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THE **BOEING** *Aerospac* COMPANY
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PHASE II SYSTEM DESCRIPTION

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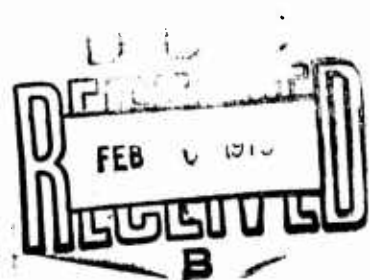
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INTRODUCTION

This document has been prepared as a result of Phase II of the Advanced Technical Data Research Study initiated in March 1973. Phase I documentation, D180-17523-1, "Abstracts of Data," was released 11 July 1973. The objective of this portion of the study was to devise or select a complete publications system to advance the T.O. publications state-of-the-art. A comprehensive review was made of the total publications field. Significant new concepts were reviewed (reported in D180-17523-1). Consultations were held with industry and government publications personnel, and visits were made to military bases to determine extent and type of technical publications problems. All of this research data was then reviewed to determine what the most viable program was that could be developed. Because the life cycle of a publications program is so extensive and involves so many people and agencies, both government and industry, the scope of the Phase II effort was narrowed to concentrate on the user phase. This decision to concentrate on the user problems of technical order publications was based on the conclusion that the problems were more intense in this area, and the benefits from alleviating some of the user problems were the greatest. It is in this area that benefits are compounded by the impact of improvements in technical order publications fields on other related logistics activities such as training and spares. For example, by use of microfilm on the flight line that displayed troubleshooting procedures that assured 95% correct fault diagnosis of maintenance functions, the total time spent by maintenance personnel would be reduced. This in turn would reduce the total number of technicians required and reduce the total training cost. If the hardware fault diagnosis were correct at least 95% of the time, the numbers of spares required in the system would be reduced. Packaging and transportation costs would be less. This would further impact the number of shop and depot technicians required to repair and overhaul faulty hardware components. It is obvious that anything that improves, simplifies, or shortens the maintenance function reverberates throughout the military establishment. It was on this basis the innovations and improvements to the current publications system described in this document were selected.

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BACKGROUND

In the 52 year history of the technical order publications business, very little change has taken place; only the volume has grown as the complexity of equipment has increased. The types of specifications, the methods of production and the presentation of data have remained essentially the same. Even the user methods of handling, use, retrieval and storage have remained the same. The demands for additional or new data have always lagged behind the engineering or hardware improvements, and any improvement on additional supply of data was a result of an intolerable or dangerous hardware situation.

As the volume of data has grown and the complexity of weapon systems increased, the maintenance man's dependency on the data has also increased. The deficiencies in the data system, far from being solved, have only been magnified and amplified.

As early as 1966, Col. E. G. Triner, in a speech made to the Society of Technical Writers and Publishers, presented the Air Force viewpoint that "it should be clearly understood that the existing technical order system is performing a needed function, it must be recognized that we are rapidly approaching the useful limit of our existing method of transmitting technical information.

"Of all the various phases of maintenance essential to the fielding of our complex systems, the most costly, from every aspect, is unquestionably what we term unscheduled maintenance. Anything which can be done to decrease the downtime of an operational system has significant dollar impact. In our sophisticated system, troubleshooting takes on an importance far beyond anything that we have seen in the recent past. Much of the troubleshooting data contained in our existing technical orders are stereotyped, are not specific to the situation, and require far too much time for implementation."

During this period of time many studies have been conducted. Blue ribbon committees and councils have been established such as NSIA and AIA study groups, including the prestigious "Ad Hoc" group of the Equipment Maintenance and Readiness Council. The summation of all of the findings of the various groups is unique in their consistency of the determination of the problems plaguing users of technical order publications. A composite listing of significant problems are:

1. The technical manual system has continuously grown throughout the past years due to increased complexity of our weapon systems. The libraries have become bulky, contain numerous volumes, and the use of cross references makes the data difficult to use.
2. Shipment of basic technical manuals and all changes, which must be collated into the manual by the user, present a tremendous task when large quantities of manuals are received by the user activity; i.e., initial outfitting for aircraft carriers, etc.
3. The constant changing of hardware requires that the manuals also change. Configuration changes require different data with "before and after" instructions. The changes make the manuals difficult to read. Physical handling and processing is difficult and time consuming.

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4. The organizational level user of technical manuals does not have adequate and required documentation readily available when he needs it.
 - The Troubleshooting Data is Stereotyped
 - Data Contains Diagnostic Deficiencies
 - Excessive Cross-Reference Requirements
 - Does Not Do the Job the Data was Intended to Do
 - Permits Erroneous Removal and Replacement of Good Hardware
 - Requires Highly Skilled Maintenance Personnel to Follow Instructions
 - Manuals Bulky and Difficult to Handle
5. Technical manuals used by more than one service create a problem when one service modifies the hardware. This necessitates changing the manual, usually by a supplement.
6. Improperly prepared and outdated technical manuals may contribute to additional downtime and manpower waste.

In order to solve these problems, industry and government have developed and experimented with many new concepts, presentation devices, and total publications systems (a brief description of the more promising of these concepts, aids etc. is presented in D180-17523-1, "Abstracts of Data").

Even after fairly extensive test and evaluation of some of these new ideas, both by government and industry, not one of the possible solutions has been implemented across a single military service during the past ten years.

At the present time, the military services' prime interest is in the area of data handling, storage, retrieval and use. The Army and the Navy have launched programs to convert hardcopy manuals to microforms. In the case of the Army, it is microfiche, and in the case of the Navy, it is roll film. The Air Force is microforming their depot technical data on cassettes. They have also conducted some tests and evaluations of hardcopy viewers for flight line maintenance. Although the Army and Navy have microformed their depot and some field maintenance data, it is surprising that after many years of tests, evaluations and proven worth of microform data, they have not, as yet, ventured into microforming flight line maintenance data.

The Air Force has conducted an evaluation and service test of microfilm technical orders at the organizational level at Homestead AFB during the first six months of 1973. The results have not been published at this time, but preliminary conclusions indicate that: a) flight line use of microfilm T.O.'s should be adopted USAF-wide; and b) design of supporting hardware such as reader/printers requires a substantial amount of work to bring the hardware up to military specifications. On the other end of the publications life cycle and to a lesser extent, development and test is being conducted by the Air Force on "Fully Proceduralized Troubleshooting Aids" at organizational and field levels of maintenance.

Both the Army and Navy have developed Job Performance Aids (JPAs) that reflect either all or part of the Air Force JPA technology.

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Army Application

1. Early in 1970 the Army Material Command became interested in Job Guide Manuals. As a result, an in-house project was started at Letterkenny Army Depot, Chambersburg, Pennsylvania. This effort has resulted in the development of JPAs for six small items of equipment.
2. In addition, the Army Safeguard Missile Command, Huntsville, Alabama, has JPA supplements for their Maintenance Data System for the Power Generator that provides ground support for missiles.

Navy Projects and Applications

1. For several years the Navy Personnel and Training Laboratory at San Diego, California, has considered the use of JPAs for difficult-to-perform tasks as a supplement to maintenance manuals. This organization now has an on-going project to develop procedures for economically identifying maintenance critical tasks for which such aids will be effective.
2. Various units of the Naval Air Systems Command have on-going JPA projects. The Human Factors Laboratory Command, in Washington, D.C., is developing JPAs for an Auxiliary Power Unit - System No. NCA-8. These aids were developed without a specification. The power unit requires electrical specialists and engine specialists. The Navy plans a controlled operational evaluation of these aids. After specialists have been trained to maintain with JPAs, there will be a switch of jobs without additional training to see if electrical specialists can do engine specialist jobs and vice versa.
3. The most comprehensive Navy effort planned by the Naval Air Development Command is the development of JPAs for both organizational and intermediate maintenance for an electronic subsystem, the AN/AQA-7. The development of the aids will be based on the draft specifications found in AFHRL Technical Reports 71-53 and 71-23.

Considering the problems that are inherent and recognized in the present technical order publications life cycle and of such magnitude that the available resources could not possibly solve all of them, the alternative is to select that area where the greatest benefits can be obtained consistent with the available resources and technology. The conclusion of most studies and investigations on the subject during the past 15 years is that a reduction in Maintenance Manhours/Operating Hours (MMH/OH) is the area where the impact of improvements would be the greatest.

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SYSTEM DESCRIPTION

The concept described in this document is unique only to the extent that the combination of existing technologies is different and is applied in a manner to achieve greater benefits than previously attempted.

The basic system comprises the use of fully proceduralized Job Performance Aids techniques in the development of the maintenance data, the conversion of this data to microfilm and the use of a data van to store and retrieve data at the mechanic/technician work station.

Fully proceduralized job performance aids are step-by-step instructions for performing any maintenance task that the technician may be assigned. The step-by-step instructions are accompanied by detailed illustrations which show the technician what the components referred to in the instructions look like and where they are located on the equipment. The aids are designed to provide the technician with all of the information, in one place, that he needs to do the job and in effect "tell him every move to make." The basic concept underlying JPAs is that it is possible to simplify a job and reduce the cognitive skills required to accomplish it by "doing much of the technicians work for him in advance" through a detailed task analysis. Normally when a technician is assigned to do a task he must decide what tools to use, what actions he must take to do the job and in what sequence to perform the actions. In the development of fully proceduralized JPAs, the task analyst makes these decisions for the technician and incorporates them into the instructions. The technician does not have to generate the information himself. As a result, a less skilled, less highly trained individual can perform the job. A second advantage of this procedure is that the task analyst is in a position where he has all of the necessary information available, has adequate time to consider all possible procedures, and is better able to select the best or optimum procedure.

The overall process of developing advanced-type JPAs is shown in Figure 1. It begins with development of a data base through a process called "Task Analysis," see Figure 2. The sources of data for the task analysis will consist of written documentation and information which is similar to the process currently used in development of conventional technical data. The analyst will have to depend heavily on engineering data interviews with designers, and where possible, observation of maintenance activities will be conducted in R&D phases. The analyst may participate in equipment design decisions. But unlike the writer of conventional technical data, he cannot be satisfied with hardware descriptions only. He cannot complete his analysis until he has complete and accurate descriptions of tasks. The design of individual hardware items, the overall system design, the maintenance philosophy -- all must be complete enough to permit detailed task descriptions before the task analysis can be completed.

The first of three major steps in the preparation of Task Analysis is the preparation of a Task Identification Matrix (TIM), see Figure 3. The TIM is a matrix of all equipment end items maintainable at the organizational level of maintenance versus all types of organizational maintenance tasks. It identifies all of the theoretical possibilities for tasks at that level of maintenance. It thus tends to insure that no tasks will be overlooked in the JPA.

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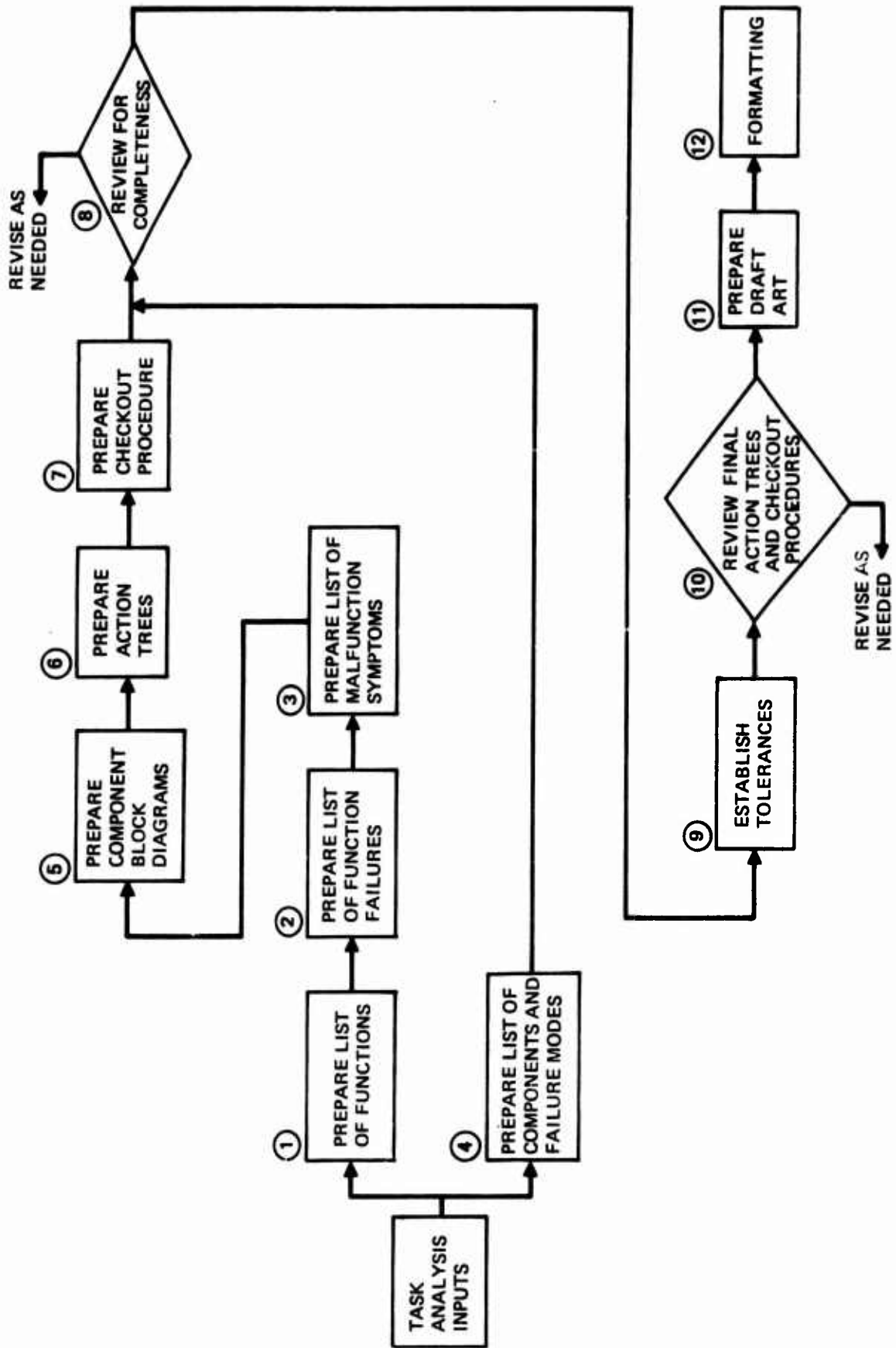


Figure 1: FULLY PROCEDURALIZED TROUBLESHOOTING AID DEVELOPMENT PROCESS

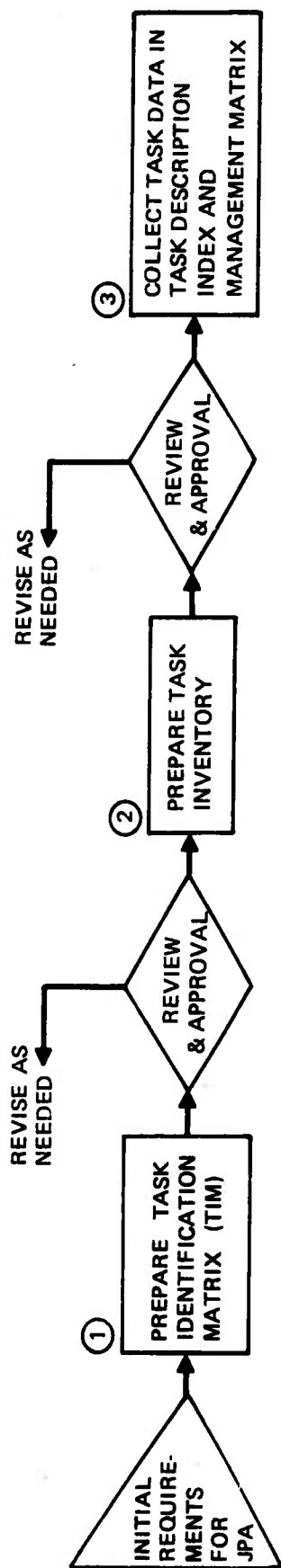


Figure 2: MAINTENANCE TASK ANALYSES DEVELOPMENT PROCESS

SYSTEM HARDWARE LEVELS	MAINTENANCE FUNCTIONS					13 TROUBLESHOOT
	1 ADJUST	2 ALIGN	3 CALIBRATE	4 CHECKOUT	
12. LANDING GEAR SUBSYSTEM	0	0	0	TL		0
.						
13. COMMUNICATION SUBSYSTEM	0	0	0	TL		0
13.1 TRANSMITTING STATION	0	0	0	TL		0
13.1.1 MODULATION EQUIPMENT	0	0	0	TL		T
13.1.1.0.1 POWER SUPPLY	0	0	0	TH		0
13.1.1.0.2 MOD UNIT	0	0	0	0		0
13.1.1.0.2.1 SPEECH AMP	0	0	0	0		T
13.1.1.0.2.2 FSK	0	0	0	0		T
13.1.2 TRANSMITTING SET	0	0	0	T		0
13.1.2.1 TRANSMITTER	0	T	0	0		0
13.1.2.1.1 OSC	T	0	0	0		T
13.1.2.1.1.1 SMO	T	0	0	0		0
13.1.2.1.2.1 DRIVER	T	0	0	0		T
13.1.2.1.2.1 MULT	0	0	0	0		0
13.1.2.1.3 P.A. UNIT	0	T	0	0		T
13.1.2.1.3.1 BUFFER	T	0	0	0		0
13.1.2.1.3.2 P.A.	T	0	0	0		0
13.1.2.1.3.2.0.1 PARTS	0	0	0	0		0
13.1.2.2 ANTENNA GROUP	T	0	0	0		0
13.1.2.2.0.0.1 PARTS	0	0	0	0		0
13.2 RECEIVING STATION	0	0	0	TL		0
13.2.1 RECEIVING SET	0	0	0	TL		0
.						
13.2.2.0.2 TT PRINTER	T	0	0	0		0
14. NAVIGATION AND RECOGNITION SUBSYSTEM						
.						
30. AIRBORNE MONITOR AND RECORDING SUBSYSTEM						

Figure 3: SAMPLE TASK IDENTIFICATION MATRIX

The headings across the top of the matrix are the normal maintenance functions or tasks performed at organizational/field level of maintenance. The headings down the side of the matrix (row headings) consist of the names and designation codes of all of the units on which maintenance is performed at the organizational level. The intersection of each row and column defines a theoretically possible task, so that the entire matrix defines the theoretical maximum population of tasks to be analyzed at the organizational level of maintenance. The cell entries indicate the actual tasks performed on each hardware item.

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 JPA. It is, therefore, critical that the list of hardware items be prepared with great care.

In the second step, a list of actual organizational-level tasks (not just theoretical possibilities) is extracted from the TIM, in accordance with certain criteria, to form the Task Inventory, see Figure 4. The Task Inventory is the list of tasks for which JPA must be prepared.

The third step in the process consists of collecting many different kinds of information about each task in the Task Inventory. The kinds of information required are either recorded on, or referenced in, the Task Description Index and Management Matrix (TDIMM), see Figure 5. This matrix is a central repository of all existing or generated data.

An example of existing data is the maintenance analysis which is a major source of information. An example of generated data is the list of theoretical maintenance tasks. The key here is to make maximum use of existing data and not duplicate data for the reason of format alone.

This document, along with all the documents referenced in it, provides the data base upon which all JPA elements are built. If computer capability is available, it can be used to store this data as well as providing an indexing and retrieval system.

The three steps described above must generally be done in serial order, although it is obvious that some overlap is possible. For example, task description data can be collected about tasks that have been identified before all tasks have been identified. The steps in preparation of the various types of support data can then proceed in parallel, assuming that the data base is there to support their development.

Development of Fully Proceduralized Troubleshooting Aids requires considerable technical expertise in applying troubleshooting strategy and in knowledge about the particular equipment system involved. Equipment functions must be identified, function failures described, equipment failure modes determined, and Action Trees prepared in accordance with a specified troubleshooting strategy. The Action Trees are then put into the specified format, supplemented by locator illustrations, to make up the Fully Proceduralized Troubleshooting Aids.

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TASK NAME	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	STAGE	PART	MAINTENANCE FUNCTION	TASK STATEMENT

Figure 4: SAMPLE TASK INVENTORY FORM

TASK ANALYST _____ PAGE NO. _____						
TASK DESCRIPTION CONTENT CATEGORIES TASK INVENTORY TASK STATEMENTS & CODES	A	EQUIPMENT DESCRIPTION & OPERATION	B	EQUIPMENT DRAWINGS	C	EQUIPMENT CONFIGURATION APPLICABILITY
						• • • • • • •
						M
						NOTES

Figure 5 : SAMPLE OF TASK DESCRIPTION INDEX AND MANAGEMENT MATRIX

A simple description of each item block in the JPA process, Figure 1, follows. The actual development process is considerably more detailed and complex.

1. List of Functions. A List of Functions shall be prepared for each functional unit. The equipment level at which functions shall be described is between the replaceable-unit level and the subsystem level. The Task Inventory section lists all of the functional units of interest. Indented under the functional unit are hardware items and associated tasks. Each hardware item which has an associated "remove" task is a Line Replaceable Item (LRI) and must be considered in the preparation of the Fully Proceduralized Troubleshooting Aids. A function is an action, operation, change of energy level, or change of energy form performed by the hardware item. For example, the function of a Hydraulic Pump is to increase fluid pressure in a closed system. The function of a Radio Antenna is to receive electromagnetic lines of force. The function of an electronic hardware item might be to amplify, process, or convert power supply voltages or currents.
2. List of Function Failures. For each function identified for a functional unit, a list shall be prepared of the ways the function can fail. On the basis of existing descriptions of functions and their major physical properties, list all of the ways that each function could theoretically fail. For example, functions are typically (a) under-performed, (b) over-performed, (c) partially performed, or (d) poorly performed, as judged against some qualitative criterion.

For each possible function failure listed, check existing technical data for additional information about the LRIs involved in the function to determine which of the theoretical function failures can actually occur. For example, the function "computes desired track" has the possible function failures of "does not compute desired track" or "computes only left of desired track correctly."

3. List of Malfunction Symptoms. A malfunction symptom is defined as the total set of indications of a function failure.

The list of malfunction symptoms is produced in two steps. The first step is to group together the function failures which have identical malfunction symptoms. The second step is to list each remaining malfunction symptom and its associated function failures. This list shall include all operations that could be performed to determine whether or not a function is being performed within nominal tolerances, and all indications that the function has failed (including odor, tactile, and sound cues).

4. List of Components and Failure Modes. A tentative list of all ways in which all end items in the Task Inventory can fail shall be prepared. Requirements for preparing this list are as follows:
 - a. Component. This column shall contain the end items associated with "Troubleshoot" tasks in the Task Inventory.
 - b. Part Number. Part numbers are the unique identification numbers assigned to components by the manufacturer of the component.

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- c. **Stock Number.** The Federal Stock Number (FSN).
- d. **Types of Failure Modes.** This column shall contain a listing of the ways each component can fail. For example, each winding in an electric motor could be open or short, or could contain an insulation breakdown.
5. **Component Block Diagram.** A component block diagram shall be prepared for each malfunction symptom. This block diagram shows all equipment end items that can be repaired or replaced at the organizational level of maintenance, and that could, by their failure, produce the malfunction symptom. Each such end item shall be represented by a box labeled with its designator or name. In addition to the active components, all interconnecting hardware items (e.g., wires, plugs, jacks, mechanical linkages, pipes, hoses, or ducts) shall each be represented by a box. The logic of configuration, arrangement, and connection shall be shown with lines between the boxes. The lines shall have arrowheads that show direction of flow (transmission) of data, mechanical force, electrical power or current, gas, liquid, and solid matter. However, the lines shall not represent hardware items that interconnect the more active components, since interconnecting components will all be represented by boxes.
6. **Action Trees.** An Action Tree is a diagram that represents the sequence of steps to take in identifying a malfunctioning component. It is in effect a summary of all the data development preceding it in the JPA process, Figure 6.

An Action Tree is prepared for each malfunction symptom within a subsystem. The action is represented by boxes which indicate forms of troubleshooting activities. There are four types of boxes used in Action Trees: the Summary Box, the Repair or Replace Box, the Test/Decision Box, and the Procedural Box, see Figure 6.

The Summary Box is the origin of the Action Tree and contains a list of the equipment control settings and operational acts that are prerequisites to observation of the malfunction symptom. The Summary Box also contains a statement of the malfunction symptom.

Test/Decision Boxes are found at branching locations within the Action Tree. The purpose of the Test/Decision Box is to specify a diagnostic test that will subdivide a chain of suspected LRIs in such a way as to expand the set of components known to be "good." These tests are used to subdivide until, ultimately, a repair or replace action is required.

The Procedural Box contains a linear sequence of steps that describe ways to modify equipment conditions by changing switch settings, or by other operational acts. Access tasks or difficult to remove and replace activities may be aided by a Procedural Box. Procedural Boxes are found preceding Test/Decision Boxes when the equipment must be preconditioned to permit the tests.

The Repair or Replace Box is found at the end of Action Tree branches. It states the repair or replace action necessary to restore the hardware to proper operation.

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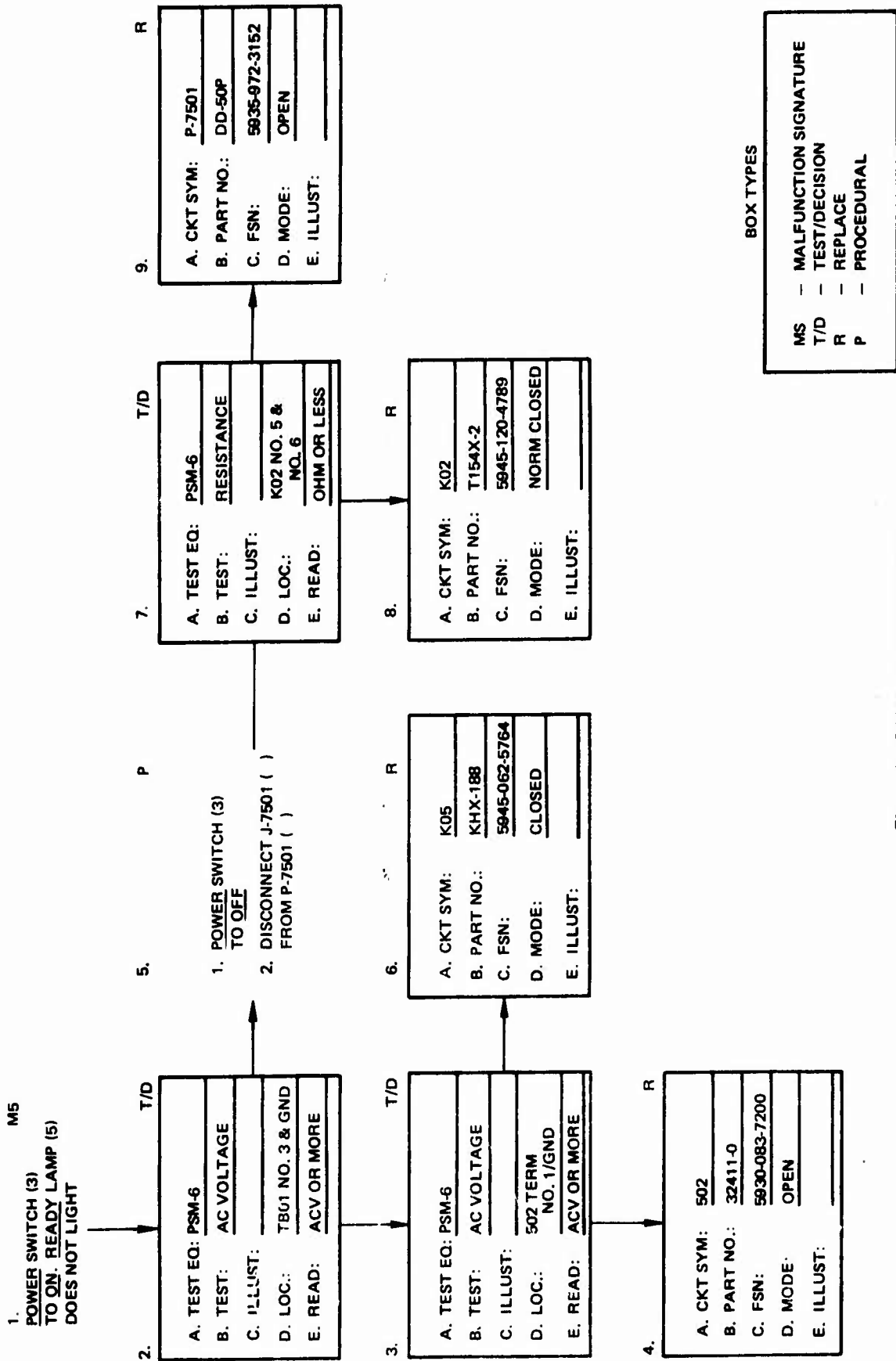


Figure 6: SAMPLE ACTION TREE

7. Checkout Procedure. A checkout procedure is prepared to link together all the Action Trees for a subsystem. The purposes of the checkout procedure are: a) to systematically manipulate the functional unit and perform measurements that allow observation of any malfunction symptom present; b) to reference the appropriate Action Tree for troubleshooting; and c) to determine that the system is completely operational after a fault has been identified and corrected.
8. Review. The completed Action Trees and checkout procedure are compared with the list of components and failure modes. If any of the possible component failure modes are not found in the Action Trees, then the Action Trees are not complete and must be appropriately modified to include all component failure modes.
9. Establish Tolerances. The measurement reading and tolerance process provides two types of information needed to complete the Action Trees. First, it determines the actual required readings to be entered in the Test/Decision Boxes. Second, it validates Action Trees by verifying that every component failure mode produces the predicted malfunction symptom. By definition, tolerance is an allowance for variation. The values allowed to vary are the individual LRI or functional unit operating parameters. The tolerances to be determined are actual LRI or functional unit operating tolerances, rather than blanket tolerances or tolerances assigned to all components of a given type.
10. Prepare Draft Art. The completed Action Trees and checkout procedure are studied to determine illustration requirements. Draft illustrations are prepared and correlated with Action Tree boxes to which they apply.
11. Formatting the Fully Proceduralized Troubleshooting Aids. The last item in the JPA process is to convert Action Trees and checkout procedures and illustrations into fully proceduralized troubleshooting aids manuals and an index manual.

As can be seen from this brief summary, development of fully proceduralized JPAs places relatively greater emphasis on technical know-how and relatively less emphasis on writing than does development of conventional technical orders. The fully proceduralized JPAs are much more specific and detailed in telling the maintenance technician not only what to do, but how to do it.

After draft copies of the JPAs have been completed, three activities remain in the process: Verification, Changes, and Production and Delivery.

Verification is the process by which technical data are tested and proved to be adequate for operation and maintenance of the subject hardware. The terms, conditions, and schedule will be developed as deemed necessary by the procuring agency.

JPAs must be updated or changed as changes occur in the hardware just as in the production of regular T.O.'s. However, JPAs differ from conventional technical data in that most JPA updating requirements are derived from changes to tasks. Hardware changes that have no task-related implications will, in many cases,

require no modifications to JPAs. Every system change must, however, be examined for possible impact. During the development process, tasks or other data packages affected by changes must be pulled from production and changed or recycled through all or part of the process, depending on the nature of the change. After the JPAs are in use in the field, each potentially affected task or activity must be examined for impact by the change. Revisions must, in order to assure that they meet the quality standards of the original material, be recycled through appropriate parts of the original development process.

The data collection forms and techniques described allow retrieval of all task and hardware-related information required for JPA updating, whether manual or electronic data processing (EDP) indexing is used.

The production and delivery activity includes conversion of verified, final draft JPA into camera-ready copy.

After the JPAs are in final form they are ready for the microfilming process, see Figure 7. The individual makeup boards are assembled in chronological page order and indexing marks applied. A final quality control check is made to determine proper assembly or indexing marks, and darkness of lines. The boards are then photographed. Brownline copies are prepared for microfilming. The resultant film strip is subjected to a photographic quality control check to determine such things as resolution, background density, position and spacing, and reproducibility. A visual inspection is made for such defects as:

Technical Manual number or title is not clear or distinct.

Characters or symbols are filled in, or too light to the extent they are illegible.

Lines are discontinuous or light to the extent they are illegible. Data are obscure, illegible, omitted or out of focus.

Extraneous information or marks in the document mark channel.

Blisters, tears or processing stains are on microfilm.

Scratches are on microfilm, touching or through the document area. Foreign material is in image page area, obliterating, or defacing page image.

Scratches, streaks, bubbles, lap marks, lumps or foreign material are over image area, obliterating, obscuring or defacing page image.

Page missing or out of sequence or is not positioned in the frame.

At this point the customer makes his acceptance check and provides cassette labels. From the master microfilm roll additional copies are made. An example of a single frame of the microfilmed troubleshooting procedure is shown in Figure 8. The cassettes are then loaded, titled, and address labels applied. The master microfilm is sent to the prime AMA and a certain number of copies sent directly to the using activity/base.

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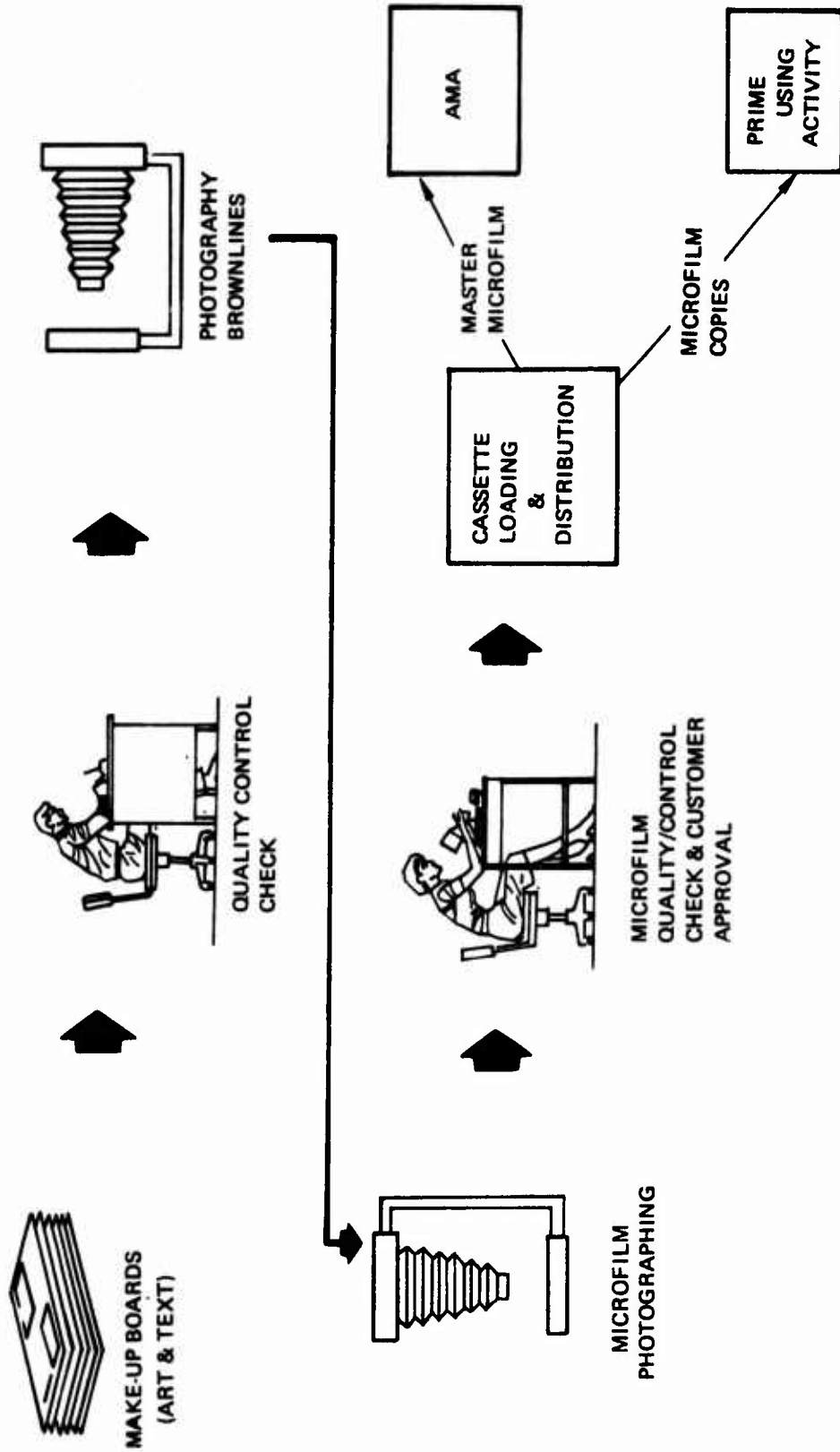


Figure 7: CONTRACTOR MICROFILM PROCESS

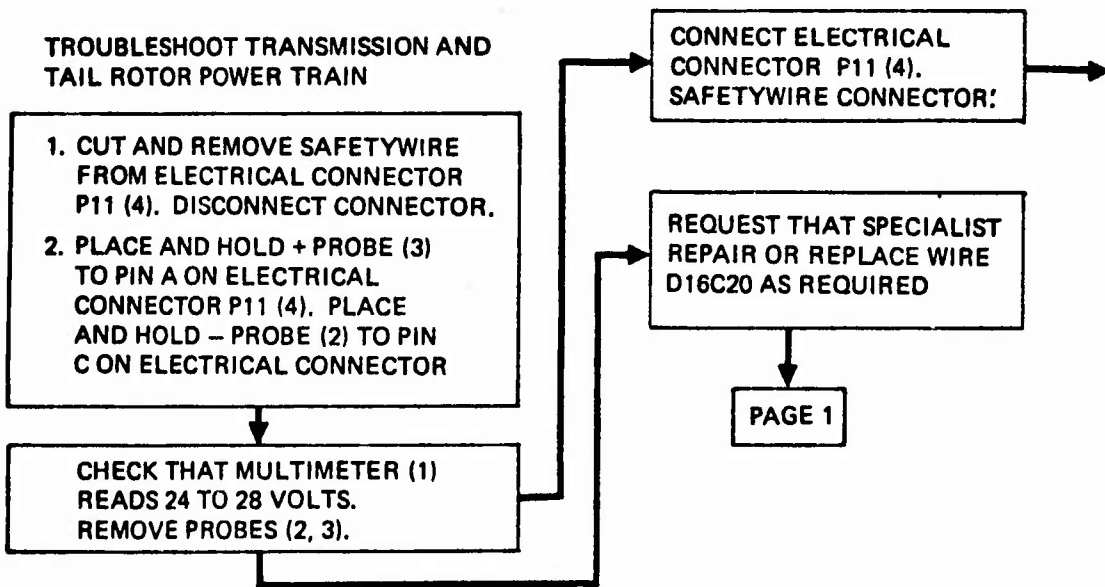
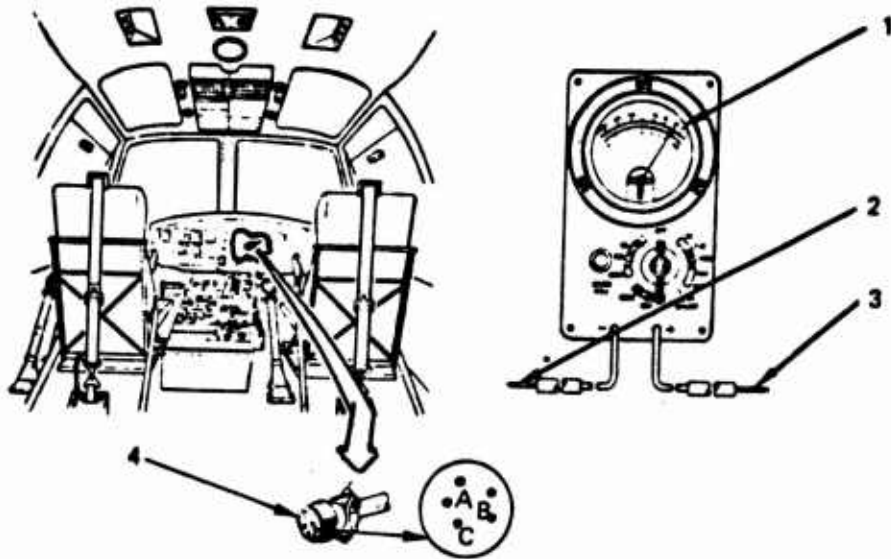


Figure 8: EXAMPLE OF MICROFILM TROUBLESHOOTING FRAME

This process is the same for original issues or changes because changes or updating require the reissue of the total microfilmed manual.

It is at this point that some of the major impact of this system begins to be observed. In the ordinary course of hardcopy manual distribution, the time span from contractor to user is as much as nine months. By this system of microfilm distribution, the data can be in the user's possession in approximately ten days.

Once the cassettes arrive at the base technical order distribution office, they are processed quickly through normal distribution channels to the squadron data vans, see Figure 9. It is during this administrative processing that additional savings in personnel and time can be realized. For example, instead of filing individual change pages in each copy of each affected T.O., the entire manual is replaced; thus, eliminating filing, recording, inventory control of individual changes, etc. By sending back the obsolete cassette, configuration control is easily maintained.

The final segment of this system is the use of a data van on the flight line. This van is an ordinary commercial vehicle outfitted with a microfilm reader/printer, power supply, cassette storage, radio communications system and provisions for mechanic hand tools, special tools and test equipment, see Figure 10.

After the data van was outfitted and placed in service, it would operate in the following manner.

An unscheduled maintenance event would take place. Maintenance control would be notified and they would schedule a technician team and the data van to restore the weapon system. Upon arrival at the flight line, the technician would locate the appropriate system T.O. cassette and install it in the reader/printer. He would locate the appropriate checkout procedure and make copies as required. By following the detailed step-by-step fault isolation procedure he would locate the faulty hardware or equipment. By use of the van radio he would order replacement components from base supply. After returning the weapon system to serviceable condition he would destroy the print copy of the procedure.

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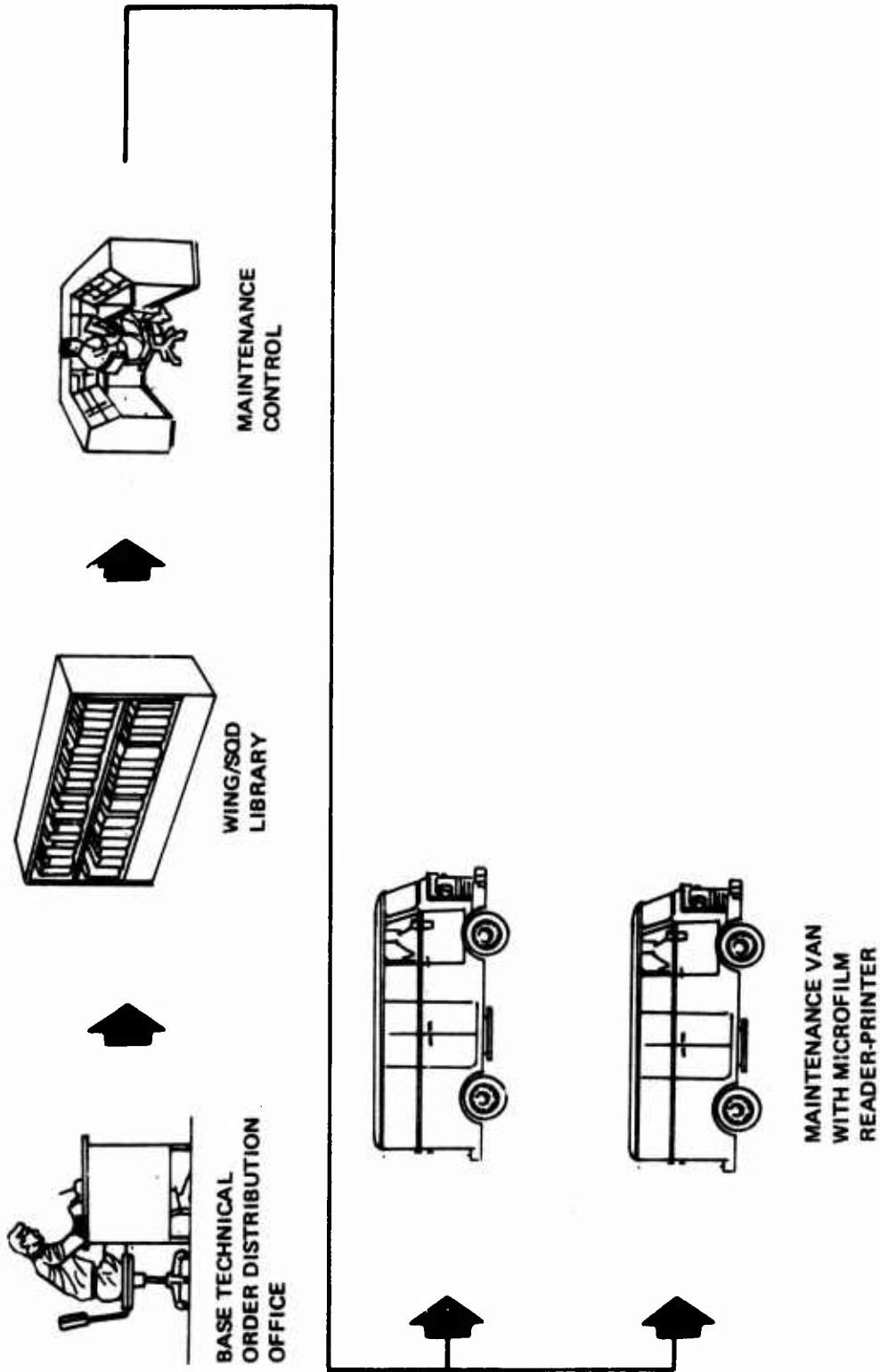


Figure 9 : MICROFILM DISTRIBUTION ON BASE

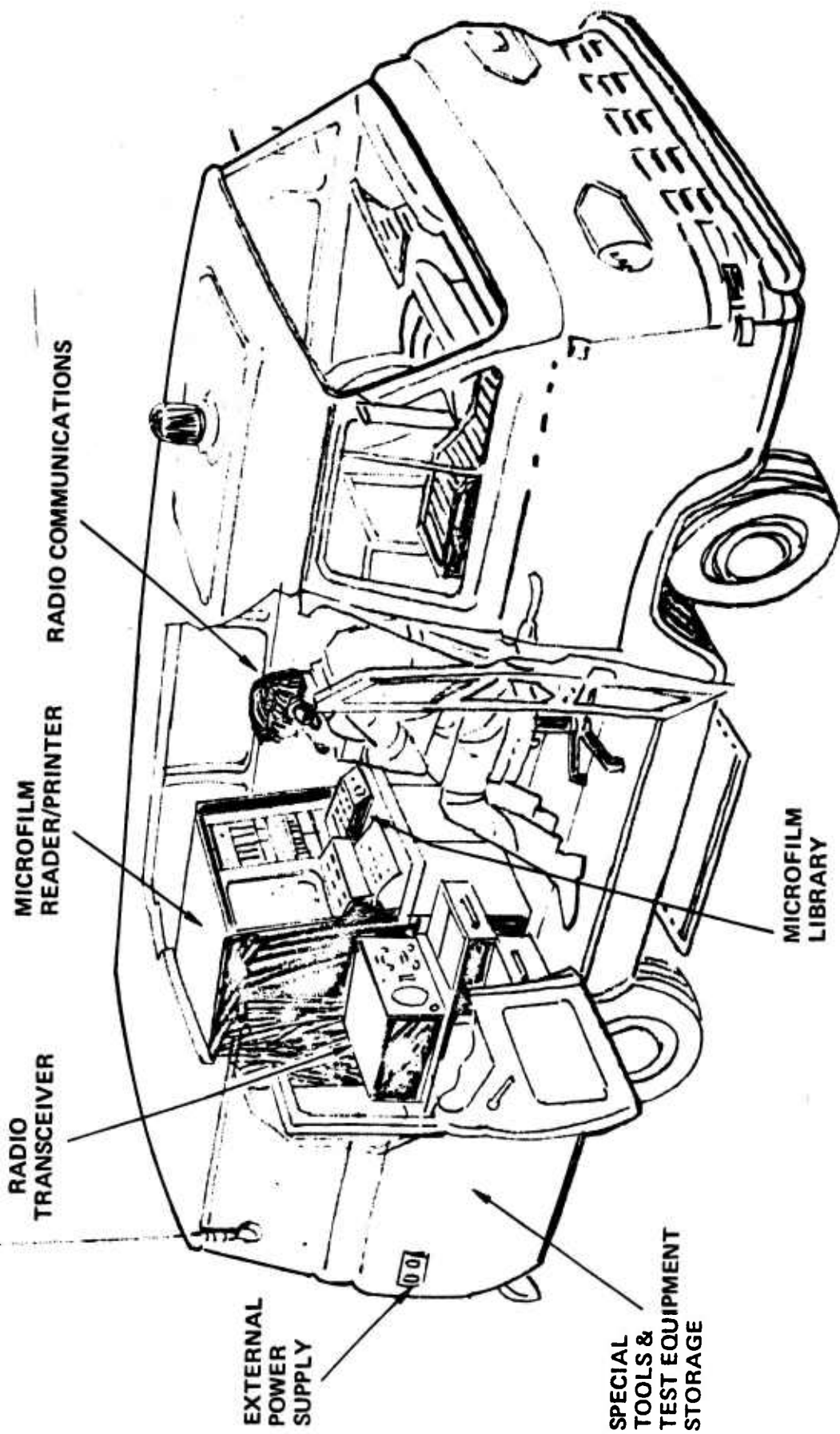


Figure 10: MOBILE DATA VAN FOR FLIGHT LINE

SYSTEM ADVANTAGES

The benefits and impact of this type of system spread over the total logistics spectrum. They affect training, spares, maintenance, all logistics costs as well as the direct impact on procurement, development, and use of technical data. All areas of logistics benefit in a very positive way, except technical data which does have a higher procurement price tag than conventional technical orders.

The orientation of technical data in this system from information orientation to task orientation has a large affect on training requirements. Under the information, theory of operation, approach, training required lengthy classroom sessions. Depending on the particular course this time period varies from nine to 12 months. Under the task orientation of technical data the same courses would require only one to three months. The training cost savings are discussed in the Cost Consideration section. Naturally, the mechanic/technician is not as knowledgeable as a graduate of the conventional training course, but entry jobs do not require the level of knowledge currently provided.

Spares requirements would be decreased because the premise of this system is 95% correct diagnostic capability. This means that fewer good items of hardware are removed and sent to the depot just to be checked out and put back in the system. If only faulty items are removed, less total quantities of items would be required. This would reduce the MMH/FH time; it would reduce transportation, packaging and storage costs. It would also reduce the field/depot technician personnel requirements.

The maintenance area is where this system would have its greatest impact. It is in this area where microfilmed fully proceduralized job performance aids have several advantages over conventional technical orders. The use of the JPAs improves maintenance effectiveness by:

1. Increasing the reliability of the performance of complex maintenance tasks. The reliability of performance on complex maintenance tasks is improved because of the method of construction of JPAs and the manner of use. The JPAs are task oriented which means that the engineering writer has determined the optimum approach to do a particular task and then precisely stated the step-by-step procedure required to perform the task. This method precludes the mechanic from devising his own procedure on a random basis.
2. Reducing total maintenance task time. Because the step-by-step procedures are determined during analysis the best maintenance task time lines are incorporated into the system. The use of these optimum procedures reduces total maintenance time.
3. Decreasing dependency upon personnel of extremely high aptitude. Use of these procedures permits the realignment of task assignments because lower skilled personnel can perform 95% of the maintenance tasks as efficiently as higher skilled personnel. Not as many high skilled people would be needed to perform the remaining 5% of the maintenance tasks that require judgment, interpretation, and diagnostic skill.

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4. Reducing manpower requirements. If reliability of performance is increased and maintenance time is reduced, less total manpower is required to do the same job.
5. Facilitating the transfer of maintenance personnel from one system to a different system. Rather than learning the details of a particular hardware system and theory of operation, informal training courses, the candidate technician learns how to use the data system which is applicable to any hardware system so he can move from system to system without much of a problem. He learns the theory of operation through on-the-job training or supplemental courses as he performs his tasks.

The result of the increased maintenance effectiveness is a decreased MMH/OH, an increase in weapon system availability, and ultimately a reduced weapon system cost.

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COST CONSIDERATIONS

The cost of developing JPAs is considerably higher than the cost of conventional manuals. This is because of the degree and depth of task analysis that is required to define and design all of the possible maintenance tasks before the JPAs can be written. Studies have indicated that JPAs may add as much as 35% to 40% to the cost of a conventional publications program. This additional cost is more than offset by the substantial reductions in other logistics functions.

Many studies have indicated that a mechanic spends approximately 30% of his time searching for data. A Homestead AFB microfilm T.O. study indicated that this search time could be reduced by as much as 50% just by using microfilm rather than hardcopy manuals. Using a labor rate of \$4.16 per hour for flight line workers (AFM 177-101) the savings could amount to approximately \$1200.00 per technician per year.

By the use of JPAs on microfilm the mechanic/technician efficiency would be increased, and the effect on training would be two-fold:

1. If the mechanic/technician efficiency is increased it means that more maintenance tasks can be accomplished in a given period of time. This would result in reducing the unit manning level and therefore require less total manpower requirements and less replacement training.
2. The JPA concept is based on the maintenance fault isolation diagnostic decision to be made but once. That would be by the engineering writer analyst. The requirement to teach every mechanic/technician the theory of operation so that he may make diagnostic decisions every time he troubleshoots is not required. It is therefore conceivable that training requirements could be reduced. As an example, electronic technicians training at present is approximately 55 weeks. Using the fully proceduralized JPAs training requirements would be reduced to 12 to 15 weeks and still qualify as a candidate for an electronics entry level job. At the rate of \$4.16 per hour from AFM 177-101 this would amount to \$6656.00 savings per electronic student technician.

Administrative personnel costs associated with the distribution, storage, and T.O. maintenance of technical manuals can be reduced by 66% or roughly two of every three T.O. administrative personnel would not be needed.

Other life cycle cost savings may be more difficult to assess but, nevertheless, just as real as the savings quoted above.

The Homestead study also described the impression the team members had of more personnel always on the flight line, even though the mechanic/technician cadre had been cut by 40% while the airplane crews and aircraft availability remained at 100%. This indicates that by use of microfilm, a data van and streamlined standard operating procedures, mechanic/technician efficiencies were improved enough to offset the effects of personnel reductions.

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Replacement hardware costs or spares are affected in two ways:

1. Air Force statistics for electronic gear show that at least 50% of hardware items returned to the depot for repair are not faulty and should not have been removed. The premise of the described system for 95% correct diagnostic capability would reduce the depot repair workload for a weapon system by better than 45%.
2. By not having good hardware units in the supply pipeline the requirement for spares replenishment would be lowered.

The integrated logistics system life cycle yearly cost of a typical present day weapon system is described in Figure 11. Superimposed on these curves is an extrapolation of the possible delta costs of the system described in this document. If it had been used rather than the conventional data system the total logistics cost savings for a single weapon system could be as much as 20 million dollars. Not included in the cost curves is the cost of hardware such as reader/printers and data vans, as that cost would vary with the type of organization supported.

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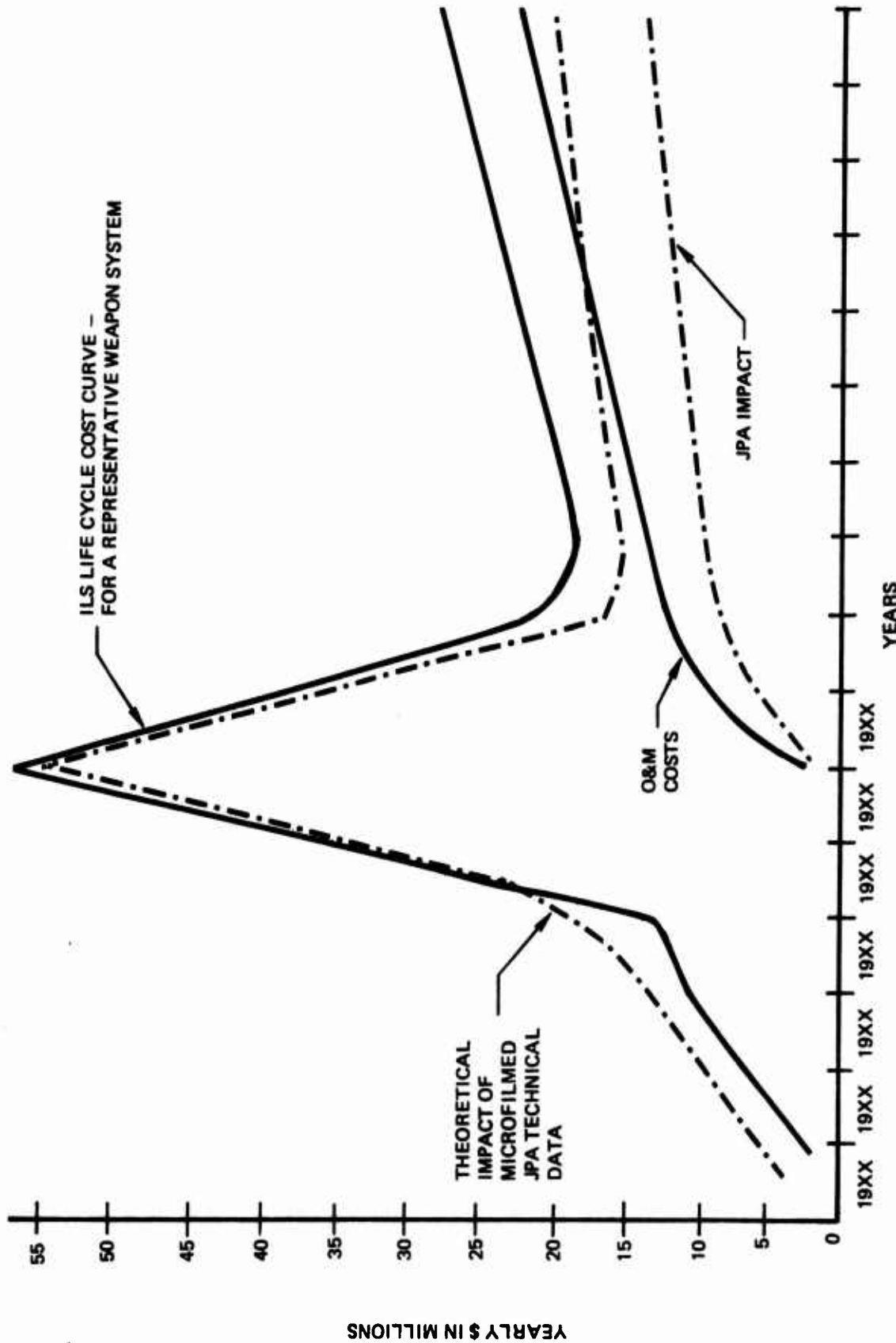


Figure 11: ILS LIFE CYCLE COST COMPARISON - CONVENTIONAL INTEGRATED LOGISTICS VS MICROFILMED JPA IMPACT

RECOMMENDATION

The selection of the data system described in this document was based on the studies, investigations of existing data, field trips and the applicability/feasibility of new concepts applied against the realities of current conditions. At the present time this system is only a theoretical possibility. Much work needs to be done to develop a viable system. A capability must be developed to conduct the analysis to a depth required to assure a 95% correct fault diagnosis function. The system must be tested to prove the premises of improved maintenance efficiency. The supporting hardware must be improved to provide maximum utility. The system must be developed to the point where the services' interest is sufficient to provide the necessary vehicle (a large scale program) to fully implement the improved data system.

The steps necessary to achieve the confidence that the system will perform as proposed is displayed in the schedule, Figure 12.

It is recommended that SRAM technical data be selected as the system on which to conduct the tests of this data because it is a mature electronic system. The data is conventional and has been used at a considerable number of bases. It has a fault simulator already developed that can be used as an impartial control device in testing the concepts of microfilmed performance aids versus conventional manuals. By use of the simulator the effect of the human element on the validity of the test can be minimized.

The conversion of the SRAM troubleshooting procedures to JPA format can be accomplished by use of SRAM publications personnel who are familiar with the SRAM hardware and need only to learn JPA task analysis procedures.

One drawback, in using the SRAM as a test bed, is the use of the van would not be appropriate in missile checkout where the simulator could be used most effectively. Although, the reader/printer could be used in the shop in the same manner as it would in the data van.

The detail tasks to be accomplished by using the SRAM missile program as the test bed is shown as a block diagram, Figure 13. The block tasks are briefly described as follows:

1. Selected writers would develop a capability to analyze tasks to the degree necessary to assure at least 95% of all possible maintenance actions are identified and considered.
2. Coordinate with the Air Force Human Resources Laboratory to obtain approval to conduct tests on SRAM equipment and with SRAM personnel.
3. Review and select those maintenance procedures that would provide the widest range of maintenance actions that would test the JPA concept.
4. Convert the selected SRAM maintenance procedures to JPA format.

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- 5.-8. Develop a test plan and coordinate with the Air Force for site location, test schedule, identify personnel, identify equipment to be provided by the Air Force and by Boeing, procedures to be followed during test, provide method for recording results.
9. When JPA procedures are developed, they are converted to microfilm.
10. Conduct preliminary tests to assure that the test plan can be conducted (dry run in-house).
- 11.-12. Conduct the demonstration and document test results.
13. Prepare final report detailing the study and the results of the demonstration with recommendations for follow-on activities. As part of the final report an analysis will be conducted to determine the proper allocation of data equipment to various types of weapon systems; for example, a B-52 squadron would require considerably more equipment than a SRAM missile squadron.

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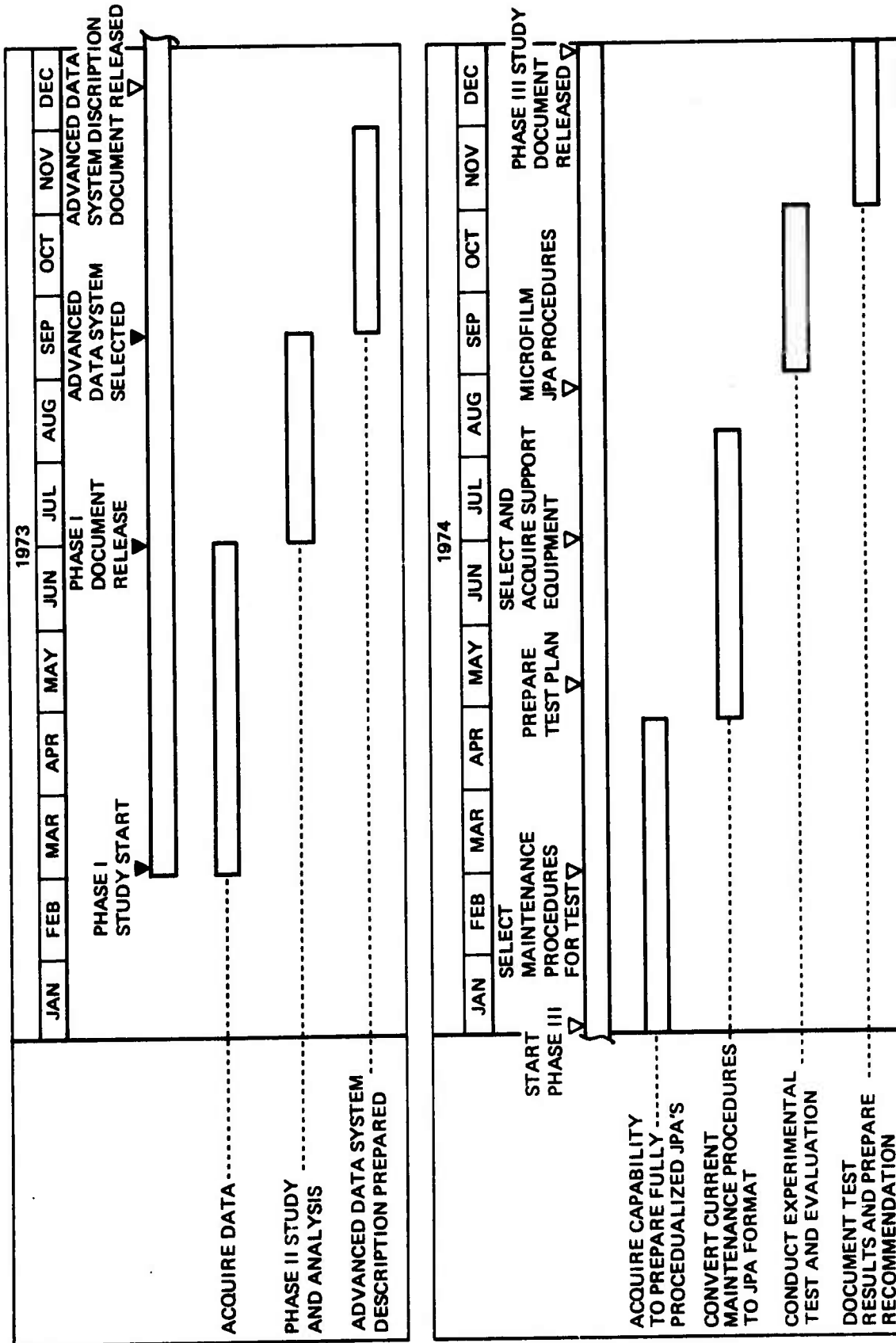


Figure 12: ADVANCED TECHNICAL DATA SYSTEM STUDY SCHEDULE

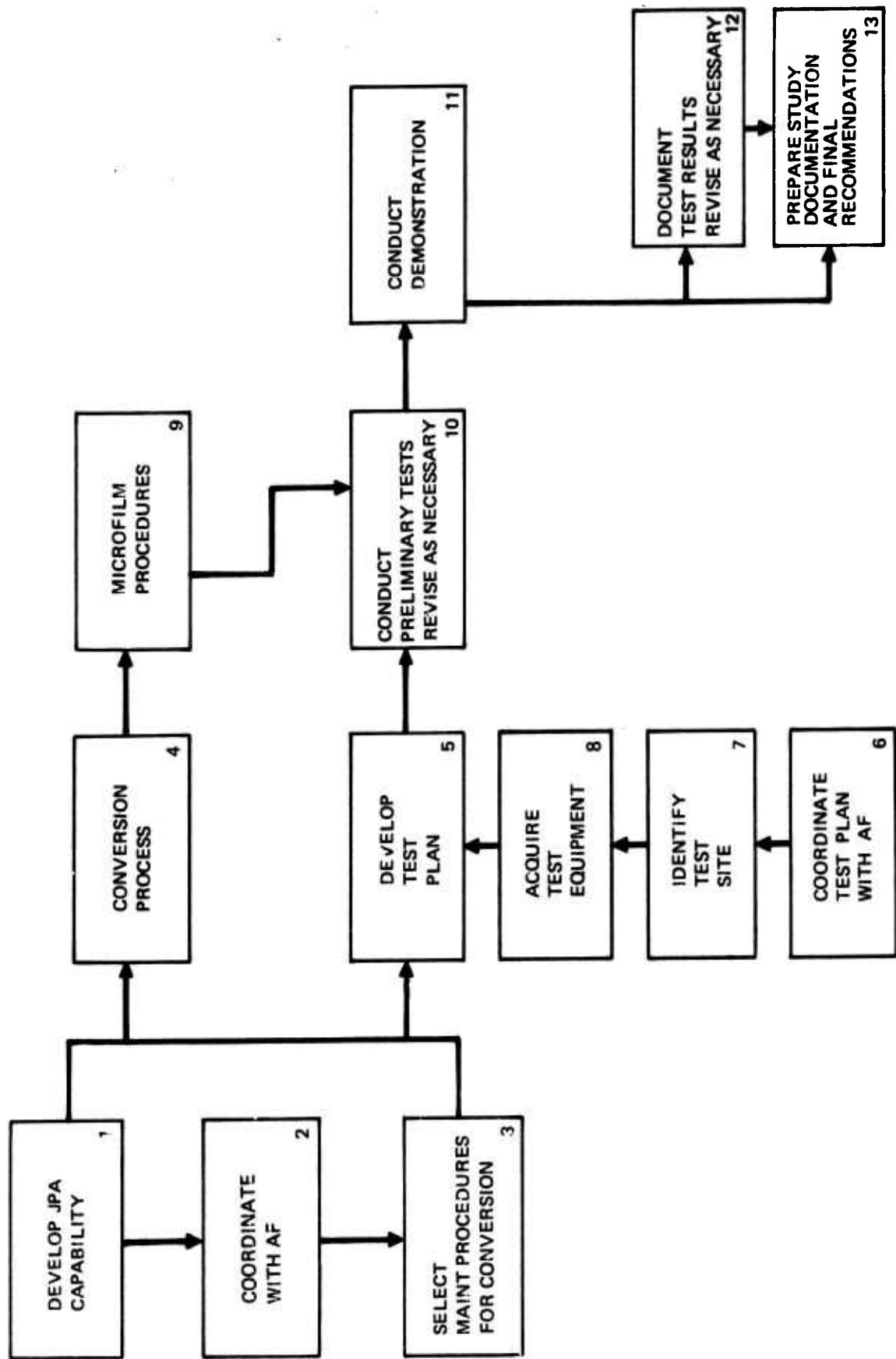


Figure 13: BLOCK FLOW DIAGRAM FOR 1974 FOLLOW-ON STUDY TASKS