified, or when test equipment settings must be specified.

Include a corrective action step at the end of each branch of the AT, and identify any follow-on or related tasks (e.g., return to checkout) that the LTTA developer should know.

**6.6.6.3 Action Tree Data.** Action trees shall contain the following information:

- a. Brief procedural steps that will provide the LTTA developer with technical guidelines on developing the checkout and logic tree troubleshooting for operations where no decision is required, such as in Figure 39. In the statement "Check air pressure for 35 psig and engine rotating at 28-34%," the analyst provides data for the LTTA developer to use as source data in preparing detailed Logic Tree test/decision boxes.
- b. Repair or replacement steps, which direct the repair or replacement of a faulty component. The component to be repaired or replaced should be identified by the same nomenclature or reference designator, as listed in the TIM.
- c. Decision branches in the tree should identify the diagnostic tests to be made, the possible outcomes, and the action to be taken as a result of each outcome. Make certain that the following data are included:
  - (1) Name and model number of test instrument (if any)
  - (2) Type of reading (e.g., pressure, voltage)
  - (3) Location of test points
  - (4) Range of acceptable values for the reading
  - (5) Action to take as a result of each possible outcome of the check.



**6.6.6.4 Action Tree Development Rules.** The analyst shall develop each AT according to the following rules and strategies. Refer to Figure 39 for application of these rules to a sample action tree that an analyst would have developed. Letter callouts in the rules below refer to those on the sample figure.

a. Only one fault symptom is observable at a time and only one fault exists in the system at a time.

b. Each point of test shall be selected to obtain the greatest amount of fault isolation information for the action taken (i. e. , the modified half-split strategy). Instructions for performing the test shall be concise, simply worded, and arranged in specific steps (see A). The analyst shall make reference from the test steps to an attached drawing or other reference, for physical identification and location of components involved (see B).

c. When a test result shows that the fault does not lie in a specified section of the system, the branch of the tree representing that section should not be accessible for later trouble isolation tests (i. e. , no further testing is permitted in that section of the system) (see B).

d. The first tests to be done will normally be those that use meters, switches, annunciators, warning lights, and other built-in test equipment. The human senses for sight, sound, and touch should also be used to advantage in the testing process.

e. Tests that must be done with external test equipment will normally appear later in the testing process.

f. Two or more tests shall not cause a closed loop in the strategy (i. e. , a situation wherein one fault is isolated from two branches of the action tree).

g. No test shall result in a dead end (i. e. , a situation in which the LTTA developer is left to devise a strategy for continuing the trouble isolation procedure).

h. Every test must yield a reliable result compatible with a "yes" or "no" question. There shall be no possibility of a third ambiguous result.

i. A serial (nonbranching) sequence in which one item after another is checked for a pass/fail condition until the fault is found (as in doing a Checkout) is permissible only where it is the only possible sequence for testing.

j. The tests in each branch shall result in accomplishing one of the following, as applicable to the respective maintenance level and authorized maintenance procedures:

- (1) Determine which one of two components is faulty.
- (2) Determine that a component is faulty or that an additional test must be made.
- (3) Determine that further checkout or test must be made.

k. Each AT test instruction shall provide the LTTA developer with enough information to develop complete logic tree instructions (see C).

l. Corrective action instructions at the ends of the branches shall include both the corrective action to be taken and the follow-on to be done (see D).

m. Corrective action instructions shall include one of the following as required actions:

- (1) Repair, replacement, adjustment, or alignment of a specific unit, part, or piece (see E).
- (2) Further testing of the assembly or subassembly to further isolate the fault (see F).

6.6.6.5 Action Tree Format. The specification permits any format that produces a well organized AT structure and is logical, legible, and complete. The same AT in Figure 39 would be acceptable in its neatly handwritten format.

## 7. QUALITY ASSURANCE OF MTI&A

7.1 Quality Assurance Plan. The Quality Assurance Plan described in this section must be developed at the outset of the MTI&A planning phase and become a coordinated part of the Task Analysis Plan described in the Draft Specification, AFHRL-TR-79-50, Section 3.1.3. The purpose of the Quality Assurance Plan is to assure the Acquisition agency that the contractor has all of the requisites for a thorough and successful MTI&A development program. As emphasized throughout this handbook, the specification requires significantly greater discipline and depth of detail than is required in planning and developing conventional technical manuals. Consequently, even a quality assurance organization that is experienced in controlling conventional military technical manual programs may require considerable organizational and procedural adjustment in order to control the quality and technical integrity of MTI&A programs. If the contractor does not have an ongoing QA capability for technical data programs, the task of assembling one which will satisfy all contractual requirements and ensure its success is a substantial one. The Quality Assurance Plan will be given serious consideration by the Acquisition agency, because it reflects the

contractor's knowledge and capability to perform the complex task analysis. Plans that are too general in content to address the specific quality control problems of task analysis may suggest a lack of attention or understanding by a contractor concerning the importance of quality assurance. Such plans may be considered unacceptable by the Acquisition agency. If the contractor does not have a formal QA structure, the QA Plan must provide substantive detail in explaining the contractor's understanding of the specification and its requirements for data quality and completeness. It must explain how the contractor will select personnel to perform QA on task analysis, their background for the assignment, and the organizational support they will receive. To ensure against costly false starts, the QA Plan should be reviewed and approved by the Acquisition agency before the research and task analysis begin.

Copies of the approved plan should be distributed to all potential QA participants so that they can become familiar with their expected role. Copies should also go to task analysts so they know the inspection criteria for task analyses and the products of the analyses.

**7.2 Quality Assurance Organization.** Ideally, a contractor should have an existing QA function that is an arm of management and is independent of the department responsible for task analysis. The QA function ensures that problems of quality and accuracy are found and corrected early enough to forestall schedule delays and cost increases; i. e. , long before they appear in a deliverable document. In this way, the contractor ensures that products will reflect a constant level of high quality and technical accuracy. A QA organization will prove inadequate if it is oriented toward random surface checks or sampling the data for minor inconsistencies and errors. In order to forestall quality and accuracy problems, a contractor should review the type of technical data work its QA function normally controls and compare their normal findings with the detailed specification and review requirements set forth in the specification and this handbook. For example, does QA normally check and control LSAR data outputs when it is required by contract? If they do perform in-depth checking of LSAR, they may be well qualified to perform MTI&A QA.

The specification does not require rigid formatting of MTI&A products. Instead, it requires a technical integrity and completeness which must be the guideline for QA tasks.

It is important that personnel who will review the technical quality and accuracy be interested more in the technical substance of data than in cross-referencing errors and typing errors. Checks for technical quality require that the reviewer care about, for example, completeness of the TIM, the accuracy of the reader profile, the maintenance concept, the appropriate tools to be used, and the most logical approach to troubleshooting. Some QA reviewers are satisfied with their

contribution when they find any kind of error. If their time, however, is taken up by inspecting for trivia, a review for substance sometimes occurs only at validation or verification, and that, of course, is much too late in the cycle to be learning that the task analysis has serious technical deficiencies.

The QA staff should include well qualified technical personnel who can assess the technical validity of data by means of review of the preliminary products, even in the early stages of development. It may, for example, prove necessary to temporarily assign a cognizant engineer to the QA function in order to ensure accuracy of early efforts, such as the TIM and the Support Equipment Guide. Such a technical reviewer should be knowledgeable of the equipment and its maintenance philosophy (test equipment, logistics support, user, etc.) and should be capable of detecting technical inconsistencies and misconceptions.

Personnel assigned to quality assurance must be familiar with the entire task analysis process and know the purpose of each product and its effect on final accuracy, correctness, and completeness.

**7.3 Quality Control Forms.** Quality assurance personnel must be able to communicate their corrections and critiques to the analyst in such a way that the types of errors will not recur in future analyses. Reviewers who find quality and accuracy problems should not only explain the inaccuracies and return them to the originator's supervisor but should also recommend the way that type of error could be permanently eliminated. For example, QA Review Evaluation Guide forms are simple to fill out but they expose and record recurring quality deficiencies. Figure 41 is a sample of a form that can be effectively used by QA reviewers. QA reviewers should refuse to accept material for review that has not been checked for accuracy and completeness and approved by the analyst's supervisor.

**7.4 Technical Quality Control.** The output of the task analysis effort is a set of products that must be thoroughly reviewed for technical accuracy, consistency, and completeness before submission for in-process review, validation, or delivery.

MTI&A products, therefore, are the method by which the analyst organizes the logical, accurate approach to the problems of maintenance. The efforts of analysts in preparing the products, such as the TIM, User Profile, Support Equipment Guide, Level of Detail Guide, Task Analysis Worksheets, and if required, Checkout Summary, Fault Symptom List, and Action Trees must be reviewed for technical quality while they are in progress. The role of task analysis and preparation of intermediate products is first to ensure the in-depth study necessary to completely define and design the maintenance and troubleshooting tasks,

MTI&A QA Review Evaluation Guide

Subsystem/Equipment \_\_\_\_\_ Reviewer(s) \_\_\_\_\_ Date \_\_\_\_\_

Review Task	Reviewer--Initial and Date			Customer Approved?	Comment
	YES	NO	NA		
1. TIM was prepared IAW approved System GAPL, or other formal parts breakdown.					
2. TIM includes all replaceable components designated for Organizational and/or Intermediate Level.					
3. TIM reference designators, codes, and part descriptions are accurate, complete, and comply with 3.2.1.1.					
4. Maintenance task decisions in each TIM cell are 3.2.1.3.					
5. Support Equipment Guide is based only on customer-approved equipment.					
6. Standard Statements developed for each test equipment function IAW 3.3.2.5.					
7. If LSA is required by contract, the TIM reflects the appropriate LSAR data sheets as in 3.5.					
8. Each ? in the TIM has been eliminated as in 3.2.1.4.					
9. The Definitized User Profile reflects government-generated Preliminary User Profile plus contractor recommendations.					
10. The Level of Detail Guide reflects the approved Definitized User Profile.					
11. The Level of Detail Guide reflects typical task actions as in 3.3.3.1 as well as all others appropriate to the system technologies and skill requirement.					
12. The Task Analysis Worksheets contain all data including attached illustrations as required by 3.3.4.1.					
13. A Task Analysis Worksheet has been prepared for every "J" entry in the TIM.					

FIGURE 41. QA review evaluation guide (sheet 1 of 2).

**MTIA QA Review Evaluation Guide**

Subsystem/Equipment \_\_\_\_\_ Reviewer(s) \_\_\_\_\_ Date \_\_\_\_\_

Review Task	Reviewer--Initial & Date			Customer Approved?	Comment
	YES	NO	NA		
14. The task analyst has accumulated complete set of annotated source documents for Performance analysis that reflect all performance parameters as in 3.4.2.1.					
15. A Checklist Summary has been prepared for each TIM cell coded: OL, IL, or BL.					
16. Has the TIM been annotated to reflect all items that can be the cause of a fault symptom IAW 3.4.2.1?					
17. The Fault symptom list directly correlates with the performance parameters in the Checklist summary.					
18. Has an Action Tree been developed for each identified fault symptom?					
19. Have the ATs been developed IAW 3.4.3.3 and the AT development rules in this handbook?					
20. Has the TIM, the Task Analysis Worksheets, and Action Trees been thoroughly validated IAW specification requirements?					
21. Errors, omissions, and improvements required through validation were incorporated in each product.					
22. Has a validation record been signed by contractor and government personnel attesting to completion of MTIA validation?					

FIGURE 41. QA review evaluation guide (sheet 2 of 2).

and then to form the basis for day-to-day technical review of the data. The quality control reviewer should use the QA Review Evaluation Guide (Figure 41) to ensure that task analysis and the preparation of products have been performed with technical thoroughness, completeness, and compliance with the specification.

**7.5 Validation.** The specification (AFHRL-TR-79-50) defines validation as the process by which the contractor ensures the adequacy, accuracy and completeness of the MTI&A products and their suitability for the intended purpose. Procedural data are validated by actual performance on the subject system/equipment, while non-procedural data are validated by such methods as comparison with source data, analysis by experts, etc. Validation is essentially a Quality and Accuracy Assurance function by means of which the contractor gains assurance that what has been developed to comply with the specification is complete and accurate, and represents a quality product. The contractor's Quality Assurance department should, therefore, schedule, organize, and monitor the entire validation process. A quality assurance inspector should be a member of the validation team throughout the validation process to ensure that it is proceeding in accordance with all contract requirements, including 4.6 of the MTI&A specification. The members of the validation team should be alert to prevent the deterioration of the validating effort if it should last for many days. Sometimes when validation is a lengthy process and the same team members participate throughout, there is a tendency to assume the correctness of some of the task data base rather than actually testing it.

**7.5.1 Preparing for Validation.** Good planning is essential to a successful validation. Planning and preparation should consist of the following steps:

- a. Consult the approved validation plan in the Task Analysis Plan (specification 3.1.3). If any changes are anticipated that change the schedule, conditions, personnel, etc., advise the Acquisition agency before proceeding.
- b. Make certain that each product to be validated is, in fact, complete and ready for review. The product should be checked for completeness, accuracy, and compliance with the specification before proceeding.
- c. Determine that the equipment involved is in its normal operating mode (i.e., functioning properly, properly aligned, etc.) and reserved for the validation team during specific periods.
- d. Determine that all support equipment (e.g., test equipment, tools, and interfacing subsystems) are assigned and operable. Test equipment should be checked for calibration before being used.

e. Notify the Acquisition agency of the date and place of validation at least 45 days in advance of validation, unless otherwise specified by the contract so that the government reviewers can witness validation, if they so desire.

f. Assign and schedule the participants of the contractor's validation team (see Section 7.5.6 of this handbook) well in advance so that they will be committed to the validation.

g. Prepare and circulate a detailed agenda for the validation. The agenda should provide fairly detailed scheduling, such as: "From 9:00 AM to 12:00 PM - Validate 'Detection Subsystem Task Worksheets'."

h. Obtain the Validation Record forms from the contracting officer and have them available for signature by the contractor and the government personnel. Validation Records are explained in the Data Item Description, DI-M-3408.

**7.5.2 Validation of the TIM.** The TIM should be validated before the analyst proceeds to develop the Task Detail Analysis and Task Analysis Worksheets. To validate the TIM the contractor should address the following:

a. Does the content of the TIM, the hardware organization, maintenance codes, and maintenance functions agree with the maintenance concept and the specification?

b. Is the TIM complete? Does each matrix cell contain an appropriate entry, and are all hardware items from the data base (such as Illustrated Parts Breakdown (IPB), Repair Parts and Special Tools List (RPSTL), provisioning list, LSAR report) listed?

c. Is the TIM accurate? Compare the hardware breakdown level in the TIM with the original document and show that they are identical.

For each cell, the subject matter expert should check if the listed maintenance function is accurate for that component and if the entry indicates the appropriate level of maintenance.

The reviewer should check all empty cells and consider the following questions:

a. Why isn't there a maintenance function for that item?

b. Is the function performed at other than O or I level?

c. Can the function be performed?



Answers to these questions might consist of:

- a. That function is only for Depot level.
- b. It is not applicable to that item.
- c. Support equipment or spares are not available in the field to do that maintenance function.
- d. The intended user is not trained to perform that function.

7.5.3 Validation of Support Equipment Guide. The contractor should demonstrate at validation that the Support Equipment Guide meets the following requirements:

- a. The format and content of the guide are in accordance with the specification.
- b. The test equipment, tools, and ground support equipment listed in the guide are those that have been approved for use by the Acquisition agency for O & I maintenance.
- c. The test equipment functions and standard statements which are included accurately reflect the user's expected capabilities, as defined in the Definitized User Profile.

7.5.4 Validation of the Task Analysis Worksheets. The contractor must show that the task analysis worksheets prepared for each task satisfy the following requirements:

- a. That entries are complete and accurate by checking all data on the system hardware. All tasks and task steps must be validated 100 percent on the equipment. Where performing tasks and task steps would damage or degrade the equipment, simulated performance may be used, if approved by the Acquisition agency. To simulate performance, the reviewer validates the order and content of procedural steps by "walking through" worksheet details as written. For example, to perform a test setup, the reviewer checks that meter settings can be accomplished and that operating controls are located as indicated, without actually performing the operations.
- b. That appropriate warnings, notes, cautions, and other safety hazards are identified.
- c. That the worksheet has sufficient detail (neither too much nor too little) to provide a JPA developer with full detail as required by the specification. The validation team should add, delete, or modify the task worksheet details as such deficiencies are found during validation.
- d. That tolerance ranges for performance parameters are checked and, if incorrect, determined empirically at each point of test.

**7.5.5 Validation of Action Trees.** The contractor shall validate all Action Trees to ensure that their functional organization of equipment is correct, that the troubleshooting strategy is complete and logical, and that procedural information is validated 100 percent. The contractor should ensure that ATs satisfy the following requirements:

- a. That they reflect the use of authorized test equipment and tools.
- b. That their testing locations were selected in a logical manner, consistent with the specification guidelines and the functional organization of the equipment.
- c. That half-split strategy requirements are properly followed.
- d. That a separate Action Tree exists for every fault symptom identified in the Fault Symptom List and that the AT steps expose every component that can produce the fault symptom.
- e. That the Action Trees for procedures are checked 100 percent for accuracy, adequacy, and performability, that the sequence of task steps is appropriate, and that injected faults do not degrade the equipment operation and thus ensure that the ATs are capable of rapid and accurate fault diagnosis.
- f. Validation shall establish that every component failure mode found by an AT produces the symptom for which the AT was written, and that the AT logic isolates the component. This validation shall be accomplished empirically by actual physical simulation of each component failure mode. This can be accomplished by developing "bugged" components such as assemblies with known malfunctioning parts, printed circuit modules with faulty components, adjusting voltages or mechanical alignments to out-of-tolerance levels, operating the system in a degraded condition, etc.
- g. An AT, or part of an AT, need not be completely validated if it can be demonstrated that it is identical to an AT or part thereof that has already been validated. In such a case, failure modes shall be simulated only to the extent necessary to determine that the symptom produced is the one for which that AT was written.
- h. The contractor, in the process of validating the logic of each AT, shall also determine the tolerance range of all application-specific readings. These tolerance ranges shall be established by simulating the failure mode in such a way that the entire range of failure (e.g., range of hydraulic pressure or range of resistance values) can be observed and the points in the range can be noted at which the symptom appears.
- i. Malfunctions that would tend to produce power supply overload need not be simulated beyond the point at which they would produce the full rated load for the supply (as measured by a dynamometer, ammeter, etc.).

j. The contractor must be able to demonstrate during validation that each AT has a corrective action (e.g., repair or replace) for every component listed as a possible cause of the fault symptom for which the AT was developed.

**7.5.6 Personnel.** The personnel who participate at all validation proceedings should include:

a. A contractor technical authority (or subject matter expert) who can attest to the technical accuracy of MTI&A products and their appropriateness to maintenance philosophy, test equipment, provisioning philosophy, etc.

b. A contractor quality assurance representative who is empowered to ensure that the validation is performed to the letter of contractual specification.

c. A government witness, at the option of the Acquisition agency.

Full or part-time attendance is also recommended for the following:

d. Task analysts who developed the MTI&A products.

e. A "subject" to perform procedures who possesses training and technical capability similar to the intended government user-technician.

f. Contractor management personnel.

**7.5.7 Schedule.** The contractor should schedule the formal validation process well in advance of contractual delivery requirements so that there is ample time for procedural revisions, corrections, and access to the equipment for revalidation, if necessary.

**7.5.8 Validation Certificates.** After MTI&A products have been validated, the Validation Certificates should be forwarded to the contracting officer. QA personnel should make certain that all corrections, improvements, or additions are quickly satisfied in the preliminary products and are revalidated if data have been changed or added.

**7.6 Verification.** The contract may require contractor task analysts or technical personnel to participate in the government verification. Even if the contract does not include this requirement, it is in the contractor's best interest to send a staff member who is familiar with the MTI&A products. The contractor can usually reduce the number of comments by being present to explain why certain approaches were taken. Where discrepancies are found during verification, changes or corrections can be prescribed that will obviate formal, time-consuming correspondence which often includes a typed set of comments, some of which the contractor might otherwise have to respond to with formal documentation.

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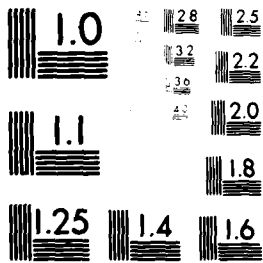
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