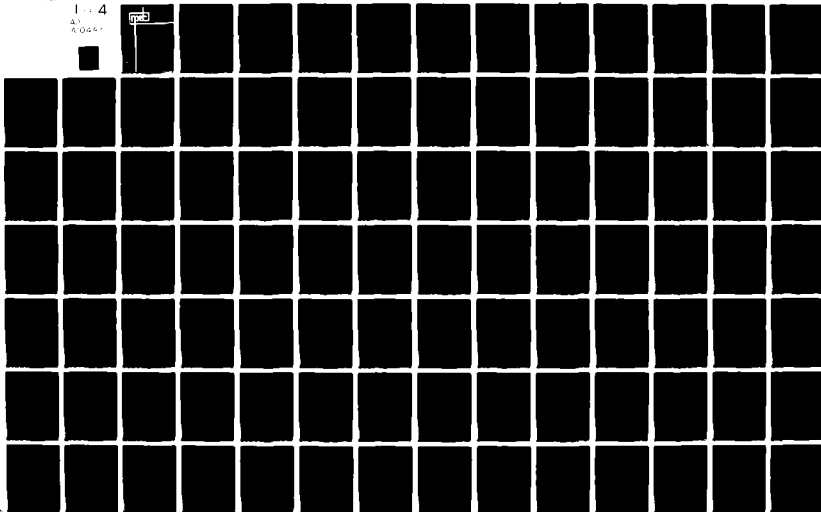


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AN ENGINEERS GUIDE TO THE USE OF
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June 1979

AN ENGINEER'S GUIDE TO THE USE OF HUMAN
RESOURCES IN ELECTRONIC SYSTEMS DESIGN

Human Factors Research, Incorporated
Goleta, California 93017

WORKING DRAFT

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Reviewed by
E. A. Koehler

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FOREWORD

This development effort has been conducted in support of Navy Decision Coordinating Paper, Manpower Requirements Development System (NDCP-20109-PN) subproject 20109-PN.03, Manpower Cost in Systems Design, and under the sponsorship of the Deputy Chief of Naval Operations (OP-01). The objective of the subproject is to apply human engineering technology in incorporating hardware/software/personnel tradeoffs and cost benefit alternatives in all stages of system design.

The objective of this study was to develop a human resources information guide for use by hardware program managers and system designers. This guide will provide manpower and personnel information needed by hardware designers and program managers to assess the impact of candidate system design alternatives on the use and cost of the Navy's human resources. It will also contain analytical tools for making manpower tradeoff assessments during engineering trade studies.

The Contract Monitor for NAVPERSRANDCEN was Mr. Ernest A. Koehler. Major contributions were provided by Dr. David Meister.

THIS REPORT PROVIDES A WORKING DRAFT OF THIS GUIDE FOR EARLY USER EVALUATION. THE FINAL GUIDE WILL BE PUBLISHED LATER THIS FISCAL YEAR.

DONALD F. PARKER
Commanding Officer

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CHAPTER I

INTRODUCTION

INTENDED USE

This guide is intended for use by program managers and system designers early in the conceptual design phase of a new weapon system development. It addresses the impact of various system design alternatives on the use and cost of human resources. It provides manpower and personnel information needed by designers and program managers in making design tradeoff decisions. It also provides analytical tools for conducting manpower tradeoff studies.

DATA PROVIDED

The guide provides data on human resources needed to operate and maintain shipboard radar, sonar, communications, fire control, and data processing systems. For the first time it brings together information on:

1. Most of the specific tasks performed by the technical personnel who operate and maintain these systems:
 - .Data Systems Technicians (DS).
 - .Electronic Technicians (ET).
 - .Fire Control Technicians (FTM).
 - .Radiomen (RM).
 - .Sonar Technicians (STG).
2. The level of proficiency exhibited in performing each task by personnel of different experience levels (pay grades).
3. The projected availability of these technical personnel, by pay grade, over the next 5-year period, including evidence of critical shortfalls.
4. Billet cost data for personnel of different experience levels, for system life cycles up to 20 years.
5. A listing of NECs (specialist codes) established for each technical rating.

6. A list of manpower and training support-related system design concepts and their estimated relative impacts on such criteria as:

- .Numbers of operator and maintainer personnel required.
- .Skill levels of personnel required.
- .Amounts of training required.
- .Costs of tools, test equipment, maintenance facilities, and supply.
- .Initial system acquisition costs.
- .System reliability and maintainability.
- .System operability and operational effectiveness.

THE PROBLEM

The guide addresses the very serious problems of manpower supply, costs, and training requirements, all as related to early system design decisions. The Navy is confronted with serious deficiencies in the timely supply of adequate numbers of skilled manpower for operating and maintaining new and modified weapon systems. Manpower and training support costs are enormous. The identification of manpower and training support requirements typically occurs too late in the weapon system acquisition process (WSAP). The Fleet's estimates of required manpower for new systems often exceed those made by system designers and manpower specialists.

RESPONSIBILITY

Responsibility for consideration of human resources as an element of design clearly rests with system designers and program managers. Historically, the Navy's manpower supply system, which is responsible for manning Navy systems with properly trained and sufficiently skilled personnel, has operated in a reactive mode; that is, by responding as best it could to requirements dictated by system design. Today, this is neither working nor is it affordable. Rather, the situation demands that manpower and training support requirements be considered as design tradeoff variables. This places the responsibility for

early consideration of manpower and training support squarely in the hands of system designers, program managers, and the development agencies. Current Navy policy clearly reflects this fact. Manpower, personnel, and training requirements analyses are required early in the WSAP. Prior to DSARC I, there is to be a manpower and training support concept, an analysis of man-machine functions, preliminary manning estimates, and tradeoff studies (NAVSEAINST 5311.1, 14 June 1977). See Figure 1.

NUMBERS AND SKILL LEVELS

Early design tradeoffs must address not only numbers of required personnel but the skill levels likely to be available. The primary factors driving all manpower costs are the number and complexity of operator and maintainer tasks to be performed, and the frequency with which they must be performed. These factors determine:

1. The number of maintenance and operator personnel required.
2. The required aptitude levels of these personnel.
3. The experience levels required to perform satisfactorily.
4. The amount of general and specialized training required.

AN INFORMATION GAP

Designers and program managers need information they do not presently have. System designers need, but have little, specific information concerning the skill levels and availability of the personnel who will be called upon to operate and maintain new systems. Although often cited as a source of skill level information, currently used documents (Navy Enlisted Manpower and Personnel Classification and Occupational Standards, NAVPERS 18068D, Sections I and II) are too general to serve as guides to system design decisions involving manpower and training support tradeoffs. A stronger link is needed between system design concepts and their manpower, skill level, and training consequences. The largest unknown in all manpower prediction models and Ship's Manning Document predictions is what "skill level" really means in terms of system operation and maintenance.

MAJOR RDT&E PROGRAM PHASES	CONCEPTUAL PHASE	VALIDATION PHASE	FULL SCALE (ENGINEERING) DEVELOPMENT	PRODUCTION/DEPLOYMENT
PRIMARY DECISION POINTS	DSARC I	DSARC II	DSARC III	
MANPOWER, PERSONNEL, AND TRAINING REQUIREMENTS	- M, P&TS Concept - Analyses of Man/Machine Functions - M, P&TS Input to Project Master Plan - Preliminary Manning Estimates for equipment/systems - Trade-Off Studies for equipment/systems	- Draft Navy Training Plan (NTP) - M, P&TS Input to Integrated Logistic Support (ILS) Plan - M, P&TS Input to Requests for Proposal (RFP) - Trade-Off Studies for equipment/systems	- Preliminary Ship Manpower Document (SMD) or Information (SMI) - Navy Training Plan Conference - Update NTP - Draft Crew Phasing & Scheduling Plan - New NEC Requirements - Update M, P&TS Section to ILS Plan - POM Manpower Input for IOT&E, TECH-EVAL/OPEVAL, & to Support Fleet Deliveries - Develop MP&TS Contractor Evaluation Criteria - Monitor & Identify M, P&TS Problem Areas	- Update and Refine SMD/SMI - Update and Refine NTP - Refine M, P&TS Section to ILS Plan - M, P&TS Evaluation Criteria for IOT&E - Monitor & Evaluate Contractor M, P&TS - Finalize Crew Phasing & Scheduling Plan
	Monitor & Identify M, P&TS Problem Areas	Monitor & Identify M, P&TS Problem Areas		Monitor & Identify M, P&TS Problem Areas

* Typical products/actions. Specific outputs and time phasing may vary as mutually agreed.

Figure 1. Types of MP&Ts at each stage of acquisition process* (NAVSEAINST 5311.1, 14 Jun 77).

CHAPTER II
DESIGNING IN RELATION
TO HUMAN RESOURCES

CENTRAL ROLE OF TASKS

The primary factors driving all manpower costs are the number and complexity of operator and maintainer tasks to be performed, and the frequency with which they must be performed.

These factors determine:

- The number of maintenance and operator personnel required
- The required aptitude levels of these personnel
- The experience levels required to perform satisfactorily
- The amount of general and specialized training required

The objectives of the designer should generally be to minimize manpower lifecycle costs by minimizing these four items. Consequently, the basic orientation of this guide is toward assessing the impact that various conceptual designs have on the tasks that must be performed by operator and maintenance personnel.

TASK DIFFICULTY

From one-half to two-thirds of the technical personnel assigned to operate and maintain surface ship radar, sonar, communications, fire-control, and data systems will be in their first enlistment. Most will

be 3rd class petty officers (Grade E-4). Design for operability and maintainability should focus on the skill levels of these personnel. Yet, both reports from the Fleets and data presented in this guide indicate that their capability to perform many required tasks is marginal.

NEED FOR EARLY TRADEOFFS

Various system design concepts have more or less strong impacts on the resulting complexity of operator and maintainer tasks. The manpower and training cost consequences of these concepts need to be traded off against other cost-benefit considerations. This should happen early in the weapon system acquisition process.

DIRECT AND INDIRECT IMPACTS

The complete manpower development process is one of optimizing the manpower requirements for the system under development, establishing the operator requirements for various ship states of readiness, assessing all maintenance requirements, establishing total administrative and hotel support workloads, taking into account the time required for irregular and utility tasks, making allowances for average productivity levels, and so forth (Plato, 1978).

Though the system designer can not control all of these factors, it is important for him to be aware of the many variables in the overall manning equation that he does impact. These variables include the following (Plato, 1975):

1. Operator requirements
2. Preventive and corrective maintenance requirements
3. Facilities maintenance (cleaning, painting, etc.)
4. Administrative and support workload
5. Utility (miscellaneous task and evolution) requirements
6. Training and service diversion requirements
7. Productivity allowance factors
8. Rate/rank and skill requirements
9. Cross-utilization of personnel for various ship conditions of readiness
10. The standard work week as stipulated by the Chief of Naval Operations

The design engineer directly influences items 1, 2, 6, 8, and 9 through the election of various design alternatives. In addition, minimizing the number of system personnel can indirectly affect items 4 and 5. Carlson (1974) has demonstrated the important secondary savings that result from decreased requirements for onboard service and administrative personnel (e.g., commissarymen, ship's servicemen, yeomen, storekeepers, hospitalmen, and so forth). These savings can come about either through a reduction of the absolute number of operator and maintainer personnel on board, which reduces the need for support and administrative personnel, or by transferring a greater portion of the support and administrative burden to tender or shore-based facilities. Since support and administrative personnel constitute 20-25% of a typical ship's crew (Plato, 1978), these additional indirect savings can be substantial.

WHERE THIS GUIDE FITS

Those responsible for manpower and training support historically have played a reactive role to system design as opposed to directly influencing early tradeoff studies. The situation has been largely as depicted within the solid lines of Figure 2. The Navy personnel system has responded to the output of the traditional design cycle supplying, as best it could, the number of personnel required at each skill level and their required training support.

System lifecycle costs are largely determined by design decisions made prior to DSARC II. Therefore, if personnel costs are to be reduced or minimized, this must be a consequence of manpower and training support tradeoffs conducted early in the design cycle. Information and procedures are provided in this guide, shown within the dashed lines of Figure 2, that can be used in conducting the appropriate tradeoff analyses.

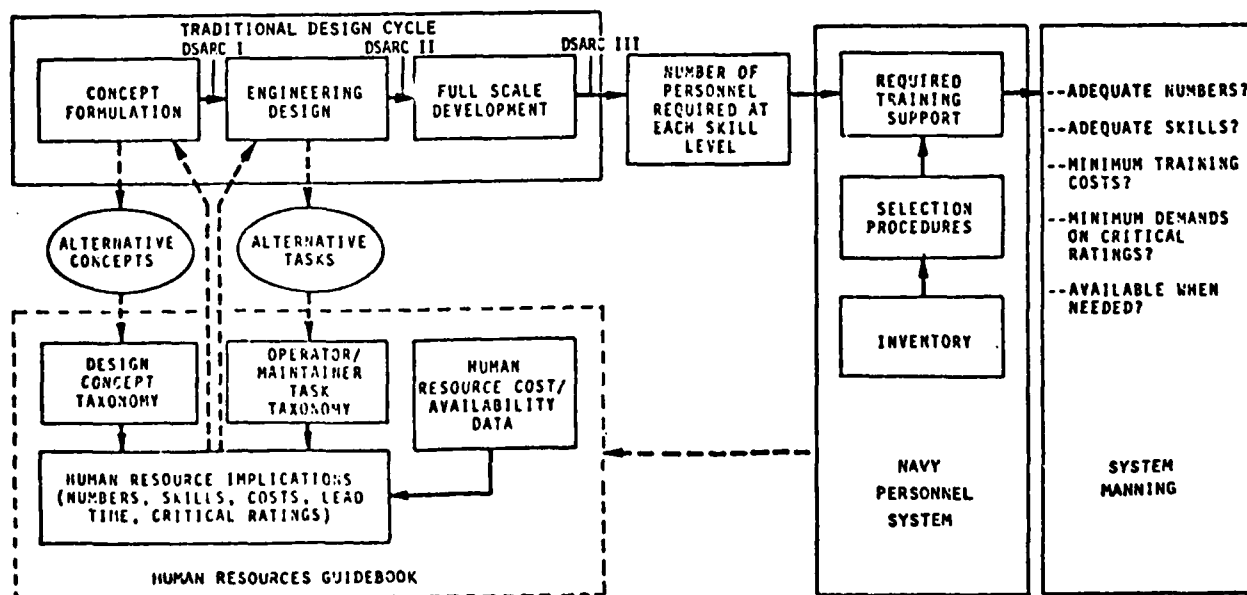


Figure 2. Relationship of the Human Resources Guidebook to system design.

NINE BASIC QUESTIONS

1. How are manpower and training support requirements affected by various operational and maintenance design concepts under consideration?
2. How do the manpower and training considerations interact with other criteria used in evaluating system design?
3. What types and numbers of Navy personnel are likely to be called upon to operate/maintain this type of system?
4. What is the projected availability of these personnel? Are they likely to be in critically short supply in the time frame of interest?
5. In view of the answers to Questions 1-4, which general design alternative best satisfies both manpower and training criteria as well as cost, potential benefit, and technical risk considerations?
6. What is the impact of the preferred system design on specific operator and maintainer tasks?
7. What skill levels and numbers of operator and maintainer personnel are required to perform these tasks?
8. What operational and maintenance training requirements are generated by the need to perform these tasks? To what extent can these be met by existing, rather than by newly developed, training resources?
9. What are the estimated lifecycle costs for the personnel required to operate and maintain the system? Are these within Navy imposed constraints?

The process by which these questions can be addressed early during the conceptual phase of the weapons system acquisition process is depicted in Figure 3. The questions listed above are shown in the figure together with the applicable sections of the guidebook that can be used to help answer them.

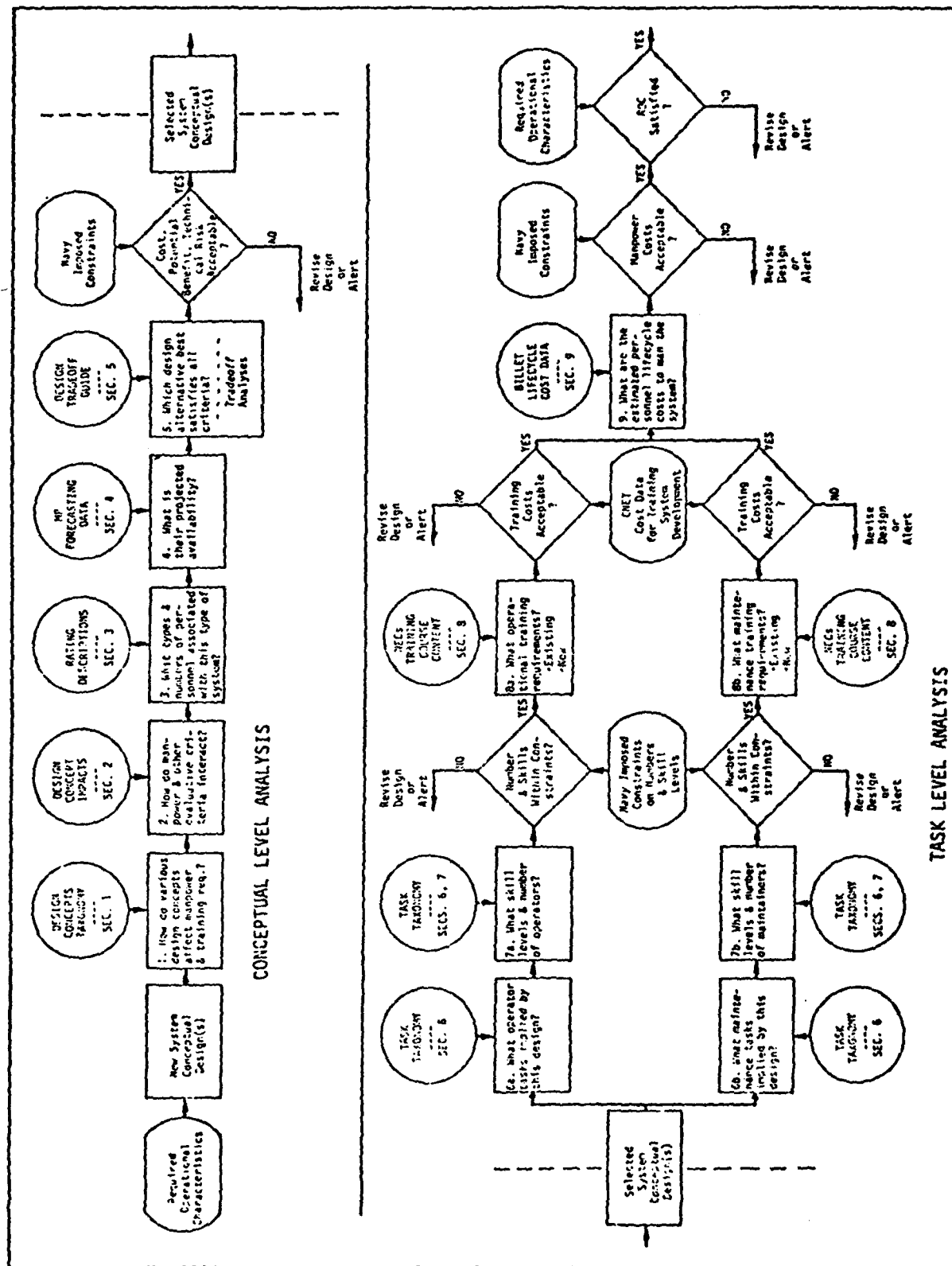


Figure 3. Designing in terms of human resources.

CONCEPTUAL LEVEL ANALYSIS

The upper half of Figure 3 is referred to as "Conceptual Level Analysis." At this level, the analysis is concerned with the impacts of various general system design concepts on manpower, training, and other important criteria. Operational and maintenance design concepts are examined in terms of how they impact operability, maintainability, required personnel skill levels, training requirements, initial acquisition costs, and other evaluative criteria.

TASK LEVEL ANALYSIS

The lower half of Figure 3 is referred to as "Task Level Analysis" since it addresses in considerably more detail the types of operator and maintainer tasks that must be performed in the kinds of systems addressed in this guidebook, the impact of those tasks on the number and skill levels of the operator and maintainer personnel likely to be required, and the question of necessary training system development.

In the final stage, the analysis addresses the predicted manpower lifecycle costs resulting from the number and skill levels of the required personnel identified in the task level analysis. If manpower and training support costs are to be minimized, this must be a consequence of design tradeoffs conducted early in the developmental cycle. An overview of how this guide can be used in following the process outlined in Figure 3 and answering each of the 9 basic human resource and training support questions will now be given.

SECTION 1
DEFINITION AND IMPACT OF DESIGN CONCEPTS

ADDRESSING QUESTION 1

How do various maintenance and operational design concepts affect manpower and training requirements?

This section contains a description of 21 design concepts that impact system maintenance and operator personnel requirements in a variety of ways. The data in this section relate to that portion of the conceptual design process shown in Figure 4.

DESIGN CONCEPT DEFINED

What is a design concept?

As used here, a design concept is defined as a general characteristic of system design that affects the number, skill levels, or training of the operator or maintenance personnel required by the system, as well as other system criteria.

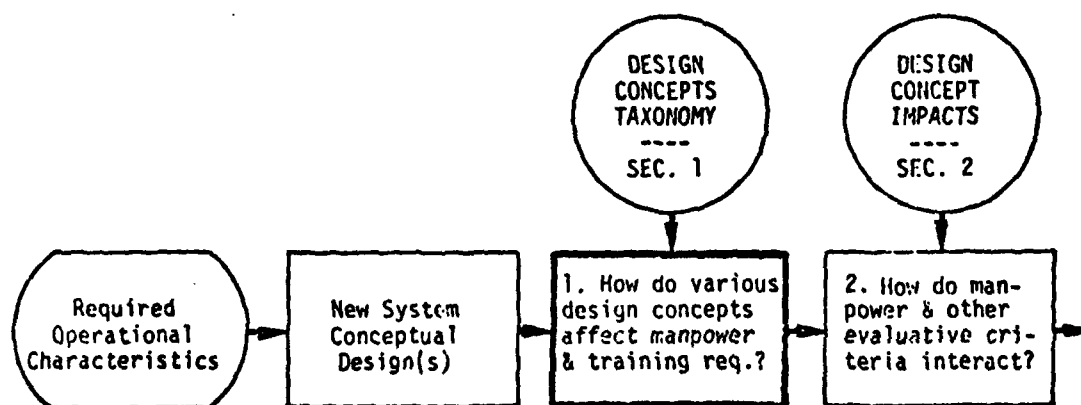


Figure 4. Addressing Question 1.

To the extent possible, while meeting the operational requirement and other constraints, it is assumed that the system designer will utilize design concepts and other, more specific design features that:

1. Minimize the number of operator and maintainer personnel required.
2. Minimize the required skill levels for system operation and maintenance.
3. Minimize new training requirements and specialization codes (NECs).

DIFFERENTIAL IMPACT

Different design concepts have very different impacts on requirements for manpower, skills, and training.

The 21 design concepts described in this section will be seen to have quite different impacts on various manpower and training criteria as well as on other important evaluative criteria (for definitions of the evaluative criteria used, see Section 2). Some concepts are more "manpower intensive" than others. Further, some concepts that are viewed as beneficial for operability are seen to have potentially adverse consequences for maintainability, clearly implying a need for tradeoff studies.

The impacts of these concepts have been summarized in the form of a profile of beneficial and adverse effects. The profiles, presented in this section, reflect the averaged judgments of 32 Navy engineering personnel who considered the relationship of system design to manpower requirements from widely different perspectives. These engineers included system designers in Navy laboratories, NAVSEC manning experts for new ship construction, human factors engineers in the system commands, research and development personnel concerned with advanced system concepts, and military technical specialists who are daily confronted with the problems of keeping systems operational aboard ship.

Though these personnel did not always completely agree with one another on the various impacts of each design concept, for the most part

agreement was high and the generalizations that resulted are believed to be reasonable. However, the true impact of a design concept may differ somewhat depending on systems-specific characteristics of radar, sonar, fire control, communications, and data processing systems. Where disagreement was substantial concerning the impact of a design concept, this is shown by a Δ at the appropriate place on its profile.

A list of the 21 design concepts is given in Table 1. To provide an overview, those that were judged to have particularly strong impacts on manpower requirements, either positive or negative, have been so identified. However, it is important that the reader become acquainted with the definition of each concept and its full profile on the pages that follow.

INTERPRETING THE PROFILES

How are the design concept profiles used and interpreted?

The scale values shown on the profile sheets reflect the average percentage improvement (or degradation) to be expected, in the view of the judges, in system operation or maintenance as a consequence of employing each design concept.* The referent for this percentage value is always the baseline system described in conjunction with each design concept.

For example, if the designer is interested in the profile for Built-In Troubleshooting Logic Aids, he will turn to page 1-26 where both this concept and the baseline concept are defined. The profile, on the facing page, then shows that a system employing this design concept, compared to a comparable system not employing it, can be expected to:

*The method by which these scale values were computed is described in Dick, R. A., Wylie, C. D., Mackie, R. R., & Ridihaigh, R. R. Research leading to the development of a guidebook on the use of human resources in electronic system design (Tech. Rep. 2702-2). Goleta, CA: Human Factors Research, Inc., 1979.

TABLE 1
RELATIVE IMPACT OF 21 DESIGN CONCEPTS ON SYSTEM
OPERATIONS AND MAINTENANCE

	Impact On:		See Page No.
	Operation	Maintenance	
1. Equipment layout to facilitate maintenance		++	1-8
2. LRUs--No spares			1-10
3. LRUs--Spares with onboard repair		+	1-12
4. LRUs--Spares with remote repair		++++	1-14
5. LRUs--Spares with throwaway maintenance		+++++	1-16
6. "Overdesign" for reliability & maintenance	+	++	1-18
7. Embedded computers		----	1-20
8. Automatic performance monitoring	+		1-22
9. Built-in test equipment	+	+++	1-24
10. Built-in troubleshooting logic aids	+	++++	1-26
11. Automatic fault localization	+	++++	1-28
12. Standard hardware components			1-30
13. Standard hardware--Cards/LRUs			1-32
14. Standard hardware--Functional units			1-34
15. Standard hardware--Subsystems			1-36
16. Operational simplicity	++++	+	1-38
17. Built-in operator performance aids	+++++		1-40
18. Automatic decision making	+++++	----	1-42
19. Automatic information transmit & display	+++	----	1-44
20. Built-in training capability	+++	--	1-46
21. Combined operator/maintainer functions	--	-	1-48

+ 10% or greater beneficial impact on one criterion
 ++ 10% or greater beneficial impact on two criteria
 +++ 10% or greater beneficial impact on three criteria
 etc.

- 10% or greater adverse impact on one criterion
 -- 10% or greater adverse impact on two criteria
 --- 10% or greater adverse impact on three criteria
 etc.

- Require about 15% less maintainer skills
- Require about 15% less system-specific training
- Reduce shipboard maintenance man-hours by about 24%
- Reduce MTTR by about 28%
- Improve overall operational capability by about 15%

but also,

- Decrease MTBF by about 5%
- Increase initial system acquisition costs by about 20%

How the data in these profiles can be conveniently used in design trade-off studies is explained in Section 5.

TECHNICAL FEASIBILITY

What is the technical feasibility of each design concept?

From their knowledge of past attempts to implement a given design concept, and the technology upon which such attempts were based, as well as changes in technology that might now be applicable, the judges also estimated the probability of successfully implementing each design concept in the near-term future. Both technical and practical risk that might be involved in implementing a design concept were considered. The results of these estimates are given at the end of each concept description.

PROFILES OF 21 DESIGN CONCEPTS

1. EQUIPMENT LAYOUT TO FACILITATE MAINTENANCE

DEFINITION

This design concept refers to such features as quick, easy access via front panels, quick release fasteners, roll out drawers; extensive, easily understood labeling and coding; test points that are easily accessed and are easy to relate to the appropriate functional unit; and modularization by function.

BASELINE

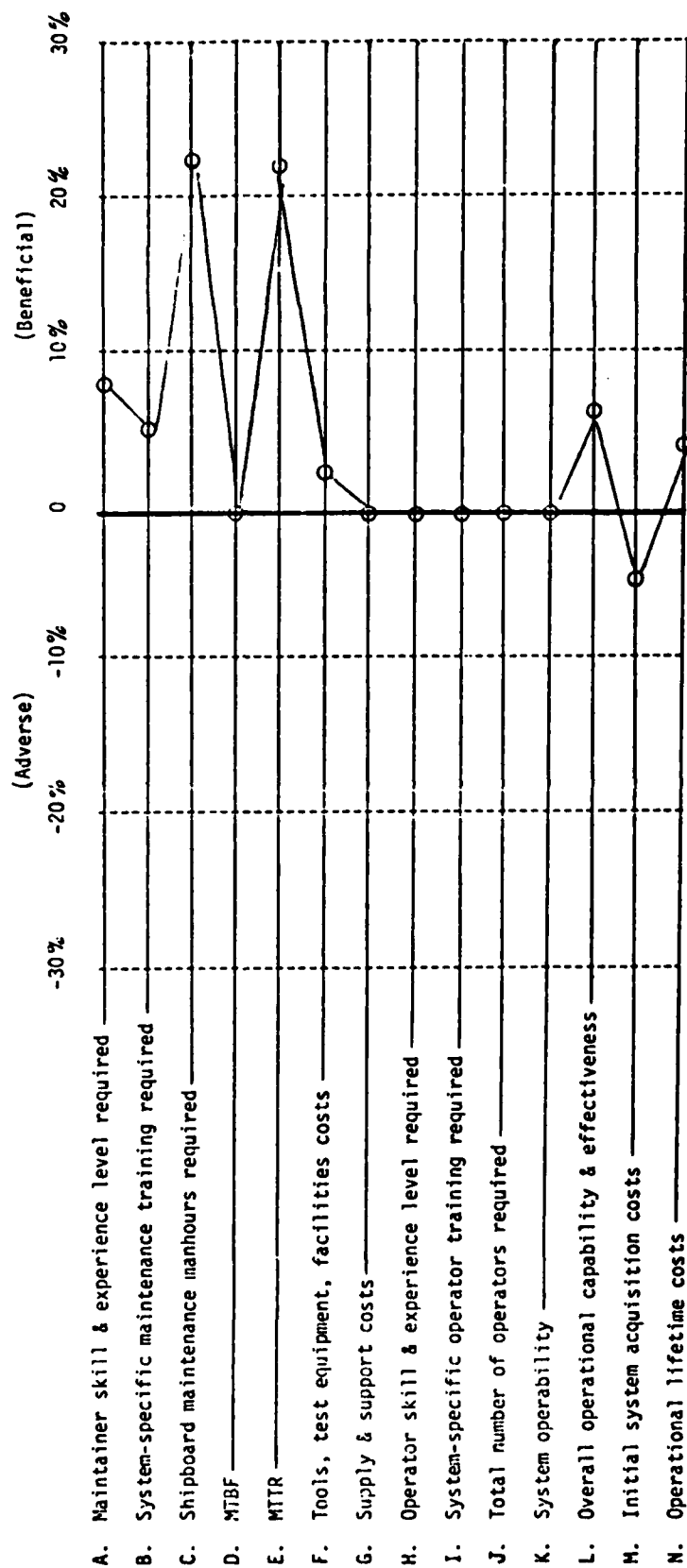
The baseline refers to systems reflecting design practices followed prior to the emphasis on maintainability and human engineering, in which little guidance beyond the engineer's own common sense was applied to equipment layout. Often equipment layout was simply the result of engineering convenience, and size and weight considerations. While new, major systems tend to reflect the approach represented by the design concept, many small systems with low visibility in the Navy are still being built according to the baseline. Rigorous specification of "design for maintainability" principles, and inspection to ensure compliance is usually carried out in the acquisition of large systems, but such considerations are often relaxed or nonexistent in the procurement of smaller systems.

PROFILE

The profile for this design concept shows it to have a pronounced favorable impact on mean time to repair and total shipboard maintenance man-hours. The only adverse impact is a slight increase in initial system acquisition costs.

The technical feasibility of this concept was rated highest (.93) of all concepts examined.

1. EQUIPMENT LAYOUT TO FACILITATE MAINTENANCE



2. LRUs--NO SPARES

DEFINITION

Line replacement units (LRUs) are used in electronic systems; LRUs are removable, plug-in modules that contain relatively small sets of components. In this concept, when repairing a fault, the faulty LRU must be removed from the chassis, repaired onboard the ship, and replaced before the equipment can be brought back on line.

BASELINE

The baseline is essentially the earlier electronics design practice wherein components were permanently mounted in the chassis. While technology has generally moved beyond this stage, the baseline characterizes the design approach used in some of the smaller systems that the Navy continues to acquire today. It is therefore a valid point of comparison for design concepts 2, 3, 4, and 5.

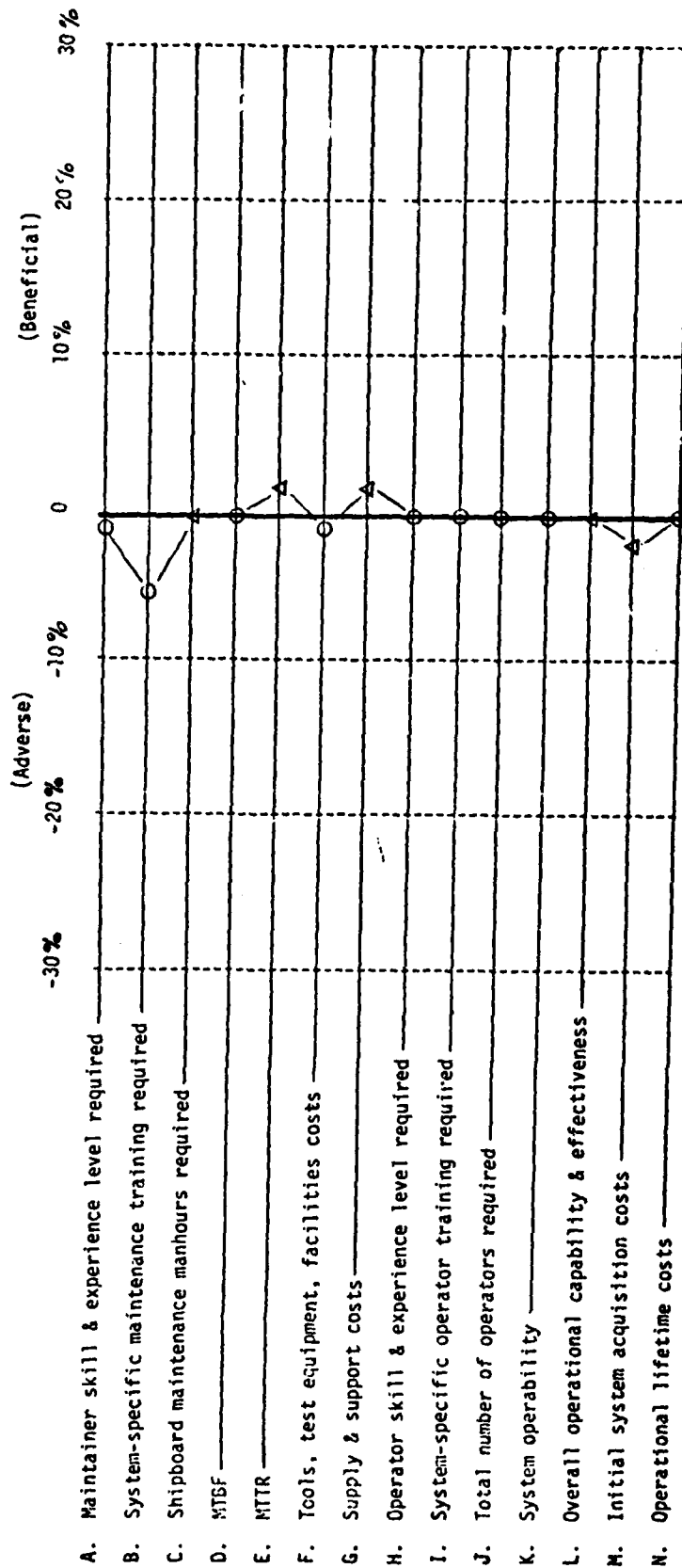
Both the baseline and this design concept, in specifying that repair of faulty LRUs occurs onboard the ship, is in accordance with a historic maintenance philosophy in the Navy of maximizing the amount of repair at the organizational level in order to maximize a ship's self-dependence, reduce the required support network, and reduce the system down time due to possible logistics delays.

PROFILE

The profile for this design concept reflects little or no difference compared to the baseline in its impact on various evaluative criteria. The largest single difference is the adverse impact of this design concept on maintenance training requirements, suggesting that the repair of LRUs may to some extent require greater systems-specific maintenance training than the baseline concept. However, it is notable that there are considerable differences of opinion concerning such important criteria as mean time to repair, total number of maintenance man-hours required, supply and support costs, and so forth. This indicates that there were about as many judges who viewed this design concept as superior to baseline as there were who viewed it as inferior with respect to those criteria.

The technical feasibility of this concept was generally rated high (.84).

2. LRUs--NO SPARES



Δ - Substantial disagreement on impact

3. LRUs--SPARES/ONBOARD REPAIR

DEFINITION

In this concept line replaceable units (LRUs) that are faulty are removed from the chassis, replaced with a spare LRU, and the equipment is brought back on line. The faulty LRU again is repaired at the organizational level (onboard the ship).

It should be noted that spare LRUs may sometimes be used as an aid to fault localization by systematically substituting spares until the anomalous condition is corrected. Navy technicians call this "Easter eggging."

BASELINE

Baseline systems are those that are constructed with components that are permanently mounted in the chassis.

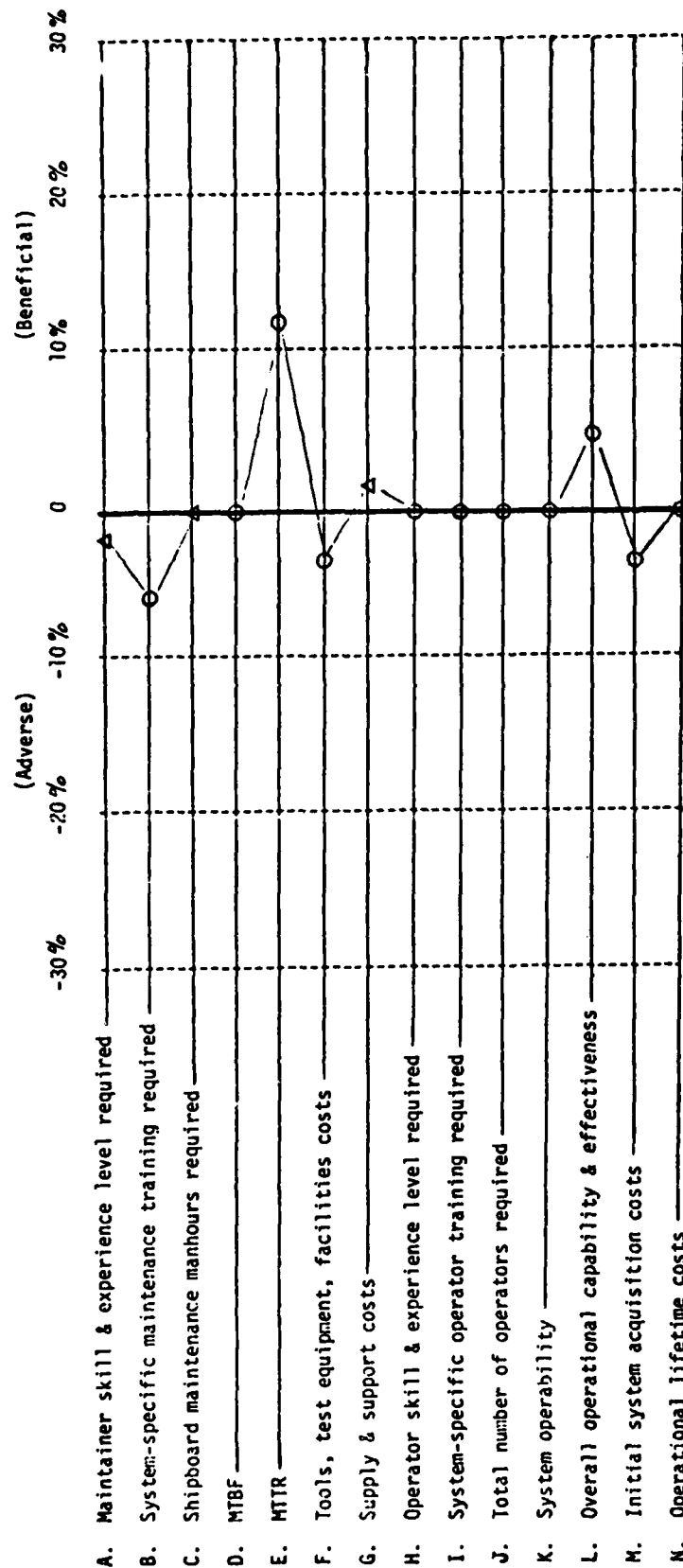
Both the baseline and this design concept specify that the repair of the faulty LRU occurs onboard the ship in accordance with the Navy's "traditional" maintenance philosophy, the objective of which is to maximize the amount of repair at the organizational level in order to increase the ship's self-dependence and reduce the support network.

PROFILE

The major impact of this design concept is seen to be its beneficial effect on mean time to repair. It is notably different in this respect not only from the baseline concept but also from design concept 2. It is similar to design concept 2 in that it is seen to require somewhat greater system-specific maintenance training than the baseline system.

Design concept 3 is regarded as having a relatively high level (.85) of technical feasibility.

3. LRUs--SPARES WITH ONBOARD REPAIR



Δ - Substantial disagreement on impact

4. LRUs--SPARES/REMOTE REPAIR

DEFINITION

This concept is similar to concept 3 in that the faulty LRU is removed from the chassis, replaced with a spare LRU, and the equipment is brought back on line. However, it differs in that the faulty LRU is subsequently sent to a tender or depot for repair as opposed to being repaired onboard.

Faulty LRUs are sent out for repair in accordance with the philosophy of minimizing shipboard manning and facilities requirements by relying upon tender and depot support for essential corrective maintenance. As with design concept 3, spare LRUs may be used as an aid to fault localization by systematically substituting spares until the anomalous condition is corrected.

BASELINE

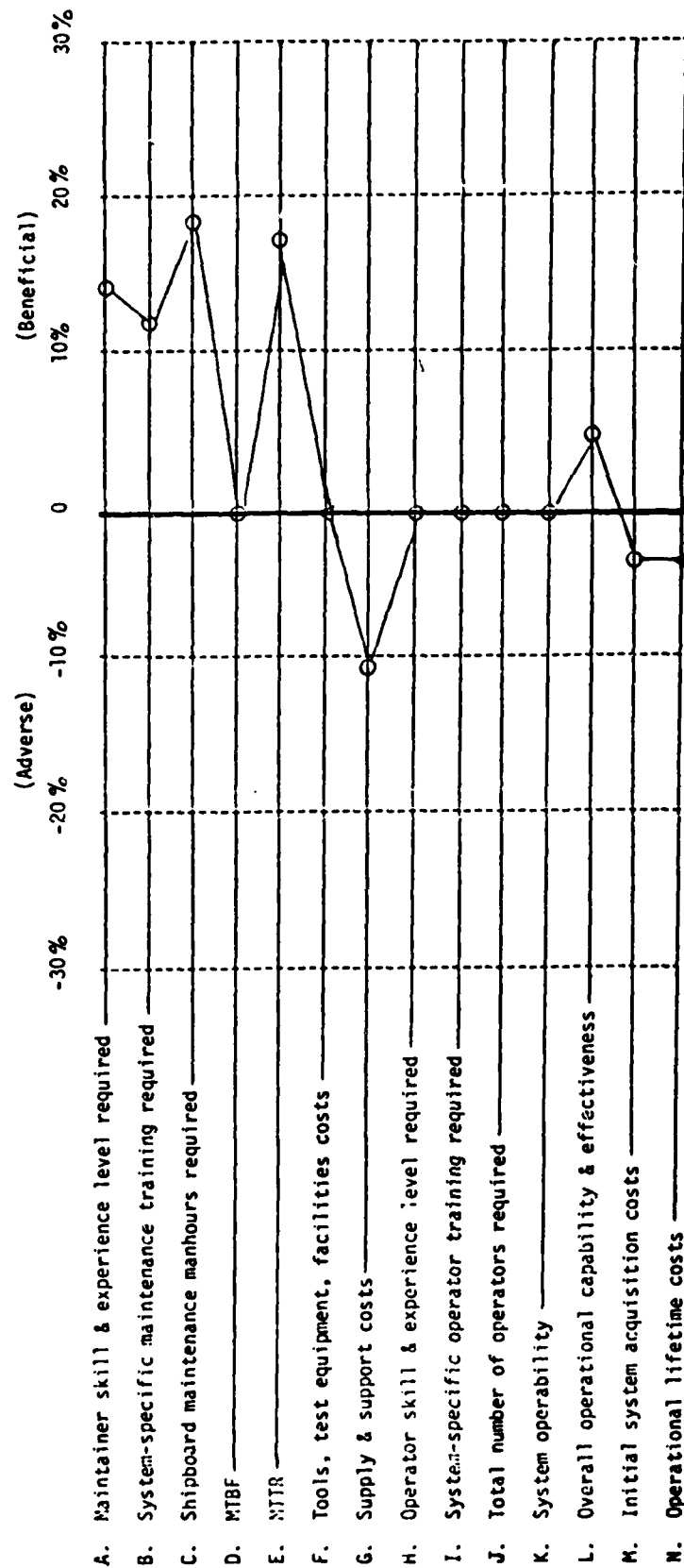
Electronic systems which are constructed with components that are permanently mounted in the chassis.

PROFILE

The profile for this design concept is seen to have strong favorable impact with respect to a number of important criteria: maintainer skill level required, systems-specific maintenance training requirements, shipboard maintenance man-hours required, and mean time to repair. However, it is seen as having a negative impact on supply and support costs.

Design concept 4 is regarded as having a relatively high level of technical feasibility (.84).

4. LRUS--SPARES WITH REMOTE REPAIR



Δ - Substantial disagreement on impact

5. LRUs--SPARES/THROWAWAY MAINTENANCE

DEFINITION

In repairing a fault under this concept, the faulty LRU is removed from the chassis, replaced with a spare LRU, and the equipment is brought back on line. The faulty LRU is then thrown away in accordance with a philosophy of minimizing manning and facilities requirements at the organizational level and at the tender/depot level. This must be accomplished by providing for additional inventory requirements and by minimizing per unit LRU costs.

Like concepts 3 and 4, concept 5 also permits the technician to use spare LRUs as an aid to fault localization by systematically substituting spares until the anomolous condition is corrected.

BASELINE

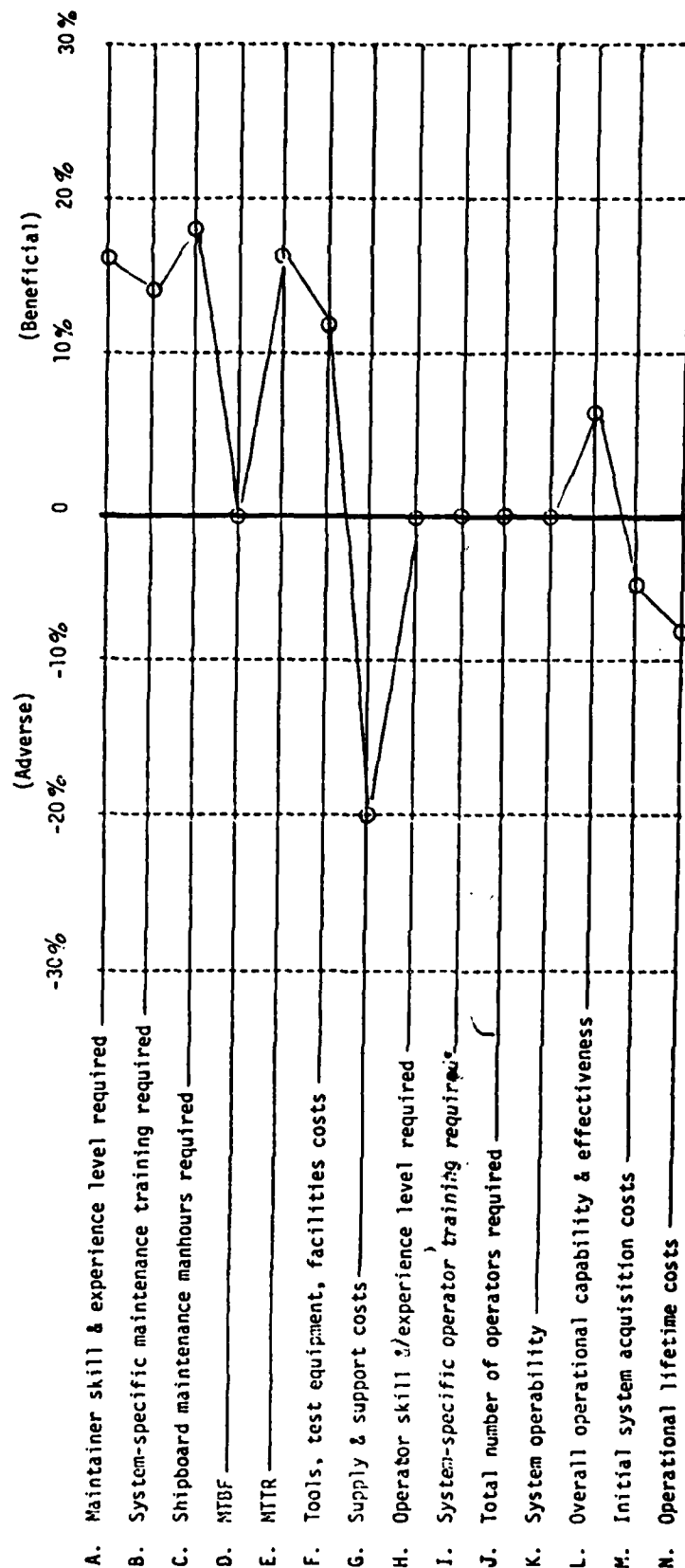
Electronic systems which are constructed with components that are permanently mounted in the chassis.

PROFILE

The profile for concept 5 is very similar to that for concept 4 in its favorable impact on skill level requirements, system-specific maintenance training requirements, man-hours of shipboard maintenance required, and mean time to repair. In addition, it is seen as having a substantial desirable impact on the cost of tools, test equipment, and facilities. However, it is viewed as having a substantial cost consequence in terms of supply and support requirements and an adverse impact on operational lifetime costs.

The technical feasibility of this design concept was rated about average compared to all concepts studied (.80).

5. LRUs--SPARES WITH THROWAWAY MAINTENANCE



6. USE OF "OVERDESIGN" TO ACHIEVE A HIGH DEGREE
OF RELIABILITY AND MAINTAINABILITY

DEFINITION

This concept refers to the use of greater than required margins of safety (e.g., higher rated capacitors and resistors than required, ultra-reliable components, redundancy, etc.) to achieve much better total reliability and highly stable circuits that require only infrequent adjustments.

BASELINE

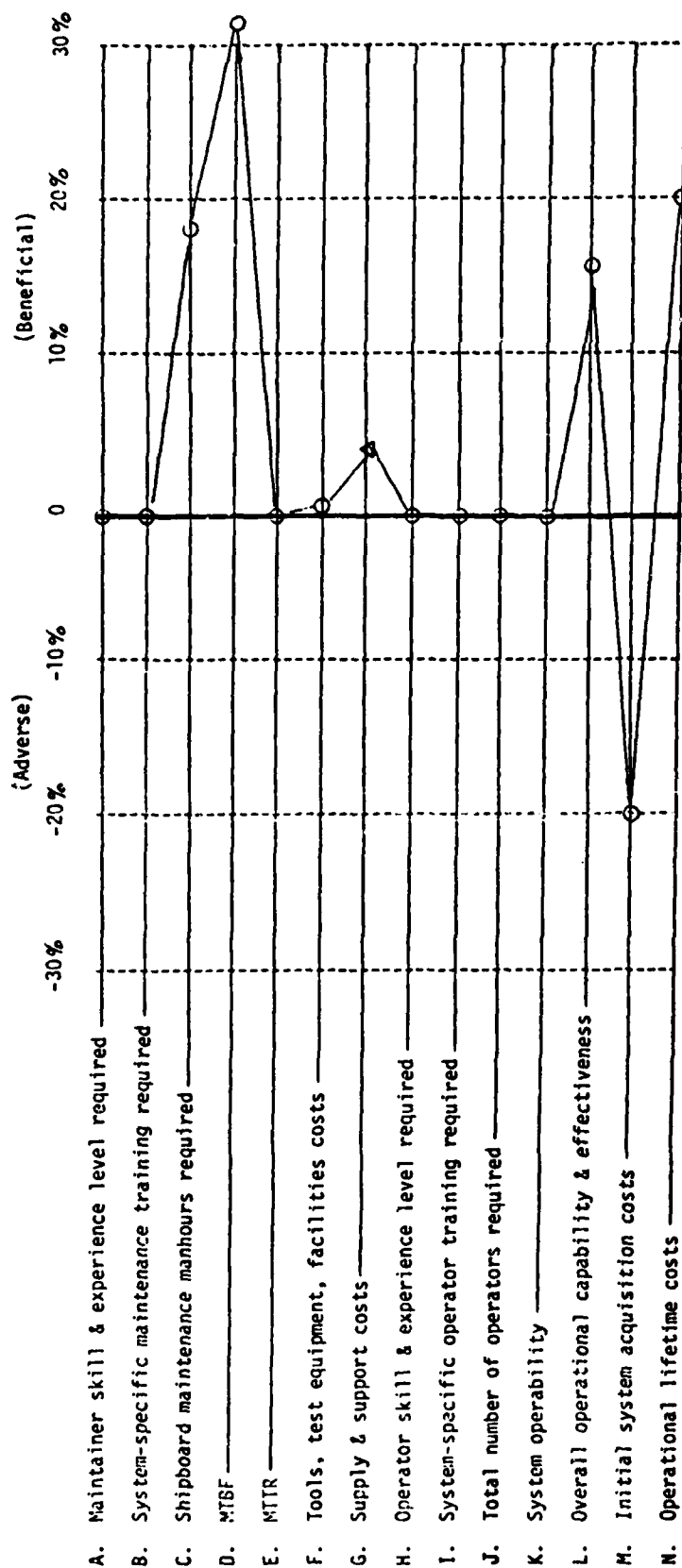
The baseline refers to designing hardware to meet but not exceed prevailing military specifications for reliability and stability.

PROFILE

The profile for design concept 6 reflects an extremely favorable impact on mean time between failures and total shipboard maintenance man-hours required for the system. In addition, it is regarded as having a very favorable impact on overall system effectiveness. While it is viewed as having a substantial adverse impact on initial system acquisition costs, its effect on subsequent operational lifetime costs is viewed as very positive.

Design concept 6 is viewed as having somewhat lower than average technical feasibility compared to other maintenance concepts (.74).

6. "OVERDESIGN" FOR RELIABILITY & MAINTENANCE



Δ - Substantial disagreement on impact

7. EMBEDDED COMPUTERS

DEFINITION

This concept refers to the tendency of some designers to embed microprocessors and other sophisticated digital circuitry in system hardware in order to permit the execution of more sophisticated processing and control functions.

The concept represents one facet of advancing technology--the extensive array of increasingly available microprocessors which is frequently utilized by designers to achieve more efficient, and perhaps more "elegant," solutions to complex requirements. Because the computer-like microprocessors may be inserted into various points in a hardware system, they often do not comprise a separately identified computer subsystem. Thus the Navy may not designate such systems as "computer controlled" and computer specialists are not usually designated to maintain them.

BASELINE

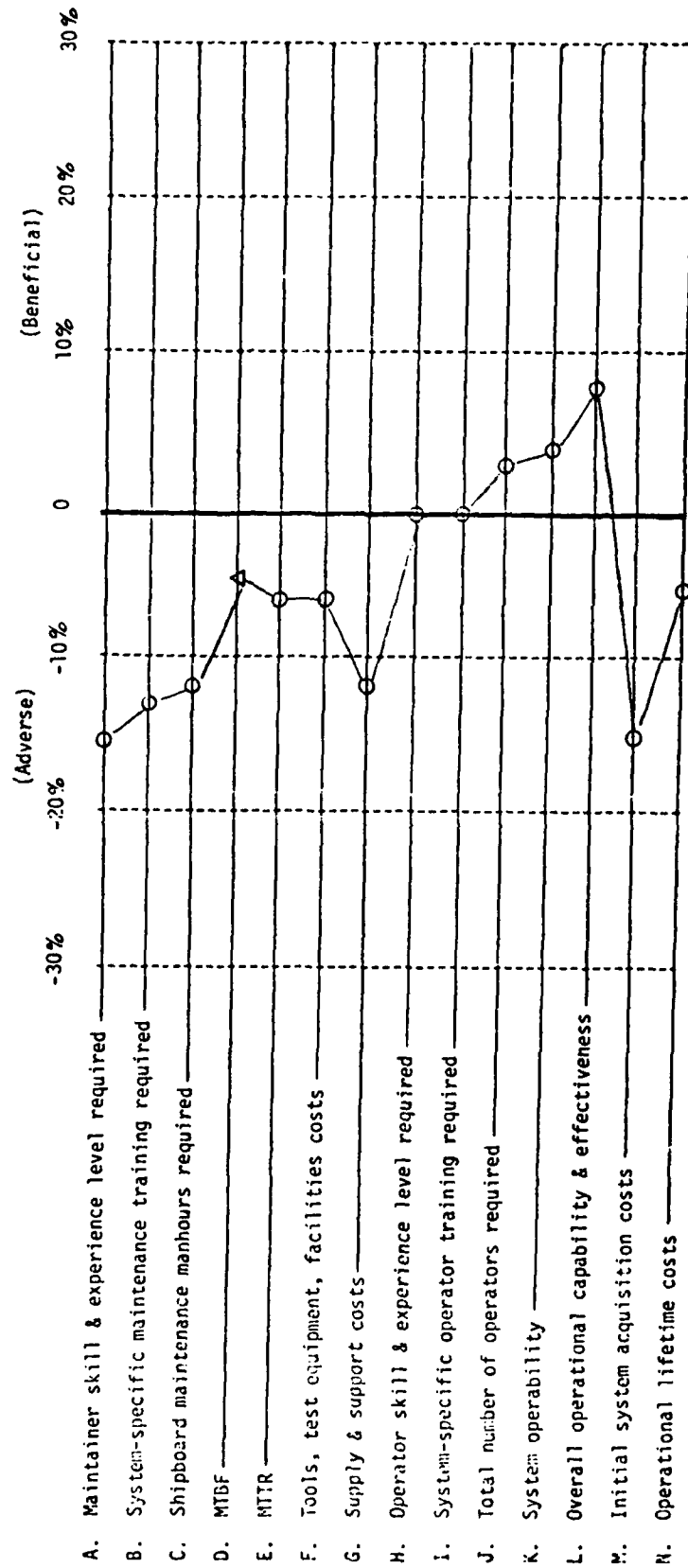
Historically, many electronic systems that have not been computer controlled have relied upon relays, analog devices, and some simple digital devices to accomplish many functions.

PROFILE

The profile for design concept 7 is seen to be negative in many respects. Although it is viewed as having a generally positive impact upon overall system effectiveness, it is felt to have a strong negative impact on required maintainer skill level, training, and maintenance man-hours required, as well as a negative impact on both initial and supply/support costs.

The technical feasibility of this concept is rated high (.85).

7. EMBEDDED COMPUTERS



Δ - Substantial disagreement on impact

8. AUTOMATIC PERFORMANCE MONITORING

DEFINITION

This design concept includes those hardware and software subsystems that perform system monitoring to detect conditions of degraded performance. In some systems automatic performance monitoring is implemented in combination with automatic fault localization. The latter is treated as a separate design concept (11) since it has some distinctly different impacts on a number of system criteria.

BASELINE

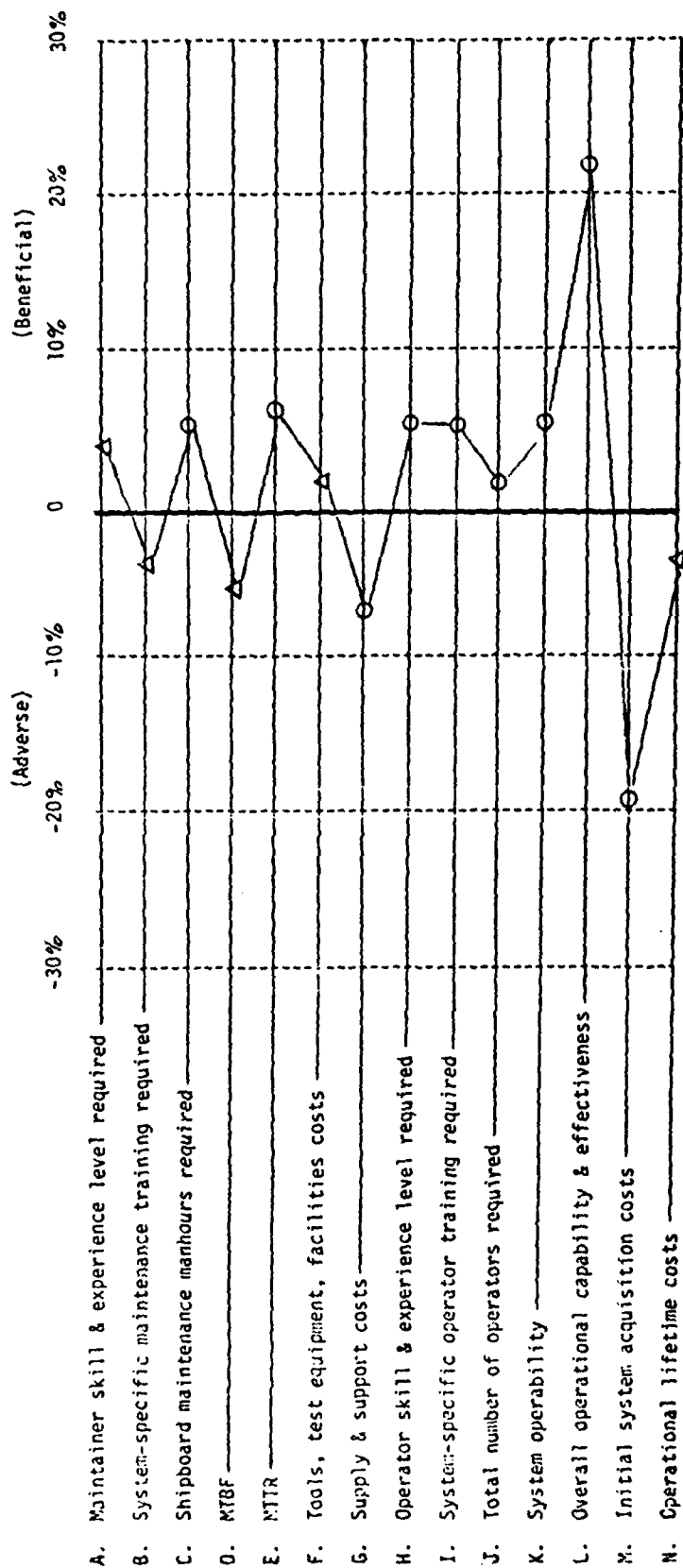
Baseline systems are characterized by nonautomatic detection of degraded performance which depends on an operator or technician inferring from an anomaly in equipment operating characteristics that some aspect of the equipment is out of tolerance or faulty. Such degraded performance may or may not be easily or promptly recognized.

PROFILE

The profile for design concept 8 is shown as having a strong positive impact on overall system effectiveness but at a considerable price in the cost of initial acquisition. It is noteworthy that there were substantial differences of opinion concerning the effect of this design concept on the required skill levels and training of maintenance technicians. Very likely this reflected the view, on the one hand, that automatic performance monitoring features should help to quickly identify malfunctioning or out of tolerance systems but, at the same time, the automatic performance monitoring subsystems themselves may add significantly to the maintenance burden.

Design concept 8 was viewed as slightly below average, compared to other concepts studied, in technical feasibility (.76).

8. AUTOMATIC PERFORMANCE MONITORING



Δ - Substantial disagreement on impact

9. BUILT-IN TEST EQUIPMENT (BITE)

DEFINITION

This concept eliminates much of the need for separate, independent test equipment; the connections between built-in displays and test points are achieved through switch selections.

BASELINE

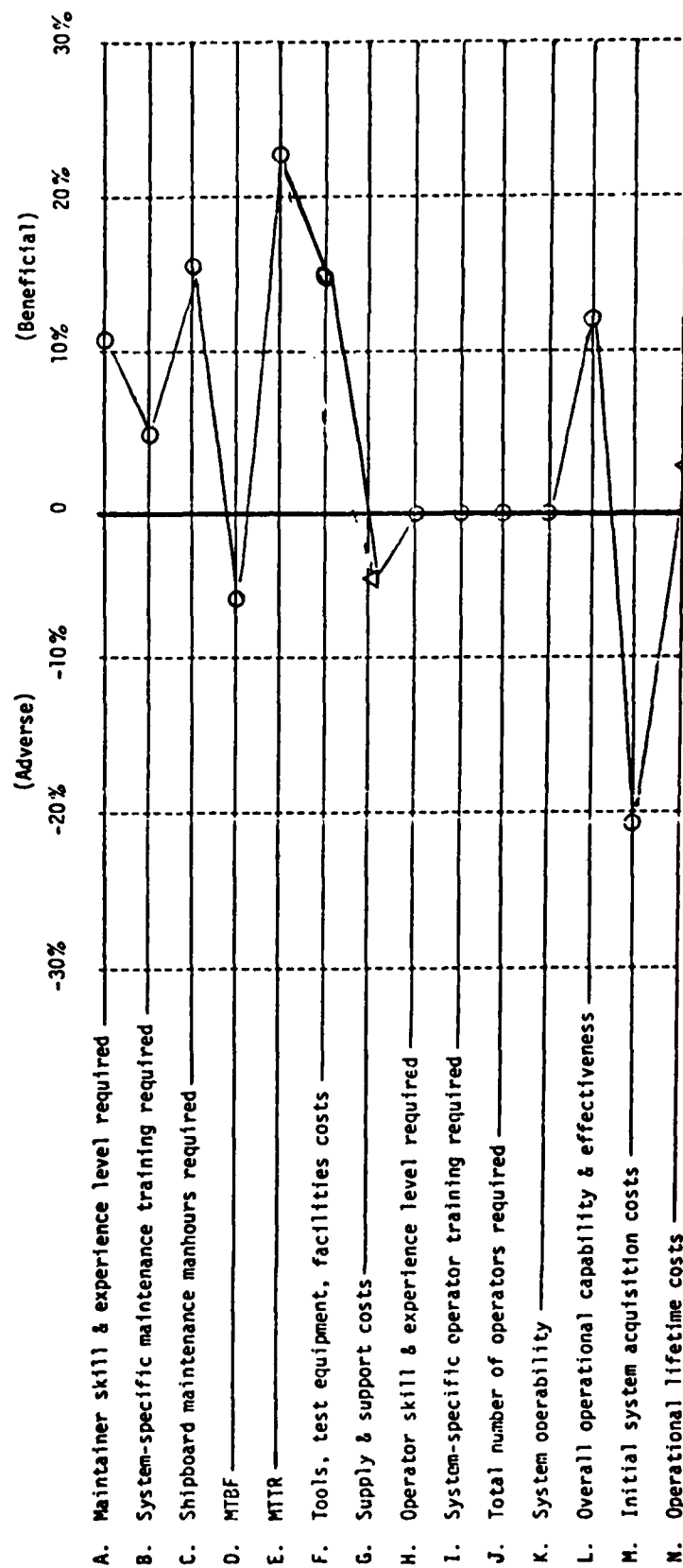
The baseline refers to maintenance and fault localization which is performed using separate test equipment and maintenance documentation. Preventive and corrective maintenance in the baseline system may require considerable time to set up separate test equipment, attach it to appropriate test points, interpret the output, reset for additional test points, and so forth, and eventually to put the test equipment away.

PROFILE

The profile for design concept 9 is seen as having a substantial positive impact on MTTR, shipboard maintenance man-hours required, tools and test equipment costs, skill level of maintenance personnel, and overall system effectiveness. Its principal drawback is viewed as high initial acquisition costs.

The technical feasibility of design concept 9 was judged to be above average (.84).

9. BUILT-IN TEST EQUIPMENT



Δ - Substantial disagreement on impact

10. BUILT-IN TROUBLESHOOTING LOGIC AIDS

DEFINITION

This design concept eliminates much of the usual need for separate maintenance documentation. Computer-based systems are provided with auxiliary software and information displays that guide personnel through preventive maintenance steps and systematic troubleshooting strategies.

The concept refers to the relatively new developments in software aids to maintenance and troubleshooting. Some of these approaches include sophisticated algorithms that take into account an analysis of the reliabilities of all of the hardware components in developing troubleshooting strategies.

BASELINE

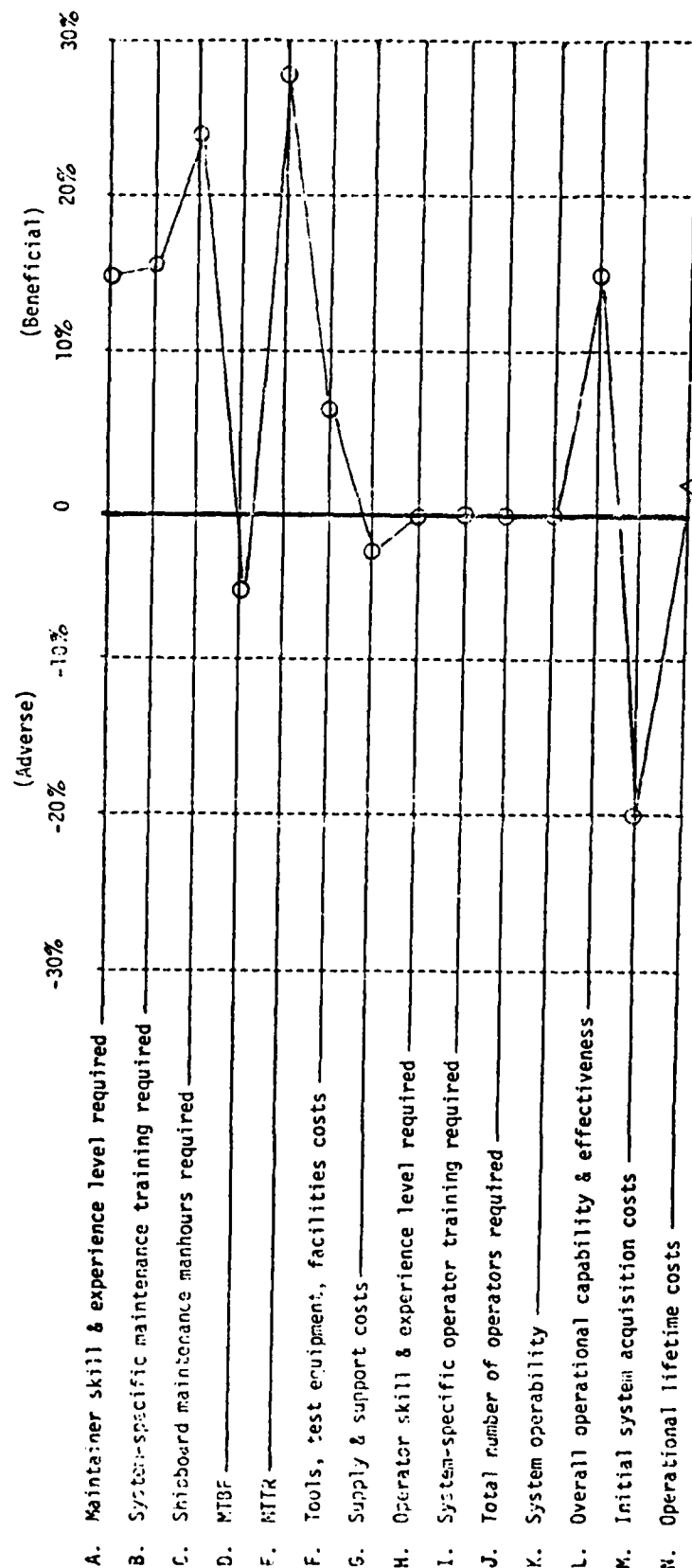
Maintenance and fault localization that is performed using separate test equipment and maintenance documentation. Preventive and, especially, corrective maintenance in baseline systems may require considerable time and skill to find the appropriate documentation, search through it, and apply it in the process of locating faults.

PROFILE

The profile for design concept 10 is seen as being highly positive with respect to MTTR, maintenance man-hours required, skill level of the technicians, and their training. It is also viewed as having a substantial positive effect on overall system effectiveness. Its principal drawback is considered to be high initial system acquisition costs.

The technical feasibility of design concept 10 is considered to be about average (.79) compared to other concepts studied.

10. BUILT-IN TROUBLESHOOTING LOGIC AIDS



Δ - Substantial disagreement on impact

11. AUTOMATIC FAULT LOCALIZATION

DEFINITION

Use of this design concept eliminates the need for separate test equipment and separate maintenance documentation to perform initial fault localization. An automated subsystem is used to perform measurements at various test points and to deduce the localization of faults to some degree of resolution (e.g., 90% of the faults are localized to "ambiguity groups" of not more than 3 PC cards).

BASELINE

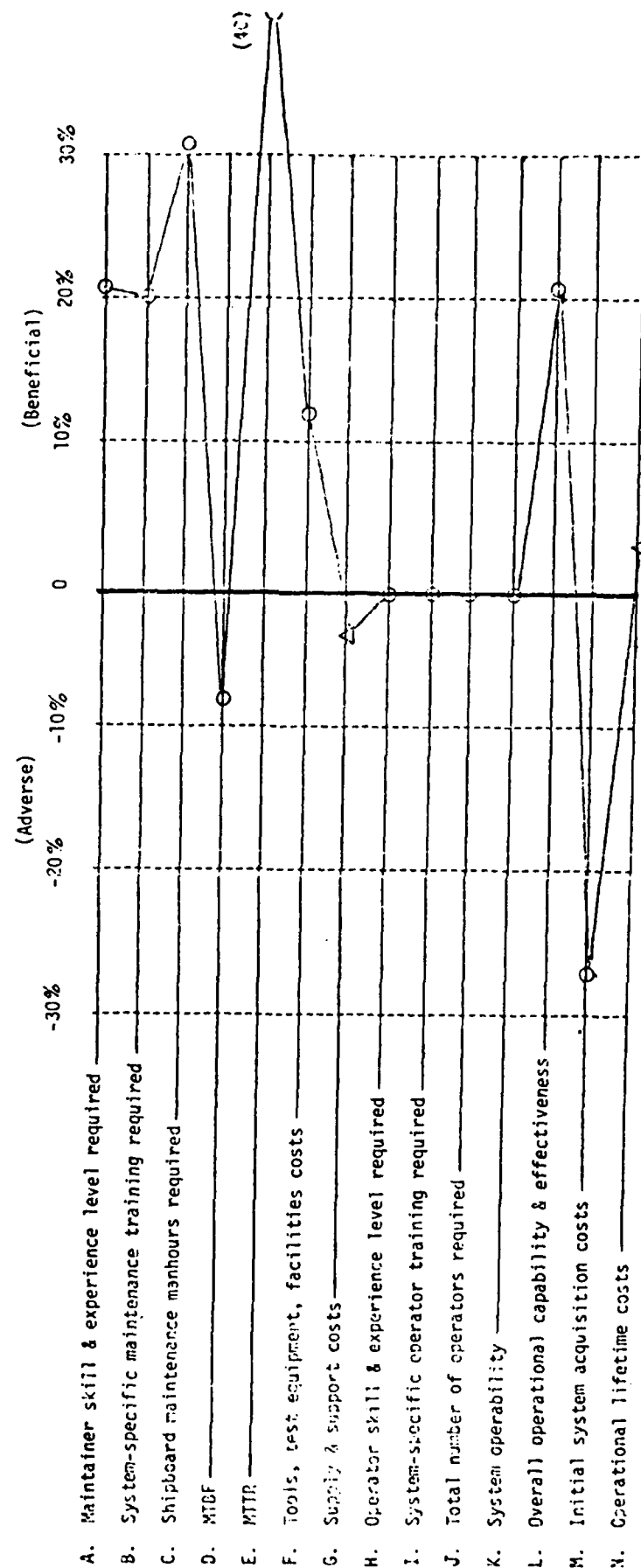
Maintenance and fault localization which is performed using separate test equipment and maintenance documentation.

PROFILE

Design concept 11 is seen to have extremely favorable impacts on MTTR and total required shipboard maintenance man-hours. It also has strong positive impacts on maintenance skill level and amount of training required, as well as on overall system effectiveness. However, it is seen as having a very substantial impact on initial system acquisition costs. It is also viewed by some as having a negative impact on MTBF, suggesting that it may be a source of maintenance problems in its own right.

The technical feasibility of design concept 11 is viewed as somewhat below average (.75).

11. AUTOMATIC FAULT LOCALIZATION



△ - Substantial disagreement on impact

12. HARDWARE STANDARDIZATION--COMPONENTS

DEFINITION

In this concept component hardware items such as transistors, resistors, chips, etc., are selected so that they are identical to items used in other shipboard systems and assemblies. Component selection is substantially influenced by their availability in the Navy supply inventory. The concept argues for ensuring, at least, that small components are standard and interchangeable among shipboard hardware assemblies.

BASELINE

Selection and use of components in an assembly of hardware is made without regard for commonality across other hardware systems found aboard ship. Little consideration may be given to the availability or obtainability of components in the existing Navy inventory.

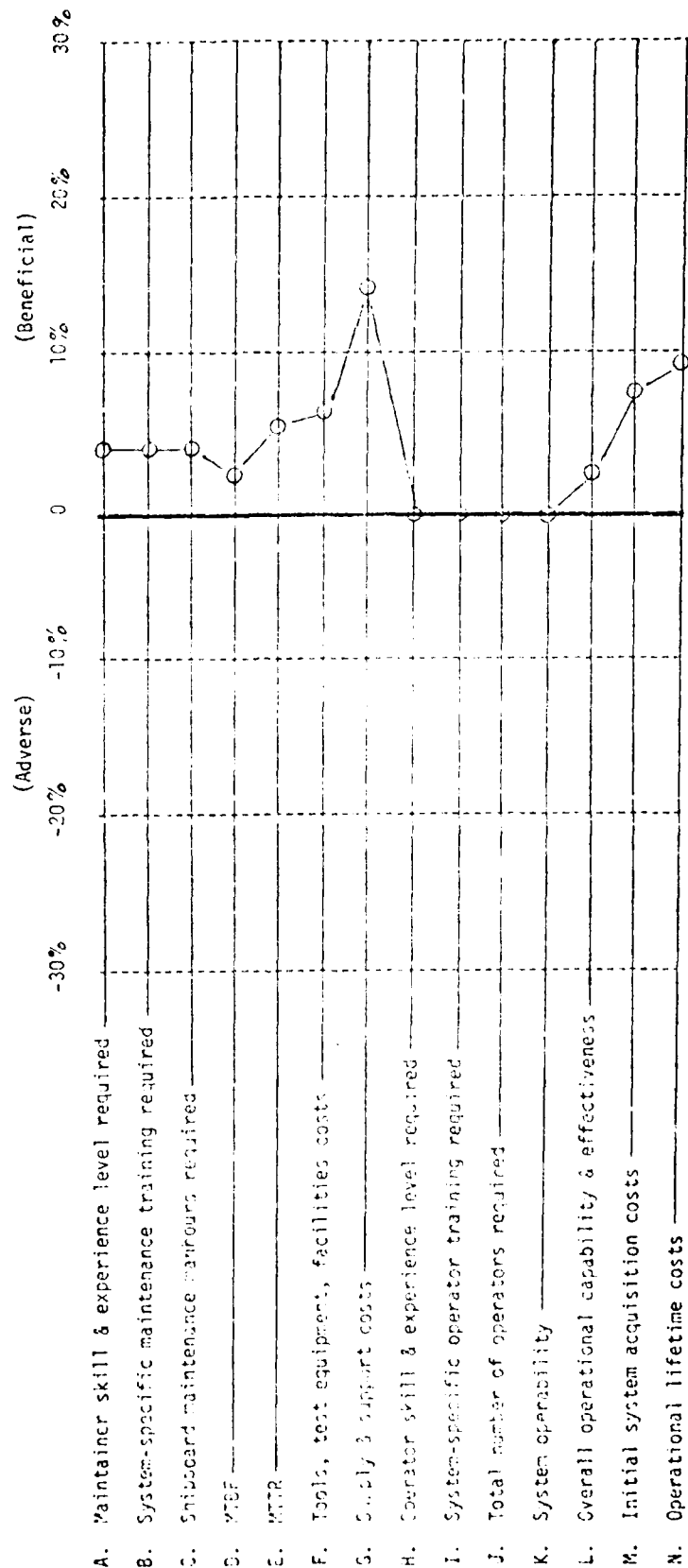
The baseline refers to a common design practice where specifications do not closely regulate the choice of hardware items that are available to the designer. Hardware designers often prefer to utilize their own unique approaches to hardware functions, because they feel able to develop new, cheaper, or "better" solutions to problems, or because they are comfortable with their own proven approaches. Thus one contractor's hardware is often much different from another's, even in systems designed to perform to the same specifications.

PROFILE

The profile for design concept 12 is seen to be largely positive with the strongest favorable impacts occurring on supply/support costs and operational lifetime costs. The impacts on maintenance personnel are seen as positive but small.

The technical feasibility of design concept 12 is viewed as high (.86).

12. STANDARD HARDWARE COMPONENTS



13. HARDWARE STANDARDIZATION--CARDS/LRUs

DEFINITION

Assemblies of hardware items such as standard electronic modules (SEMs), standard cards, etc., are selected so that they are identical to items used in other shipboard systems and are available in the Navy supply inventory. The concept argues for ensuring that cards and LRUs, at least, are standard and interchangeable among shipboard hardware assemblies.

BASELINE

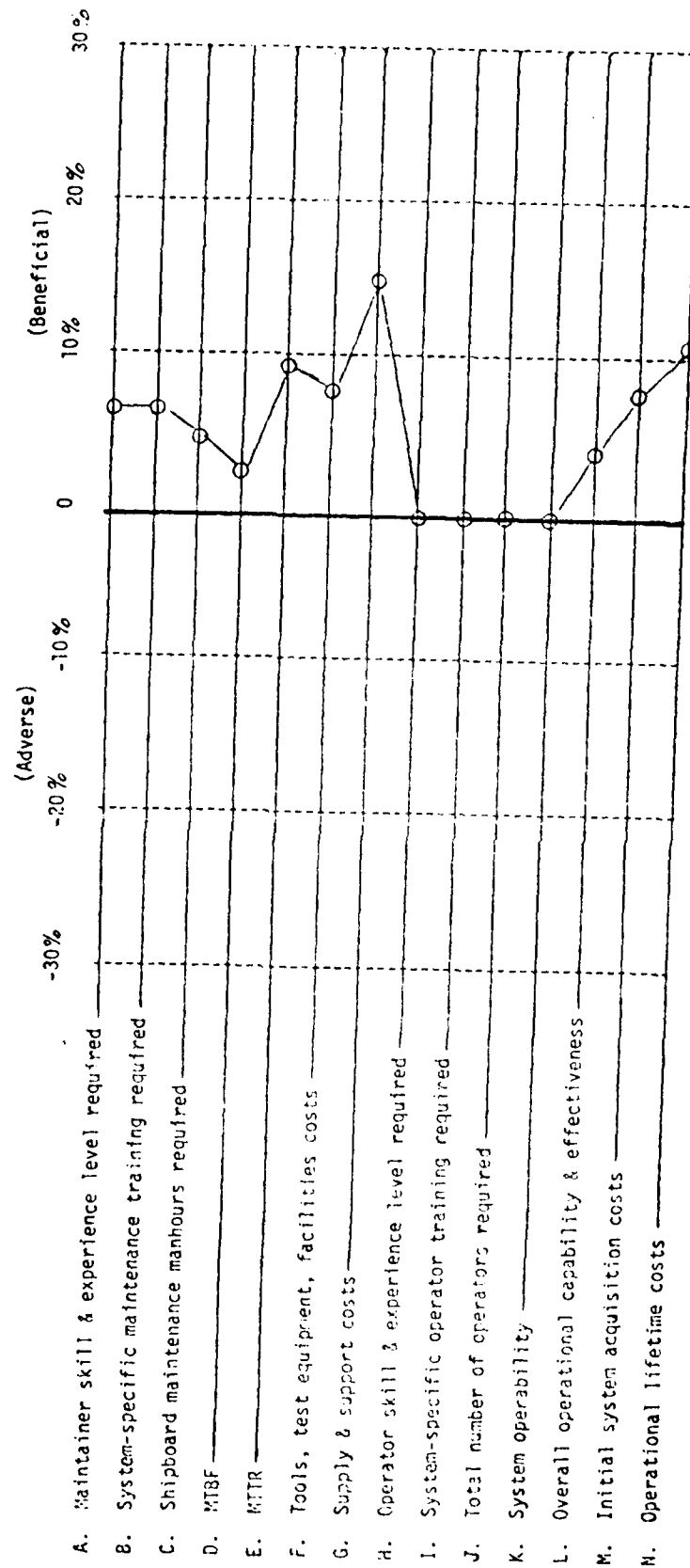
The baseline refers to the practice of selecting and using cards and LRUs in an assembly of hardware without regard for commonality across other hardware systems found aboard ship. Little consideration is given to the availability or obtainability of cards and LRUs in the existing Navy inventory. Again the baseline reflects a common design practice wherein specifications do not closely regulate the choice of hardware items that are available to the designer. Hardware designers often prefer to utilize their own unique approaches to hardware functions because they can then develop new cheaper or "better" solutions to problems or because they are comfortable with their own proven approaches. For example, SEMs are said by some to be inefficient in terms of weight and size, and to lag the state of the art.

PROFILE

The profile for design concept 13 is seen as one of positive impact, particularly on supply/support costs, operational lifetime costs, and MTTR. Its profile is quite similar to that for concept 12 but somewhat more positive.

Design concept 13 is viewed as slightly above average in technical feasibility (.83).

13. STANDARD HARDWARE--CARDS/LRUs



14. HARDWARE STANDARDIZATION--FUNCTIONAL UNITS

DEFINITION

Under this concept, complex assemblies of hardware items which perform a given function, such as power supplies, amplifiers, and so forth, and which are complete in themselves, are selected so that they are identical to items used in other shipboard systems and are available in the existing Navy supply inventory.

BASELINE

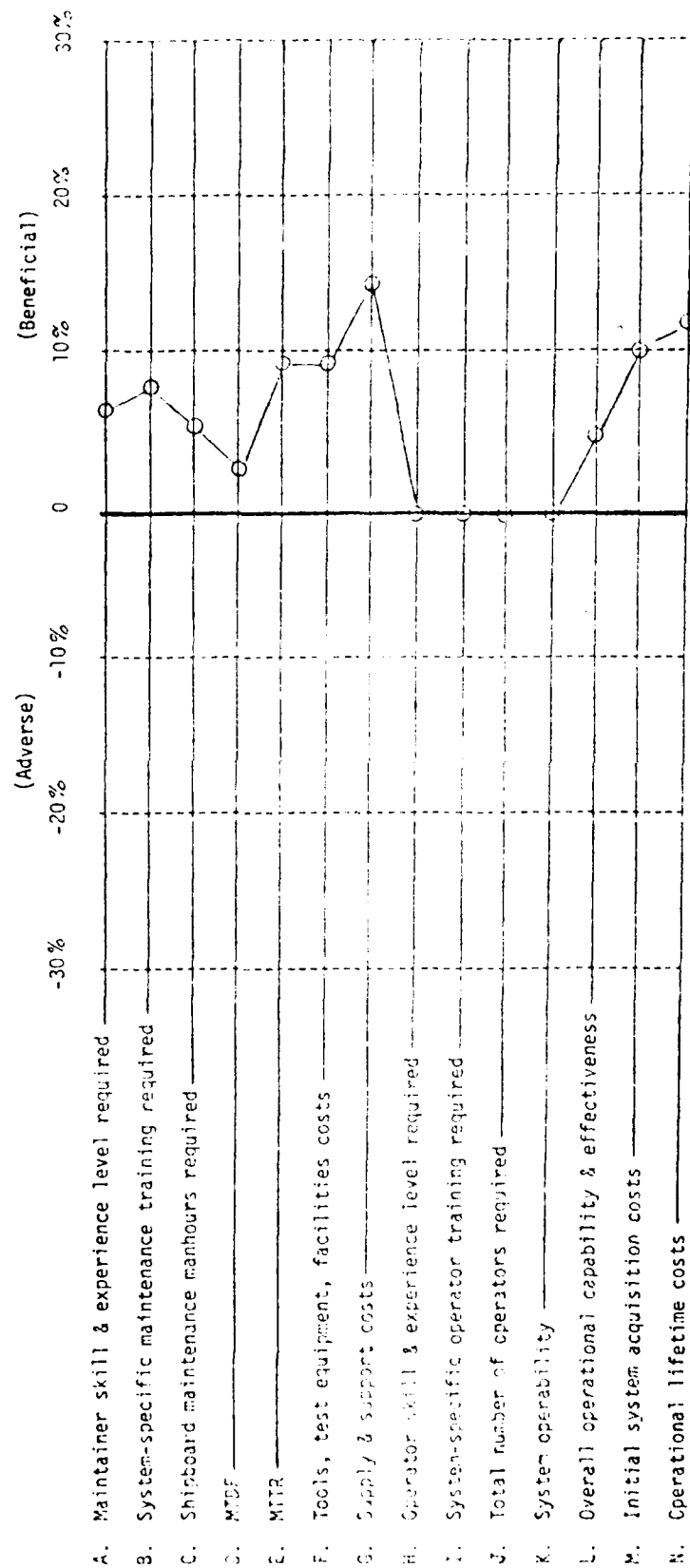
The baseline is characterized by selection and use of functional units in an assembly of hardware without regard for commonality across other hardware systems found aboard ship. Little consideration is given to the availability or obtainability of functional units in the existing Navy supply inventory.

PROFILE

The profile for design concept 14 is seen to be highly similar to that for concept 13 with the most favorable impacts occurring on supply support costs, operational lifetime costs, MTTR, and MTBF.

Design concept 14 is regarded as somewhat lower in technical feasibility than concepts 12 and 13 (.75).

14. STANDARD HARDWARE--FUNCTIONAL UNITS



15. HARDWARE STANDARDIZATION--SUBSYSTEMS

DEFINITION

In this concept, complex assemblies of hardware items which perform a variety of functions and may be operated as a separate unit such as display consoles, computers, magnetic tape units, etc., are selected so that they are identical to subsystems used in other shipboard systems and are available/obtainable through existing Navy supply inventories.

BASELINE

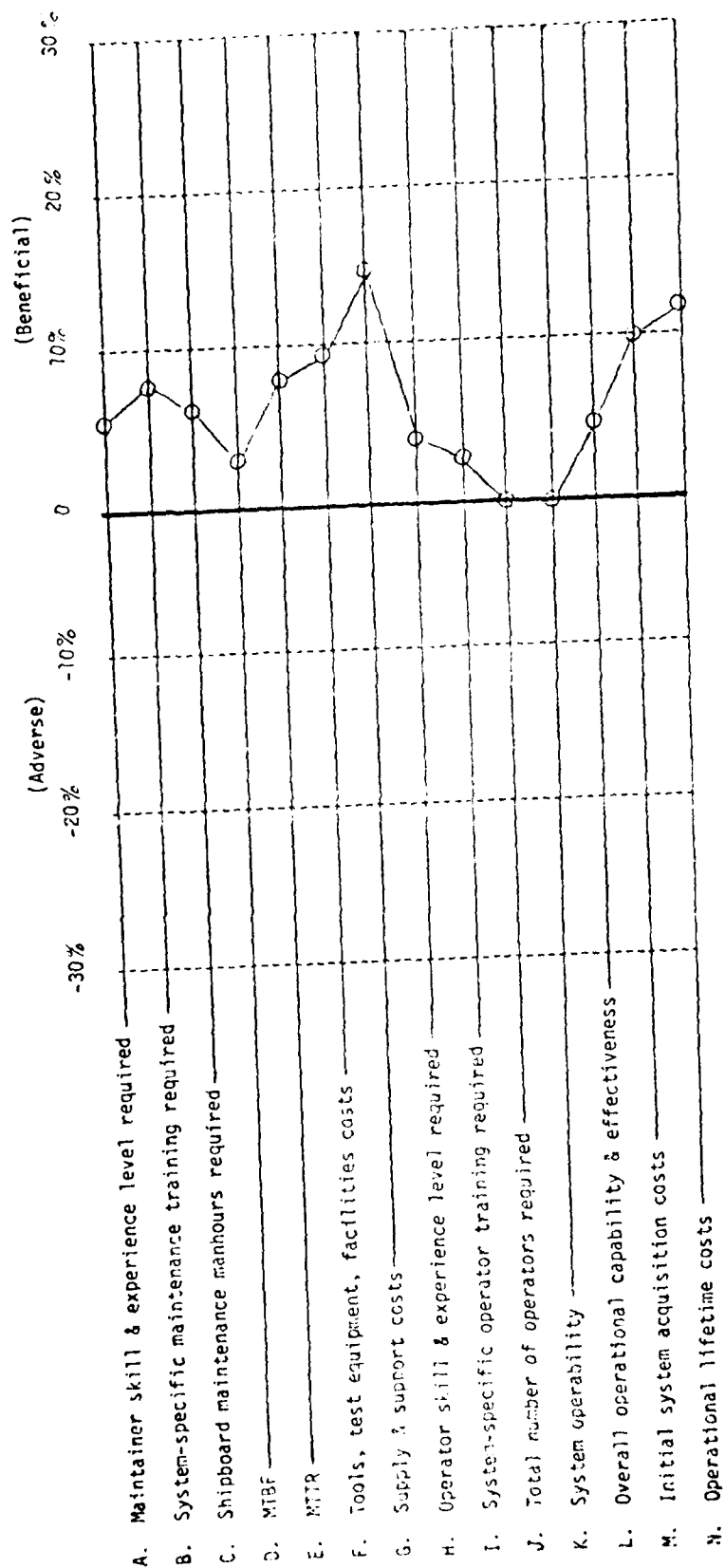
The baseline system involves the selection and use of subsystems within a system without regard for commonality across other systems found aboard ships. Little consideration is given to the availability or obtainability of subsystems in the existing Navy inventory.

PROFILE

The profile for design concept 15 is seen to be virtually identical to that for other concepts involving standardized hardware. However, standardized hardware at the subsystem level for the first time is seen to have a modest positive effect on the training and skill level of operator personnel as well as of maintainers.

The technical feasibility of employing design concept 15 was judged to be somewhat below the average of all concepts (.73), and the lowest of all concepts having to do with hardware standardization.

15. STANDARD HARDWARE--SUBSYSTEMS



16. OPERATIONAL SIMPLICITY

DEFINITION

Under this concept, equipment is designed to simplify the operator's task by minimizing the number of operating options, setup modes, processing parameters, display alternatives, etc.

BASELINE

Some systems are designed so that the operator has many choices of processing parameters, setup modes, and alternative operational configurations. This flexibility allows a properly qualified operator to optimize system operation to best fit changing operational or environmental situations.

The design concept and the baseline system represent two opposing philosophies. The baseline argues for taking advantage of all of the capability that can be engineered into the system, by giving the operator a wide range of modes and controls with which to optimize processing capability. The design concept argues for simplifying operational use by cutting out infrequently used or complex features even though this may sacrifice some potential operational capability.

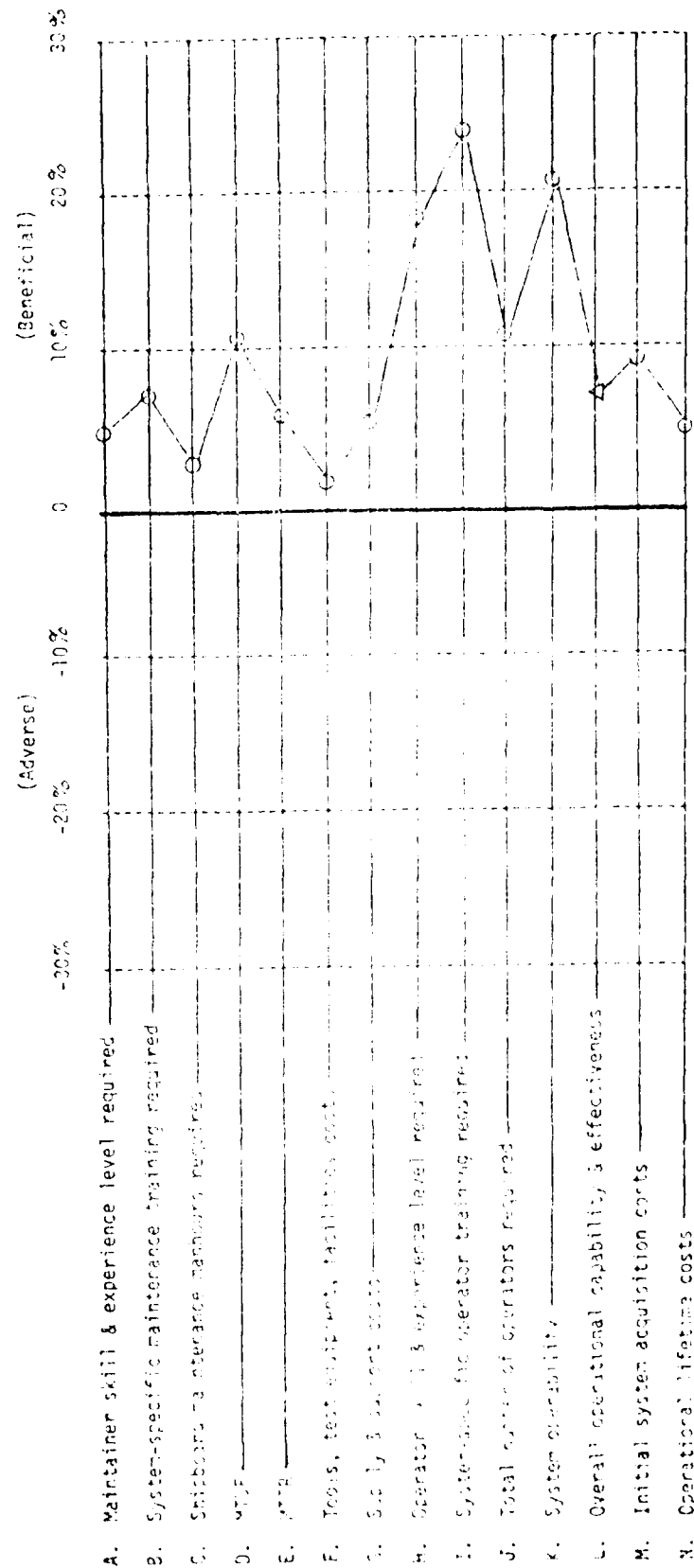
PROFILE

Concept 16 shows a strong positive profile and is viewed as having a favorable impact on virtually all system criteria. Its effects are particularly strong on required operator skill levels, operator training requirements, and system operability. Substantial secondary impacts are seen on the number of system operators likely to be required and on MTBF.

The impact of this concept on overall system effectiveness is generally seen as positive, though there was substantial disagreement on this point. One viewpoint maintains that operational simplicity will enhance system effectiveness by virtue of the fact that personnel with lower skill levels and lesser training will more likely be able to operate such a system effectively. The other maintains that operational simplicity cannot be achieved without a significant loss in overall system effectiveness. Clearly, any conflict between operational requirements and personnel skill requirements generates a major tradeoff issue.

The technical feasibility of concept 16 was rated slightly above average (.83).

16. OPERATIONAL SIMPLICITY



Δ - Substantial disagreement on impact

17. BUILT-IN OPERATOR PERFORMANCE AIDS

DEFINITION

This concept refers to computer-based systems which are provided with auxiliary software to guide the operator through setup sequences and aid him in the acquisition and management of information necessary to perform his tasks.

It includes those systems that provide operator "prompting" during menu selection tasks and other operator input functions. With such aids, systems embodying this concept can coach the operator through relatively complex procedural sequences. After beginning from one of a limited number of initial conditions, the operator has a small number of alternatives to consider at each subsequent choice point. By working through a sequence of relatively simple decisions, he eventually arrives at a point that is the terminus of a complex decision process. However, this design concept does not relieve the operator of the responsibility of interpreting displayed information and making decisions based upon it.

BASELINE

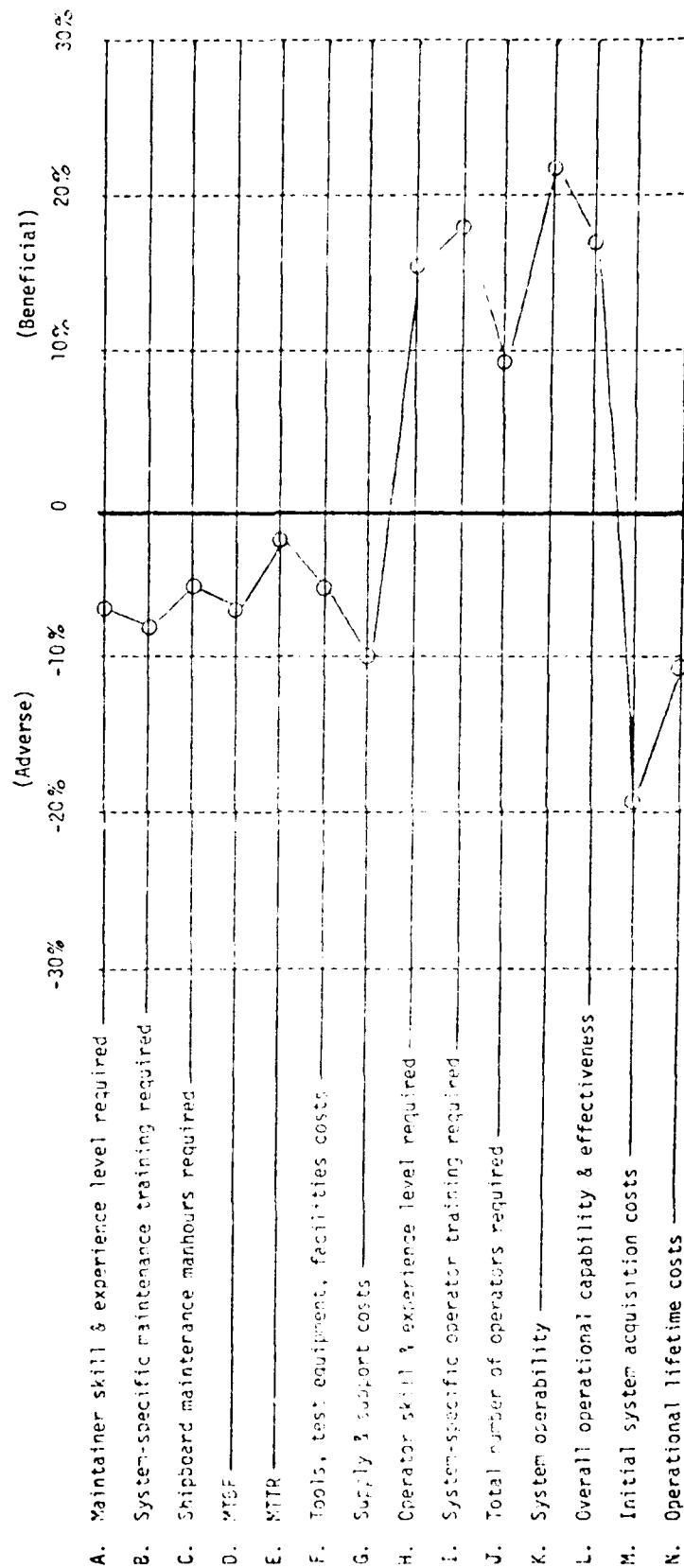
In the baseline system the operator must have complete knowledge of all the inputs required to achieve a certain setup mode or to manipulate and manage data presented by the system. Baseline systems require the correlation, analysis, and interpretation of numerous and complex types of information and rely upon the operator to set up the system to acquire various types of information, interrogate system files, integrate information, interpret it, and make decisions.

PROFILE

Design concept 17 involves a strong mixture of impacts on manpower requirements and training support. There are highly beneficial effects on system operability, overall system effectiveness, operator skill level required, and operator training. In contrast, there are substantial negative impacts on initial system acquisition costs and, to a lesser extent, on operational lifetime costs and supply/support costs. The impacts on maintenance personnel are small but consistently negative.

The technical feasibility of design concept 17 is viewed as about average (.80).

17. BUILT-IN OPERATOR PERFORMANCE AIDS



18. AUTOMATED DECISION MAKING

DEFINITION

This concept applies to computer-based systems in which primary responsibility for selecting and integrating information, interpreting it, and making decisions rests with the system software. The operator is primarily a monitor and an arbitrator of indeterminate cases.

In this concept, the operator sets up the system; then he performs monitoring and housekeeping functions (e.g., purging unwanted data). Theoretically, the operator may override or delay action on a computer decision and he may make decisions in indeterminate cases. In practice, however, many systems with automated decision making do not provide the operator with the variety of displays and information that are provided to operators of manual systems who make equivalent decisions. Thus, it may be argued that the operator/monitor of an automatic decision making system might not have sufficient information to adequately execute overriding and arbitrating decisions.

BASELINE

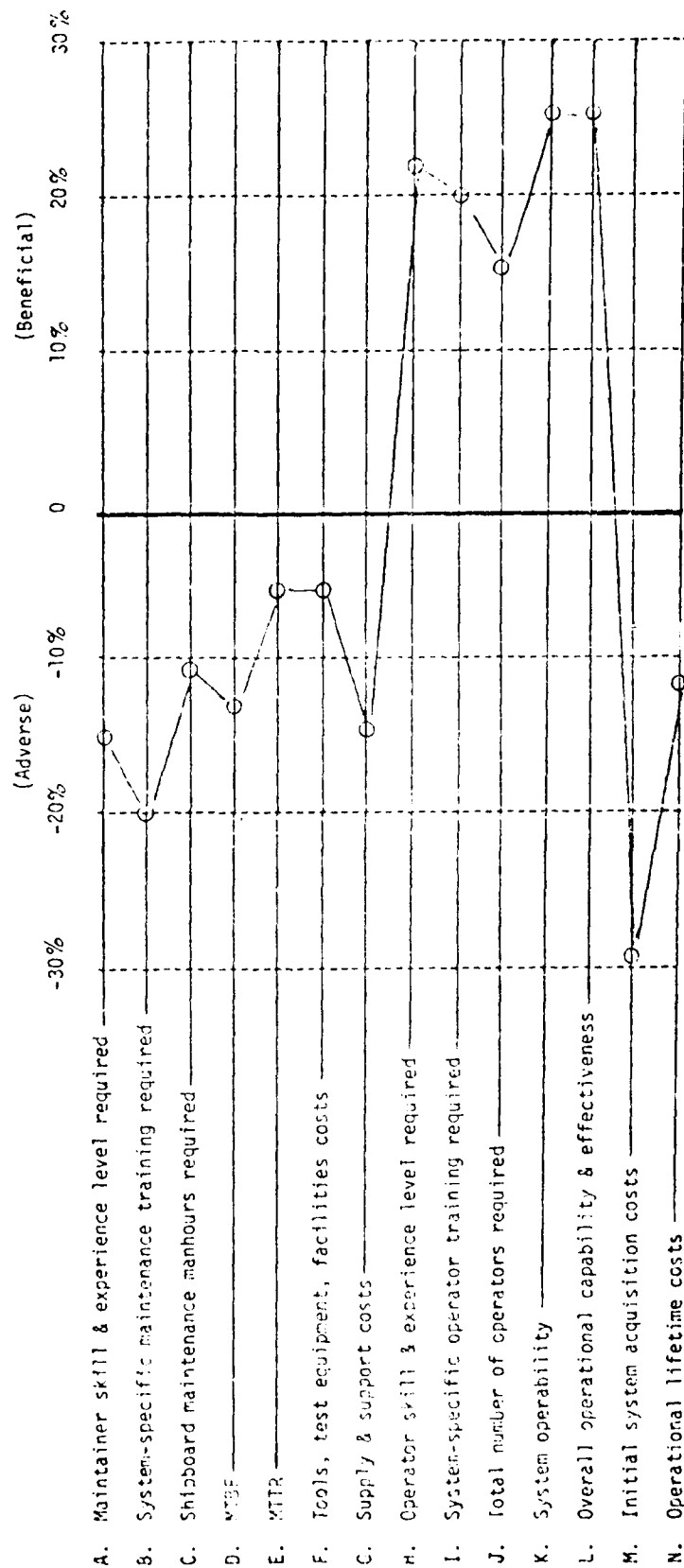
Baseline systems are those that require the correlation, analysis, and interpretation of numerous and complex types of information and rely upon the operator to set up the system to acquire various types of information, interrogate system files, integrate information, interpret it, and make decisions.

PROFILE

The profile for design concept 18 reflects highly beneficial impacts on the number of system operators, their required skill levels and training, as well as system operability and overall effectiveness. However, the profile also reflects substantial negative impacts on initial system acquisition costs and virtually all maintenance-oriented functions.

It is noteworthy that design concept 18 received the lowest technical feasibility rating (.65) of all concepts studied.

18. AUTOMATIC DECISION MAKING



19. AUTOMATED INFORMATION TRANSMISSION AND DISPLAY

DEFINITION

In this design concept, functions requiring runners, phone talkers, plotters, etc., are reduced in number through system features that automatically transfer information from one station to another and automatically format it for display.

BASELINE

The baseline refers to shipboard information transmission and display functions which are accomplished in a traditional, nonautomated fashion using phone talkers, runners, plotters, status board keepers, etc.

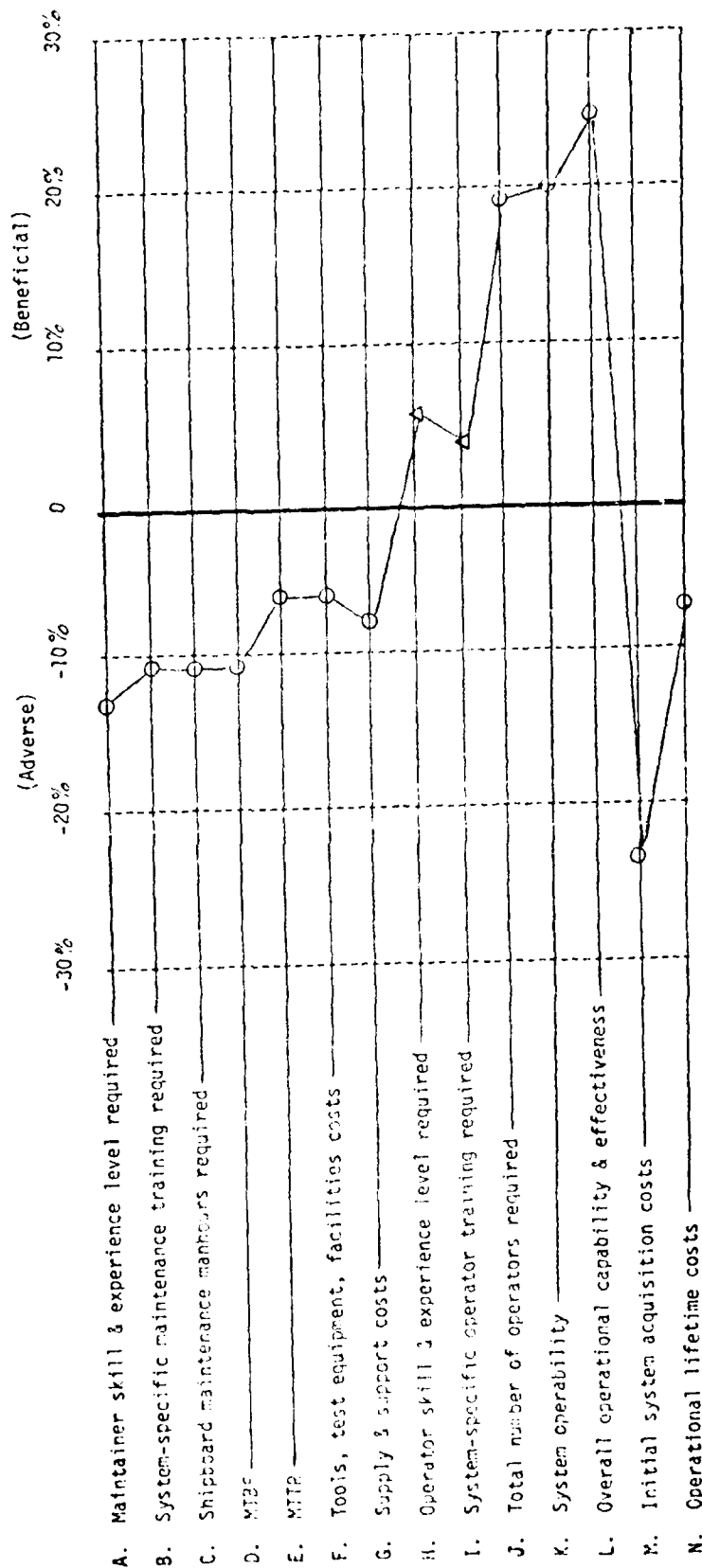
PROFILE

The profile of design concept 19 shows a very positive impact on the number of operational personnel required and on system operability and overall effectiveness. There was considerable disagreement concerning its impact on operator skill level and training, some feeling that the employment of automated transmission and display features increases required skill levels and training, though the majority felt that it would decrease them. This may be a system-specific consideration.

As with some other design concepts that are viewed as having very beneficial effects on operator personnel, design concept 19 was considered to have a negative impact on initial acquisition costs and on most system maintenance criteria.

Design concept 19 was rated average (.80) in technical feasibility.

19. AUTOMATIC INFORMATION TRANSMIT & DISPLAY



Δ - Substantial disagreement on impact

20. BUILT-IN TRAINING CAPABILITY

DEFINITION

In this design concept computer-based systems are provided with additional software and possibly some hardware (a modest instructor terminal in some cases) to perform shipboard training. The training subsystem should reflect a detailed analysis of onboard training requirements and provide additional system features to facilitate effective onboard training.

Trainees operate the system in a training mode during noncritical operating periods at sea, and when in port.

BASELINE

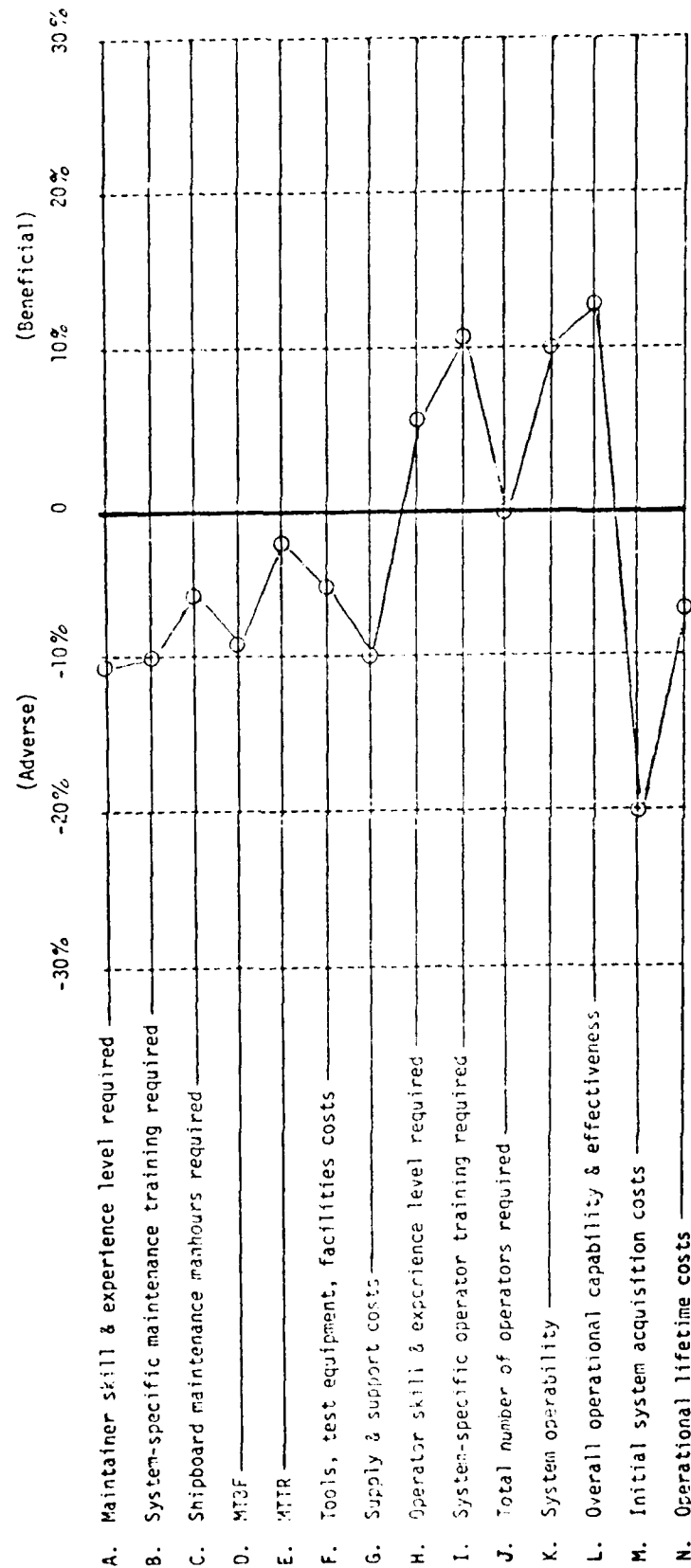
Baseline systems are those which are built to achieve operational goals only; no provisions for training are designed into them. It is expected that formal training will be accomplished primarily at shore-based facilities, and that required shipboard training will be achieved on the job or by "looking over the shoulders" of experienced operators.

PROFILE

The profile of design concept 20 shows significant benefits with respect to operator training, system operability, and overall system effectiveness. As with other design features benefiting operators, this comes at a cost to initial acquisition and to the shipboard maintenance function.

The technical feasibility of this concept was judged to be slightly below average (.76).

20. BUILT-IN TRAINING CAPABILITY



21. COMBINED OPERATOR/MAINTAINER FUNCTIONS

DEFINITION

In this concept, equipment is both operated and maintained by the same personnel. While combined operator/maintainer functions is not a design feature per se, as a concept it may have an impact on how the system must be designed in order to cope with, or take advantage of, combined operator/maintainer personnel (depending on your point of view).

BASELINE

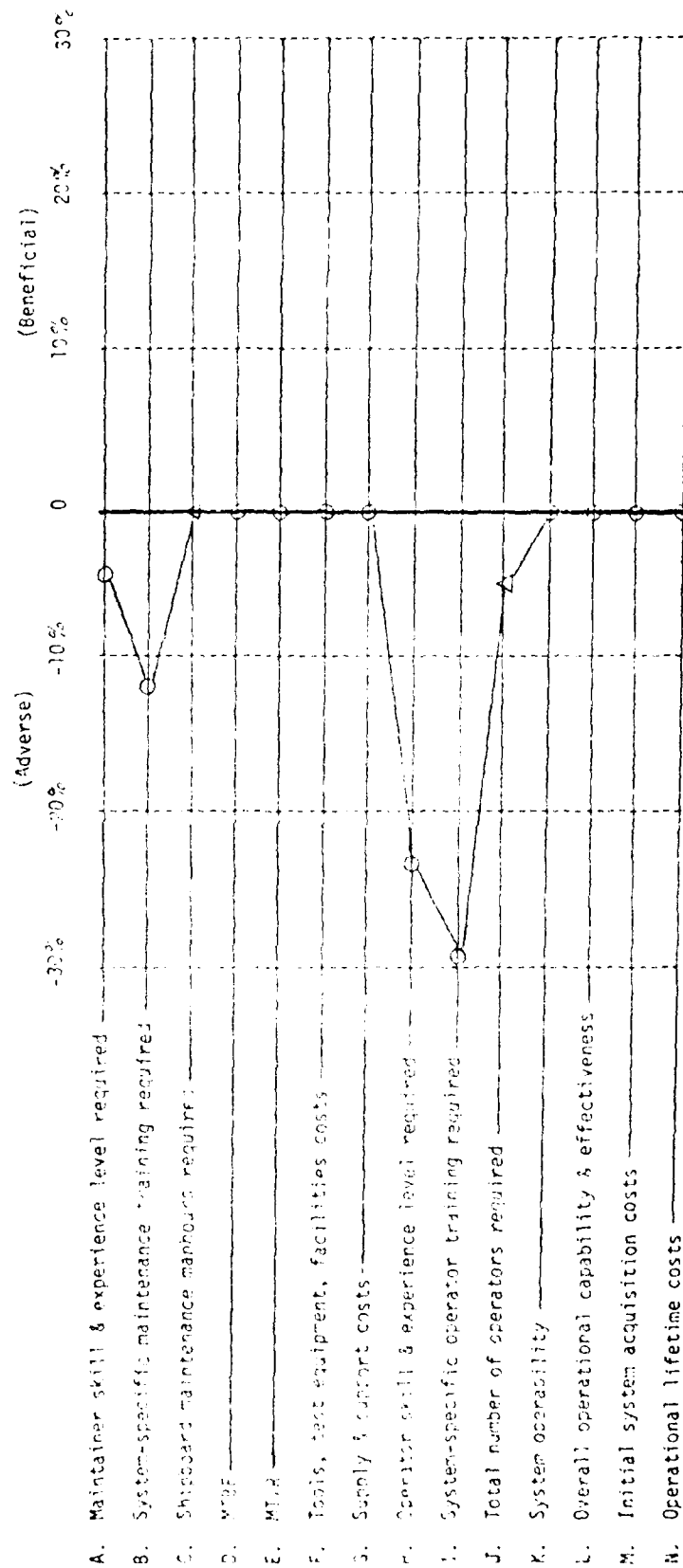
Commonly, two separate categories of personnel have been used to operate and maintain most electronic systems.

PROFILE

The profile of this concept shows that it was generally viewed as having a strong adverse impact on operator training requirements and skill levels required. This is interpreted to mean that operators would require substantially more training than they presently do if they were to be given responsibility for maintaining their systems as well as operating them. There is a smaller but still substantial negative impact on the training of maintenance personnel as well. However, it is evident that this concept was viewed as requiring a greater training increment to make maintainers out of operators than for making operators out of maintainers.

The technical feasibility of this concept was rated as relatively low (.71).

21. COMBINED OPERATOR/MAINTAINER FUNCTIONS



Δ - Substantial disagreement on impact

SECTION 2

INTERACTION OF DESIGN CONCEPT IMPACTS ON DIFFERENT SYSTEM DESIGN CRITERIA

ADDRESSING QUESTION 2

How do the manpower and training considerations interact with other criteria used in evaluating system design?

The information presented in this section is complementary to that presented in Section 1. First, all the evaluative criteria are defined, and then a profile is presented for each criterion showing how all 21 design concepts impact on it. Figure 5 shows where this information may be used in the overall design process.

EVALUATIVE CRITERIA

What evaluative criteria are we talking about?

The evaluative criteria, and the page numbers on which their definitions will be found, are as follows:

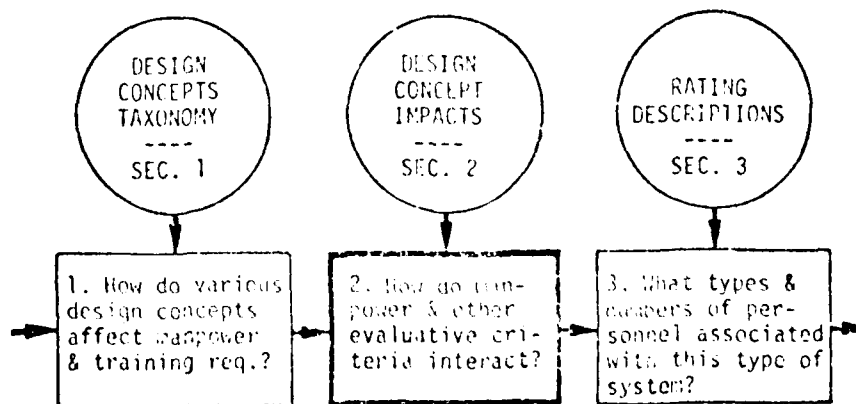


Figure 5. Addressing Question 2.

• Maintainer skill and experience level required	2-4
• System-specific maintenance training required	2-6
• Shipboard maintenance man-hours required	2-8
• Mean time between failures (MTBF)	2-10
• Mean time to repair (MTTR)	2-12
• Tools, test equipment, and facilities costs	2-14
• Supply and support costs	2-16
• Operator skill and experience level required	2-18
• System-specific operator training required	2-20
• Total number of operators required	2-22
• System operability	2-24
• Overall operational capability and effectiveness	2-26
• Initial system acquisition costs	2-28
• Operational lifetime costs	2-30

The designer may find the profiles in this section particularly helpful in identifying design concept alternatives that are more effective or less costly in some respect than his initial choice. Those design concepts that have particularly pronounced (or very little) effects on a selected evaluative criterion can quickly be spotted.

For example, if he is concerned with the amount of system-specific maintenance required, inspection of pages 2-6 and 2-7 shows that such concepts as remote repair, throwaway maintenance, troubleshooting logic aids, and automatic fault localization all impact this criterion quite favorably. The same profile also shows, however, that such concepts as embedded computers, automatic decision making, automatic information transmission, and built-in training capability impact this criterion quite unfavorably.

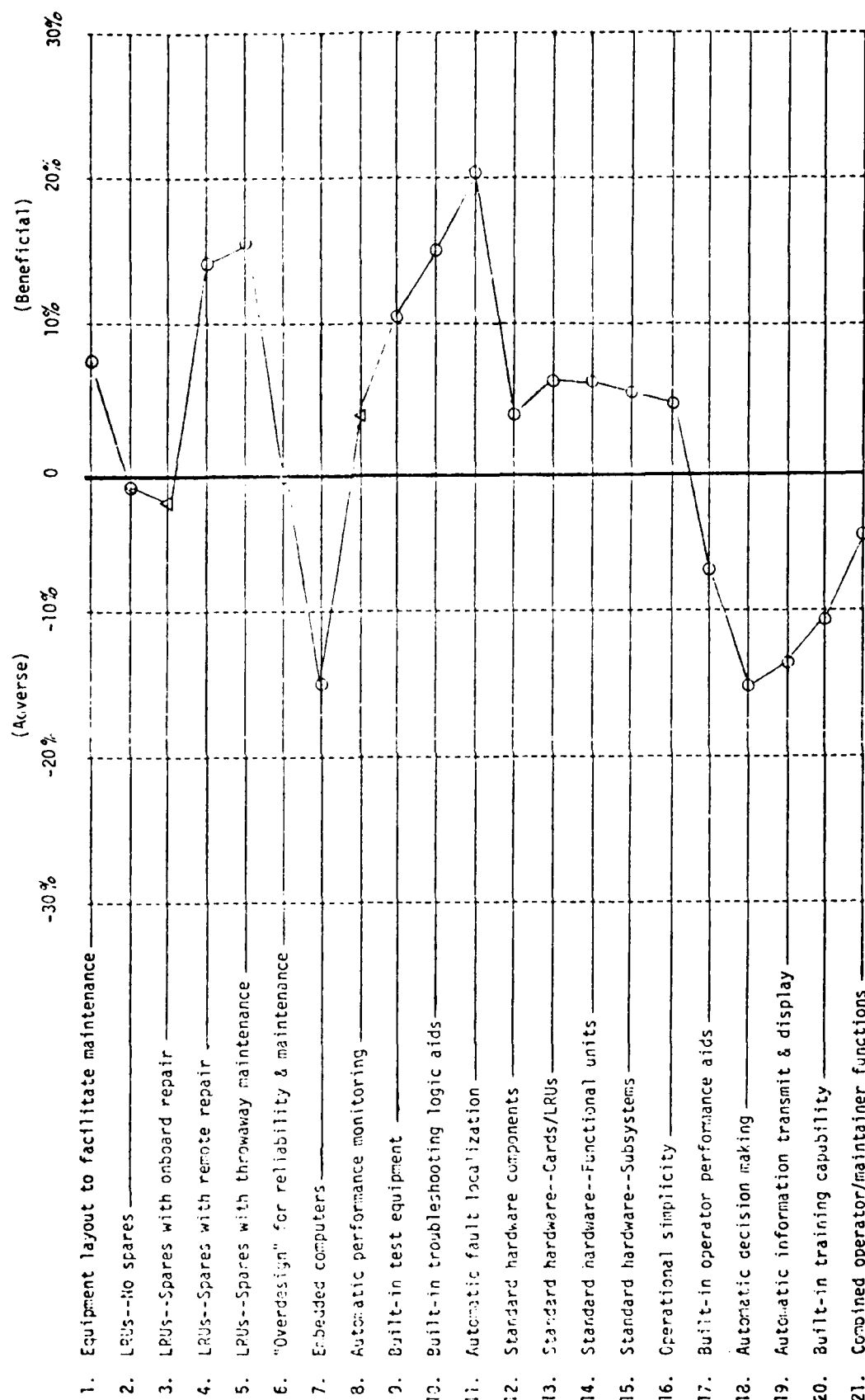
How the data comprising these profiles can be conveniently used in design tradeoff studies is explained in Section 5.

PROFILES OF SYSTEM DESIGN CRITERIA

A. GENERAL MAINTENANCE SKILL AND EXPERIENCE LEVEL REQUIRED

The judges compared the general skill and/or experience level of personnel required to effectively perform all required shipboard maintenance on the baseline system versus a system incorporating the design concept. Their ratings reflect the percentage change, upward or downward, of the number of people beyond their first enlistment required to fully maintain the system.

A. MAINTAINER SKILL & EXPERIENCE LEVEL REQUIRED

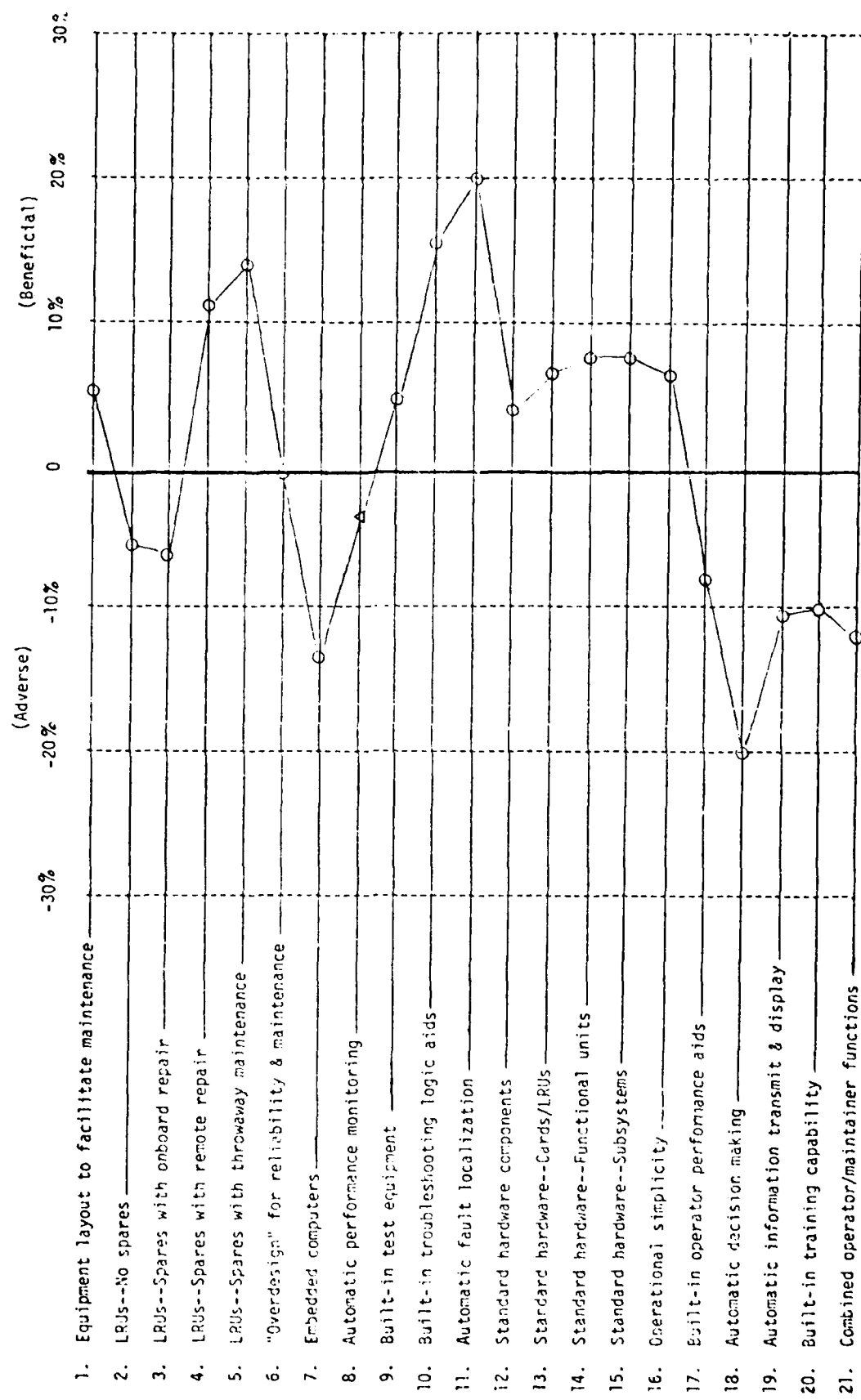


Δ - Substantial disagreement on impact

B. SYSTEM-SPECIFIC MAINTENANCE TRAINING REQUIREMENTS

The judges considered the necessary duration of all system-specific maintenance training, such as that included in C-school and other special courses, in estimating the increased or decreased training time requirements for developing a qualified shipboard maintainer of a system employing the design concept versus the baseline approach. If it was felt that prerequisite NECs would be required to be eligible for maintenance training on either the baseline or the design concept system, the training time required to achieve those NECs was considered as well.

B. SYSTEM-SPECIFIC MAINTENANCE TRAINING REQUIRED

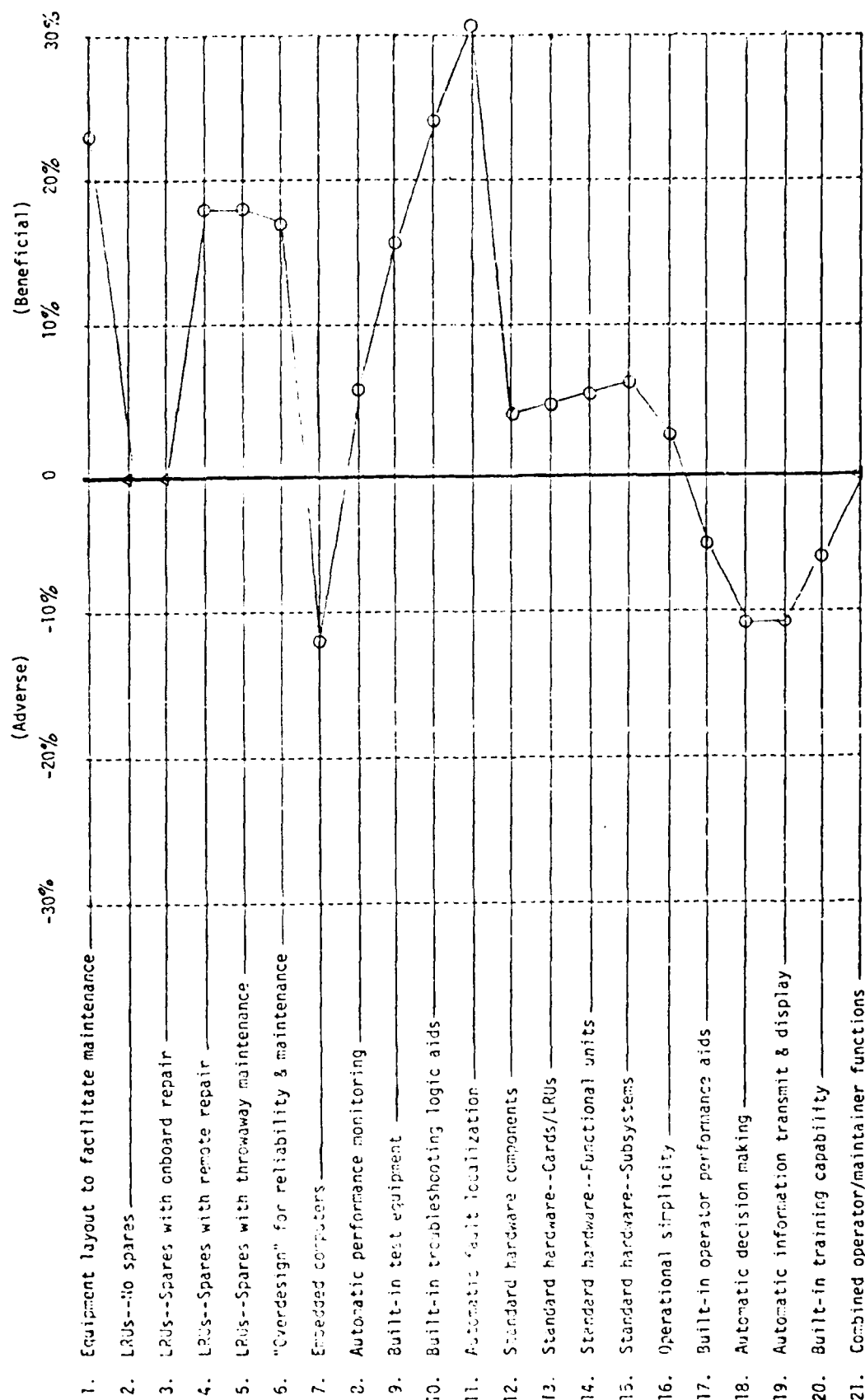


△ - Substantial disagreement on impact

C. TOTAL NUMBER OF SHIPBOARD MAINTENANCE MAN-HOURS REQUIRED

This criterion reflected the increase or decrease, in comparing the baseline and design concept systems, that would occur solely in the man-hours of maintenance required onboard ship for a given system. The total maintenance workload including both preventive and corrective maintenance was considered.

C. SHIPBOARD MAINTENANCE MAN-HOURS REQUIRED

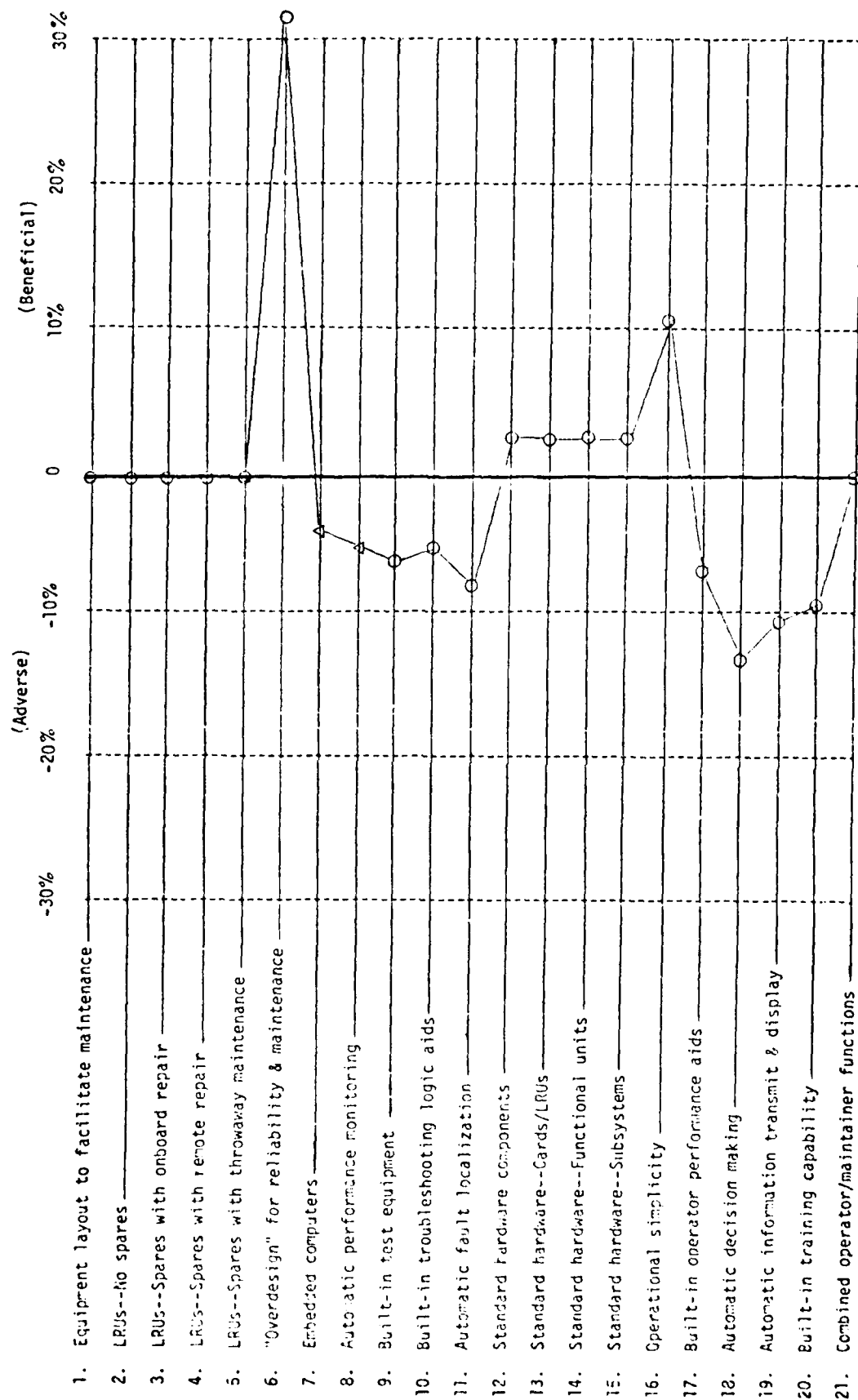


Δ - Substantial disagreement on impact

D. SYSTEM RELIABILITY--MTBF (MEAN TIME BETWEEN FAILURES)

This criterion focused on MTBF as the classic measure of system reliability. The judges considered the percentage increase or decrease in this measure of reliability that might be expected in going from the baseline to the design concept for a given system.

D. MTBF

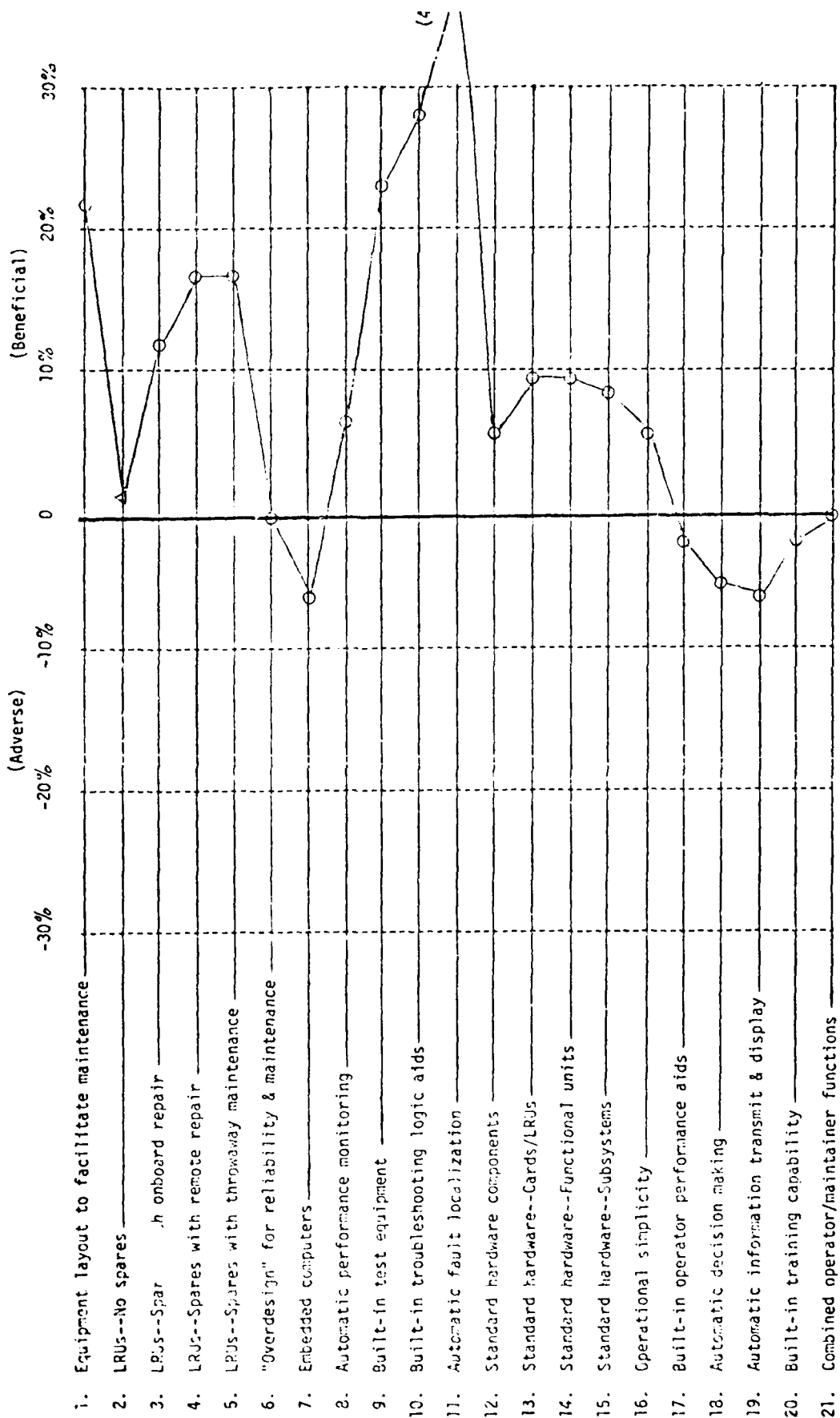


Δ - Substantial disagreement on impact

E. SYSTEM MAINTAINABILITY--MTTR (MEAN TIME TO REPAIR)

This criterion focused on one of the standard measures of maintainability, the average time it takes for a system to be repaired. This includes the time to isolate the fault, the time to repair the fault (this may be a remove-replace under certain design concepts), and the time to verify that the fault has been corrected. Supply time was not included in this dimension.

E. MTTR

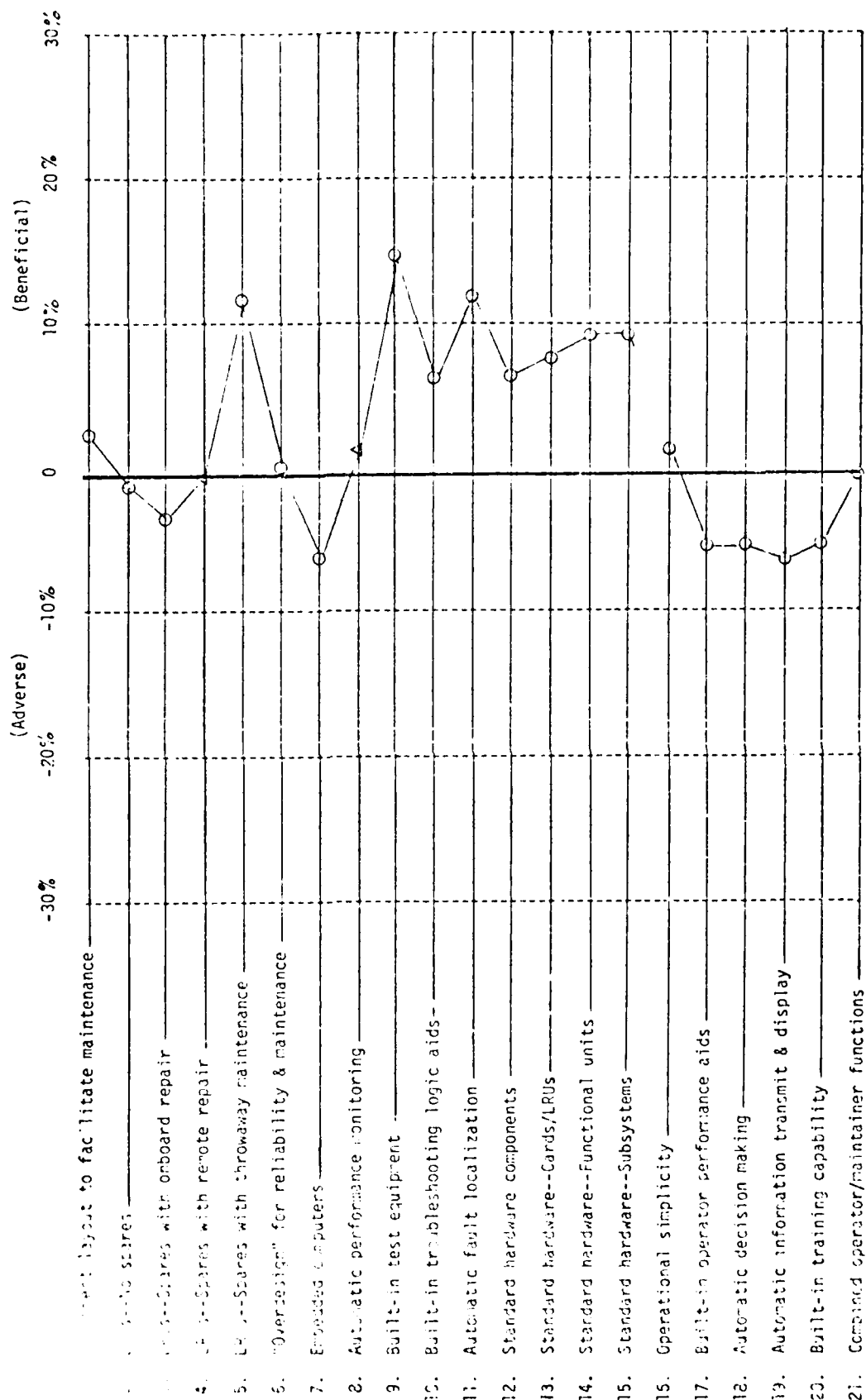


1. - Substantial disagreement on impact

F. TOOLS, TEST EQUIPMENT, AND FACILITIES COSTS

This criterion was defined as an aggregate estimate of all the costs involved in providing adequate separate tools, test equipment, and facilities to maintain a system; built-in test equipment (BITE) costs were not included in this definition. The judges considered all levels of maintenance (shipboard, tender, depot, and factory) in estimating the percent improvement (reduction in costs) or degradation (increase in costs) in going from the baseline to the design concept.

F. TOOLS, TEST EQUIPMENT, FACILITIES COSTS

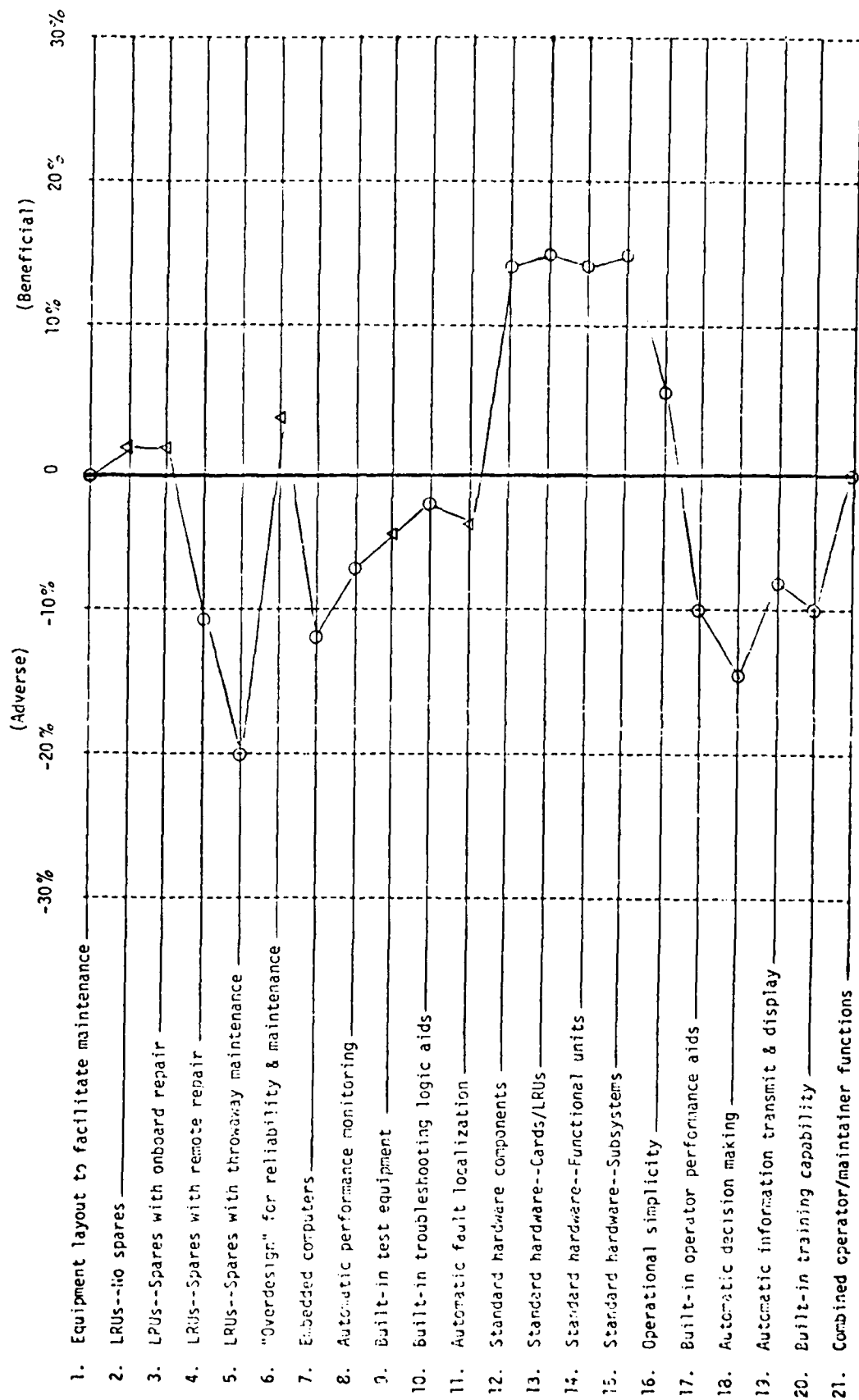


7 - Substantial disagreement on impact

G. SUPPLY AND SUPPORT COSTS

For this dimension the judges considered the costs of acquisition, cataloging, packaging, preservation, receipt, storage, transfer, issue, and disposal of spares and repair parts associated with a system that is designed according to the baseline versus one that is designed according to a design concept.

G. SUPPLY & SUPPORT COSTS

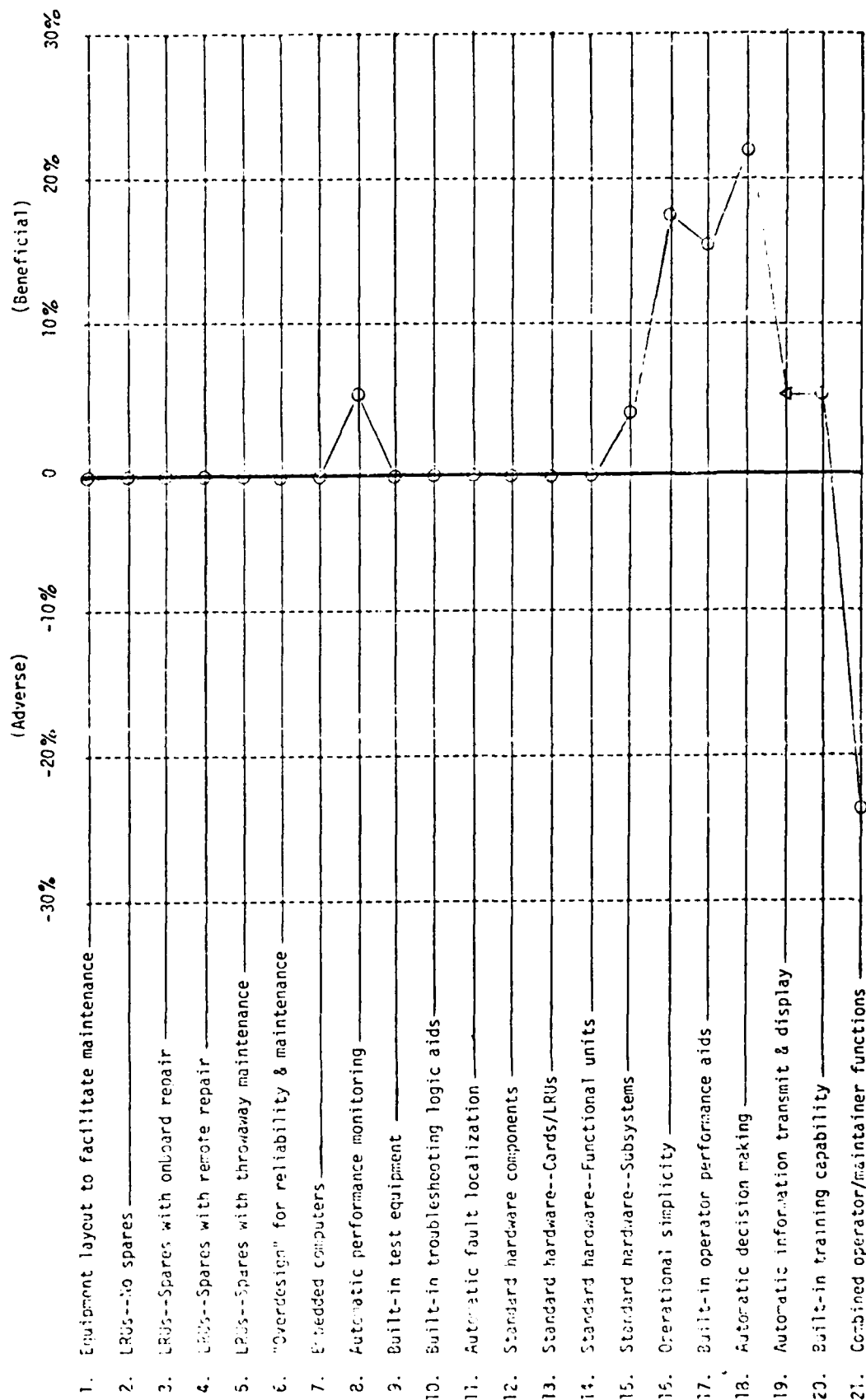


6. - Substantial disagreement on impact

H. REQUIRED GENERAL SKILL AND EXPERIENCE LEVEL OF OPERATORS

The judges considered the increase or decrease, in going from the baseline to the design concept, in the average, general skill and/or experience level of personnel required to operate the system. They estimated the percentage change, upward or downward, in the number of people beyond their first enlistment required to ensure a high degree of system operational effectiveness. They considered requirements for team coordination as well as individual skill levels.

H. OPERATOR SKILL & EXPERIENCE LEVEL REQUIRED

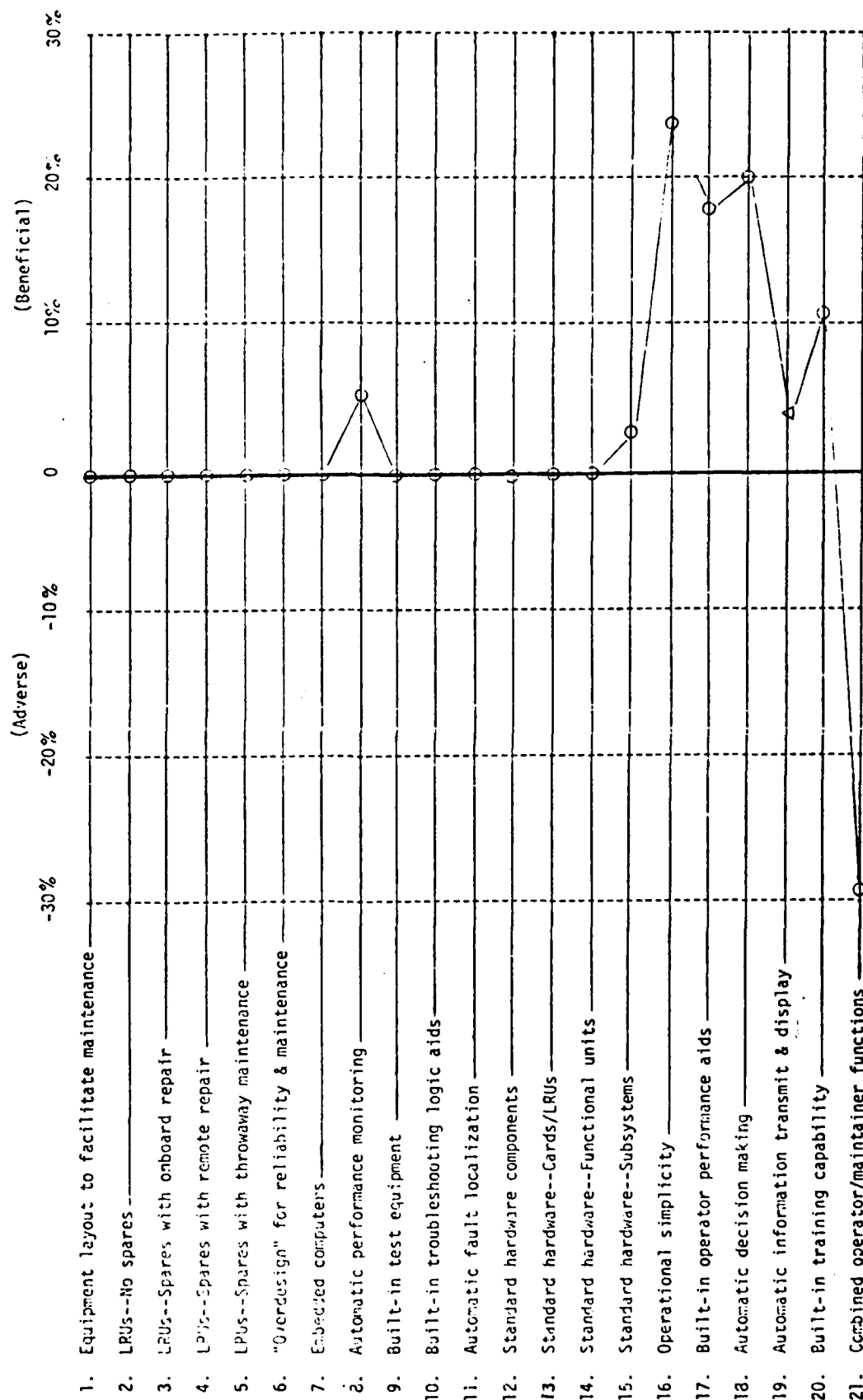


4 - Substantial disagreement on impact

I. SYSTEM-SPECIFIC OPERATOR TRAINING REQUIREMENTS

This criterion concerned the amount of initial training time required to develop qualified operators for a system and how that time might be increased or decreased as a result of going from the baseline to the design concept. The judges considered both operator training as typically given in that portion of A-school training that focuses on particular systems, as well as any special operational courses that might be required. They also considered the amount of on-the-job training (OJT) that might be necessary aboard ship before an operator becomes fully qualified.

I. SYSTEM-SPECIFIC OPERATOR TRAINING REQUIRED

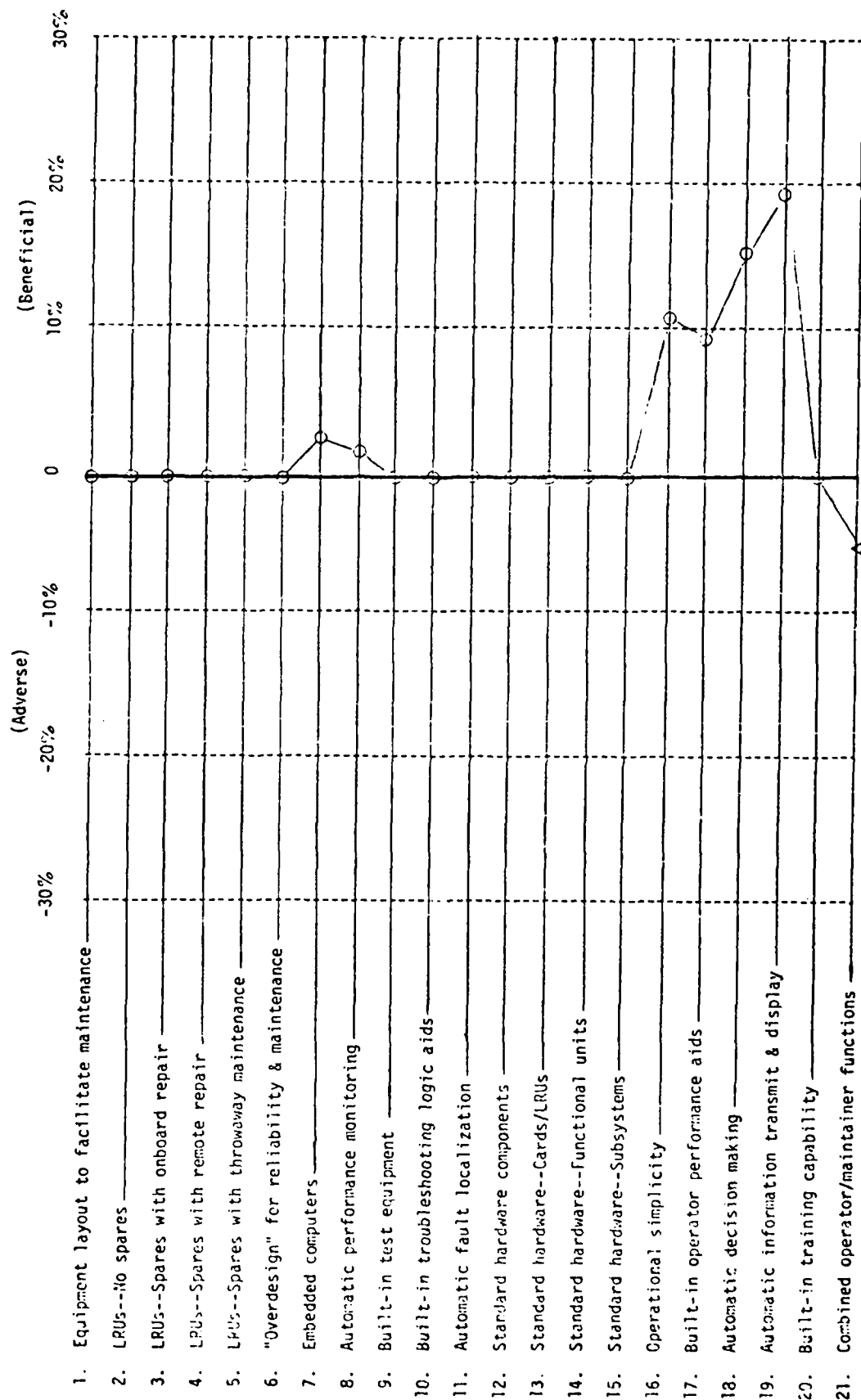


△ - Substantial disagreement on impact

J. TOTAL NUMBER OF OPERATORS REQUIRED

This criterion was defined as the total number of operators that would be required to man the system under the most demanding operational circumstances. In estimating the required number of operators for a baseline versus a design concept, the judges considered both the number of operator stations and the total operator task load associated with the use of each concept.

J. TOTAL NUMBER OF OPERATORS REQUIRED

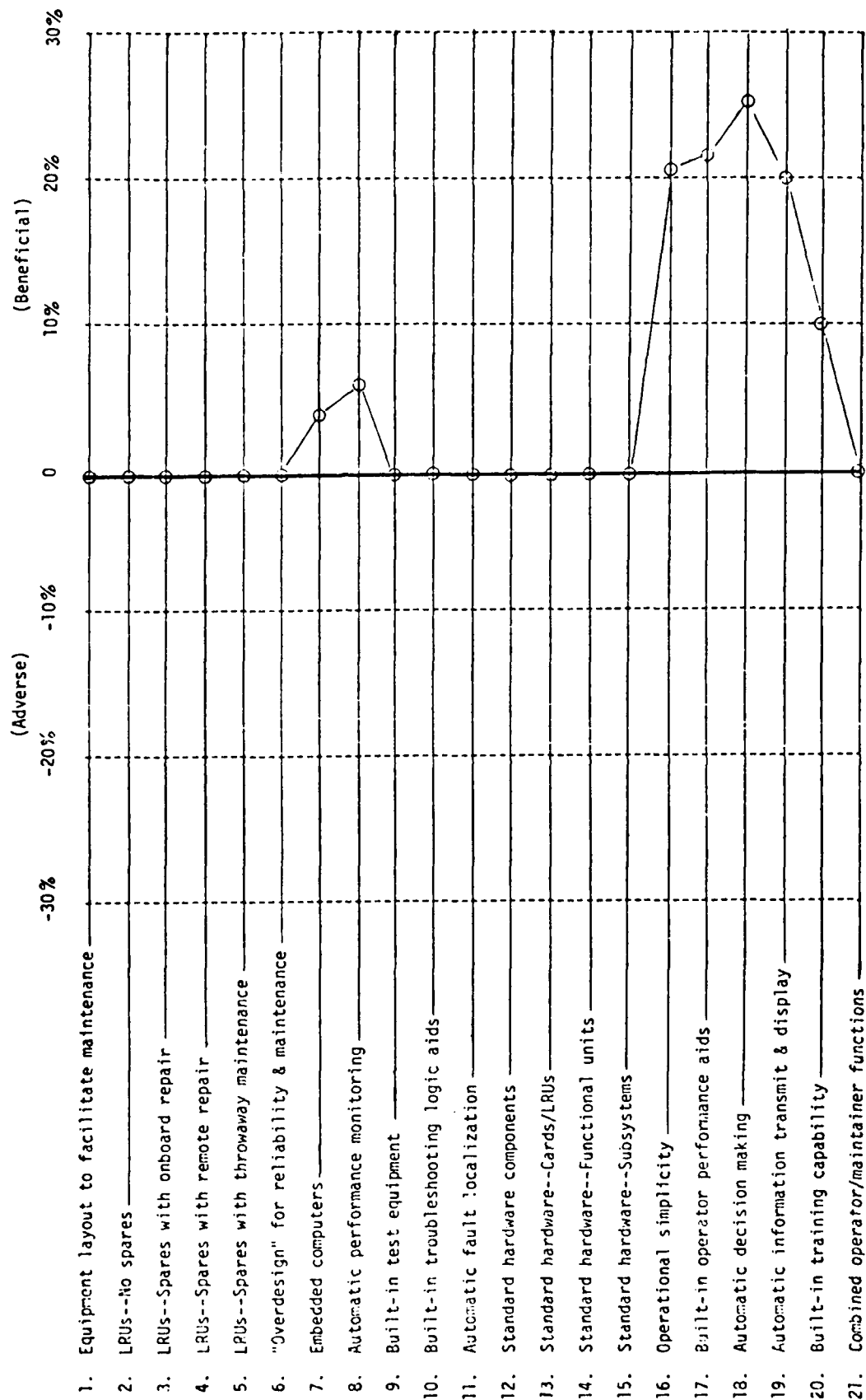


2 - Substantial disagreement on impact

K. SYSTEM OPERABILITY

This criterion focused on those aspects of the system design that relate to easy or difficult operation, operator error rate, and operational reaction time. Taking into account such parameters, the judges considered both the number of operator stations and the total operator task load associated with the use of each concept.

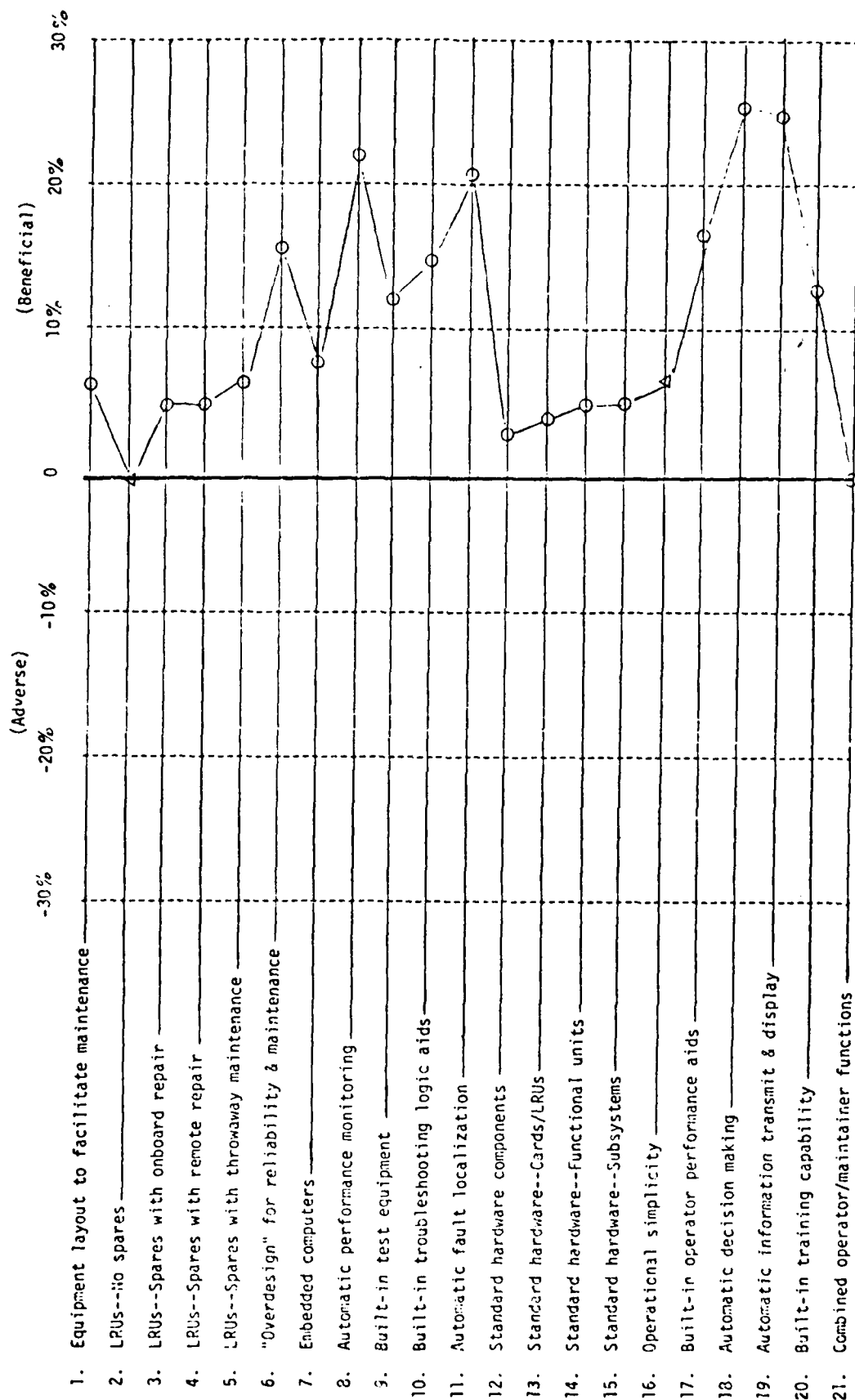
K. SYSTEM OPERABILITY



L. OVERALL OPERATIONAL CAPABILITY AND EFFECTIVENESS

This criterion concerned the capability of a system employing the design concept compared to a baseline system for fully meeting all operational requirements. The judges considered the likely improvement or degradation of total capability and effectiveness in going from a baseline to a design concept.

L. OVERALL OPERATIONAL CAPABILITY & EFFECTIVENESS



△ - Substantial disagreement on impact

M. INITIAL SYSTEM ACQUISITION COSTS

Under this criterion, consideration was given to all initial acquisition costs, including design, development, and operational shakedown for both system hardware and software. In addition, because any necessary system trainers are usually considered to be part of initial system acquisition, the cost of such trainers was included in this consideration. The judges estimated the percentage increase or decrease of initial acquisition costs for a system employing the design concept as compared to the baseline system.

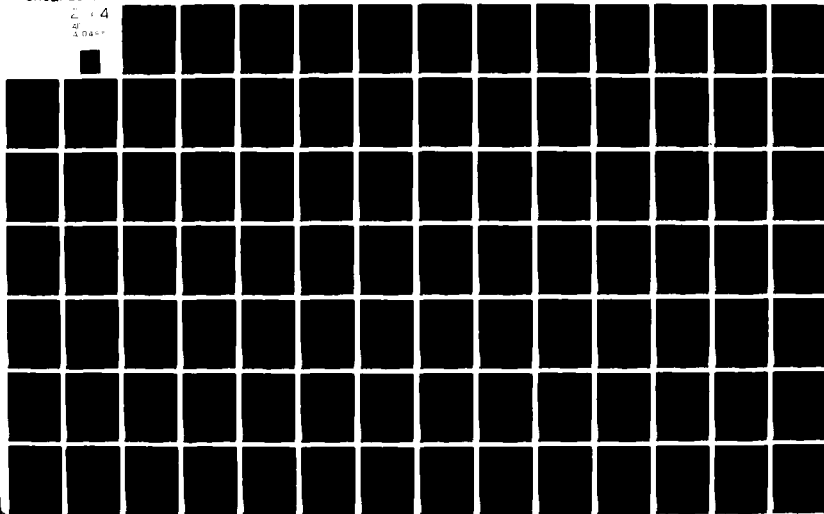
AD-A104 839 NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER SAN D--ETC F/G 5/8
AN ENGINEER'S GUIDE TO THE USE OF HUMAN RESOURCES IN ELECTRONIC--ETC(U)

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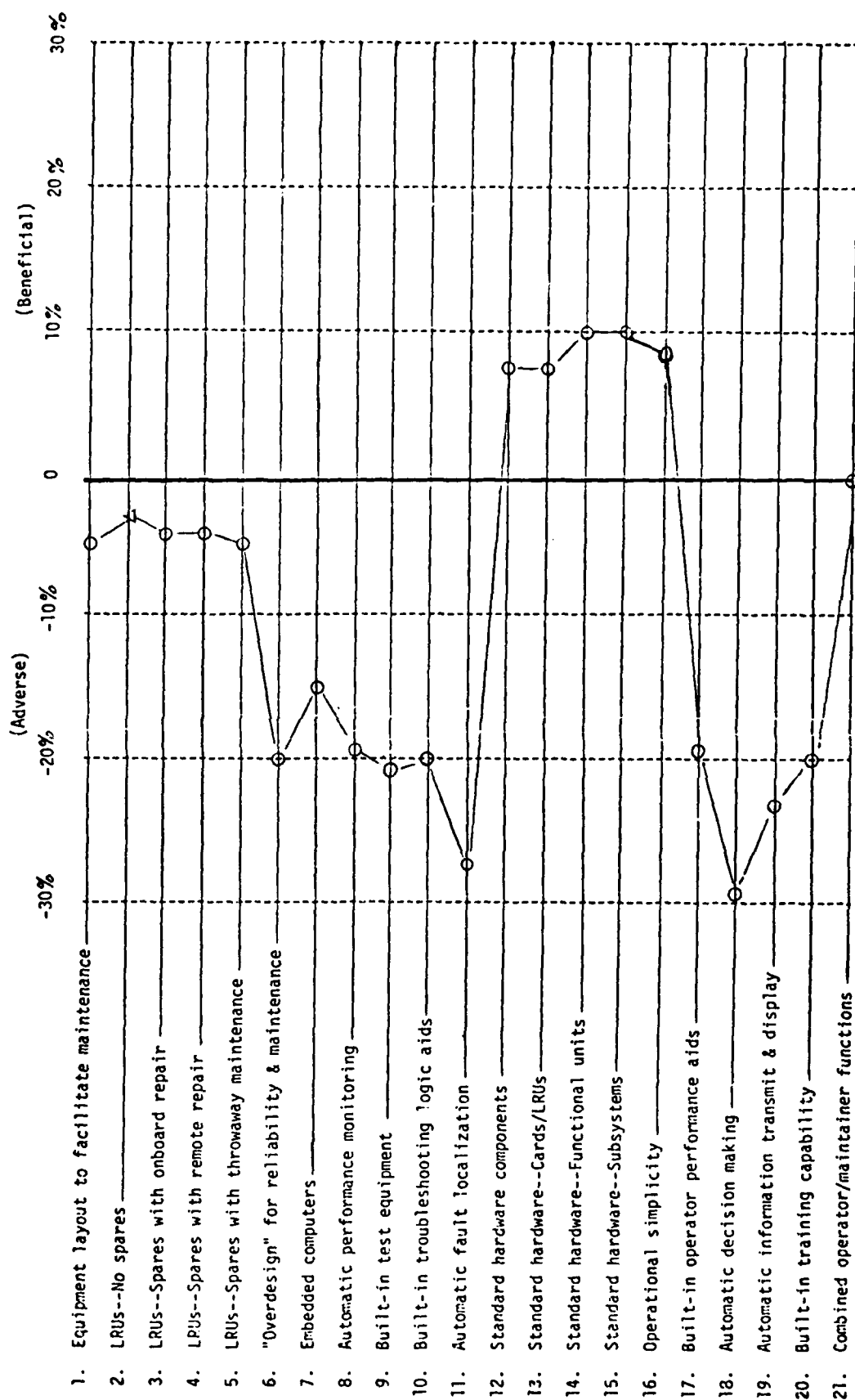
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M. INITIAL SYSTEM ACQUISITION COSTS

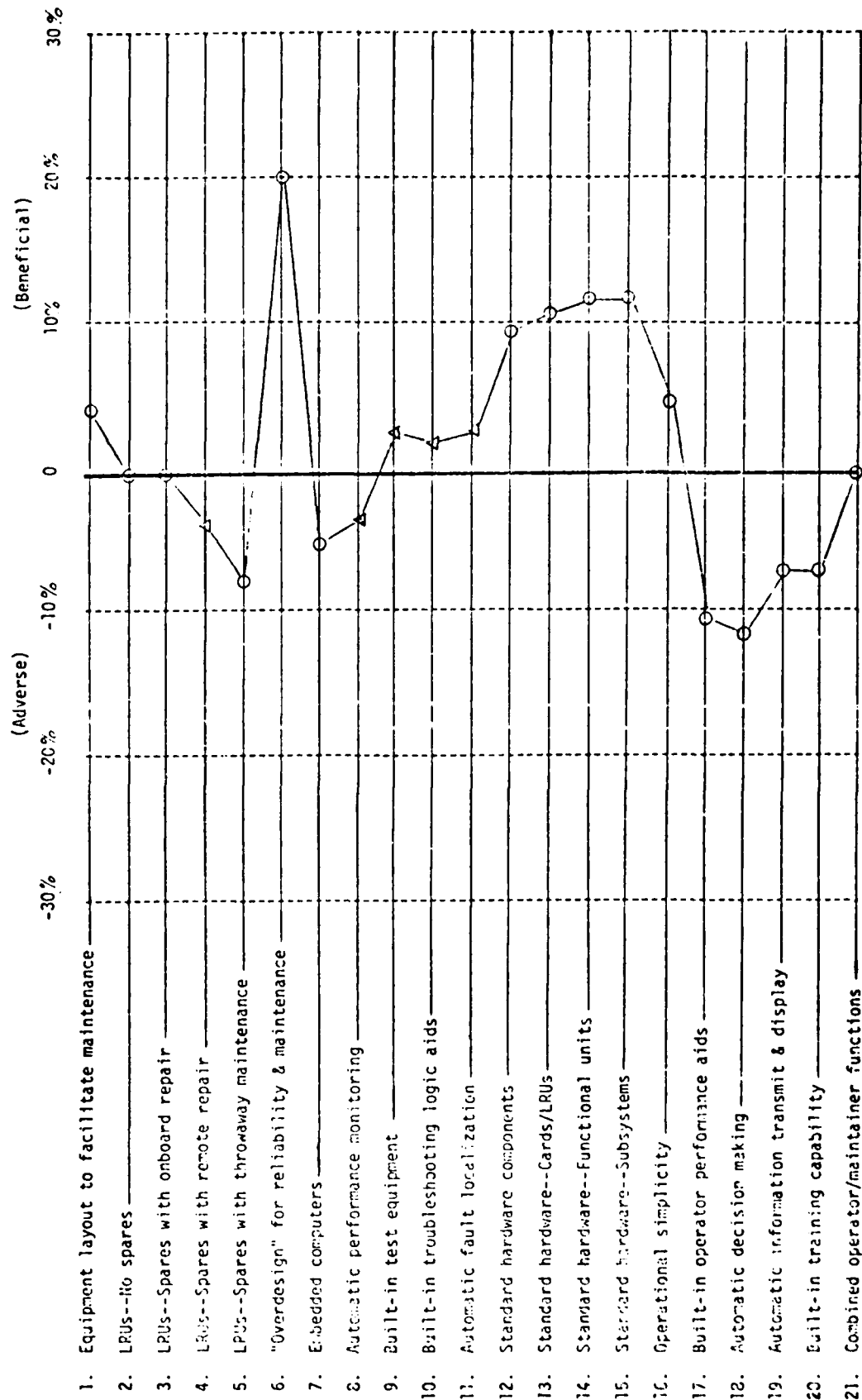


Δ - Substantial disagreement on impact

N. OPERATIONAL LIFETIME COSTS

For this criterion, the percentage increase or decrease that might be expected to result in going from the baseline approach to the design concept for a given system, for all the hardware and software required over a 20-year lifecycle, was considered. This criterion excluded initial acquisition costs and lifecycle personnel costs since the impact of these variables was considered elsewhere.

N. OPERATIONAL LIFETIME COSTS



0 - Substantial disagreement on impact

SECTION 3

TYPES OF TECHNICIANS ASSIGNED TO
SURFACE SHIP ELECTRONIC SYSTEMS

ADDRESSING QUESTION 3

What types and numbers of Navy personnel typically operate and maintain this type of system?

Table 2 and the subsequently presented descriptions identify the types of technicians, and their official responsibilities, used for the operation and maintenance of surface ship radar, sonar, communications, fire control, and data processing systems. This information is presented here for the convenience of those who are not already familiar with the Navy's personnel classifications. It will help the designer answer Question 3, as shown in Figure 6.

As noted earlier, some complex computerized systems will generate maintenance tasks that cut across these traditional areas of responsibility. This may have important implications not only for personnel supply (Section 4) but for training support (Section 8).

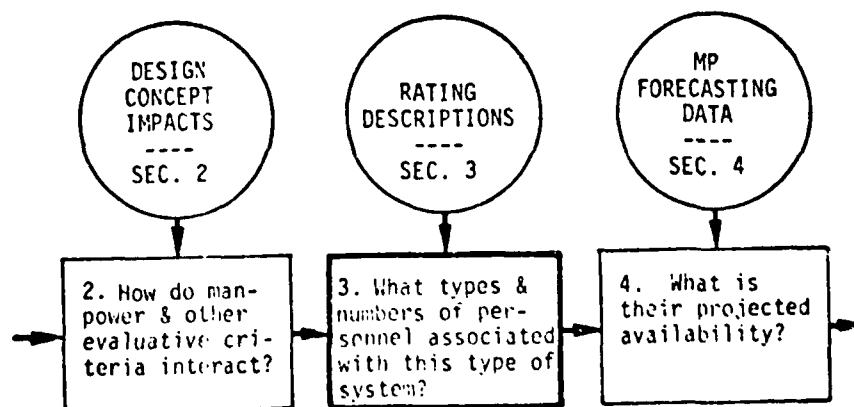


Figure 6. Addressing Question 3.

A LOOK AT PREDECESSOR SYSTEMS

The designer should be aware of the numbers and skill levels (pay grades) of personnel authorized to operate and maintain appropriate predecessor systems.

Since a design objective should be, if possible, to reduce the demand on human resources compared to earlier systems, the designer needs information concerning the officially approved manning quotas for the predecessor system that the new system will replace. This information is obtainable in official Ship Manpower Documents which are developed and maintained by OPNAV 111C1 (Ship Manpower Requirements).

TABLE 2
TECHNICIANS RESPONSIBLE FOR SELECTED
SURFACE SHIP ELECTRONIC SYSTEMS

TYPE OF PERSONNEL	TYPE OF SYSTEM					
	Data Systems	Communi- cations	Fire Control (Missile)	Navi- gation	Radar	Sonar
Data Systems Technician (DS)	M					
Electronics Technician [ET(N)]		M		M		
Electronics Technician [ET(R)]				M	M	
Fire Control Technician (FTM)			O/M		M	
Radioman (RM)		O/M				
Sonar Technician (STG)						O/M

M = Maintenance responsibility

O = Operational responsibility

OFFICIAL RESPONSIBILITIES OF SELECTED TECHNICIANS (SOURCE: NAVPERS 18068D)

Data Systems Technicians (DS) perform organizational and intermediate maintenance on electronic digital data systems and equipment; inspect, test, calibrate, and repair computers, external storage devices, digital interface equipment, digital display equipment, data link terminal equipment, peripheral equipment, and related equipment; perform preventive maintenance on test equipment; and prepare and use programmed test routines.

Electronics Technicians, Communications (ETN) perform organizational and intermediate level maintenance on communication equipment, electronic cryptographic equipment, and aids to navigation.

Electronics Technicians, Radar (ETR) perform organizational and intermediate level maintenance on electronic surface and air detection and tracking equipment, electronic recognition and identification equipment, and aids to navigation.

Fire Control Technicians, Surface Missile Fire Control (FTM) perform organizational and intermediate level maintenance on missile fire control systems (including weapons direction systems and search radars), missiles, telemetry equipment, and associated support equipment; operate, test, and repair shipboard missile fire control systems (including weapons direction systems and search radars), missiles, telemetry equipment, and associated support equipment.

Radiomen (RM) transmit, receive, and process all forms of telecommunications through various transmission media, applying the basic principles of reliability, security, and speed in accordance with appropriate doctrinal and procedural publications; operate, monitor, and control telecommunications transmission, reception, terminal, and processing equipment; advise on capabilities, limitations, and condition of equipment; employ knowledge of electronic and operational system theory in applying diagnostic and restoral techniques; perform assigned mission organizational level maintenance on telecommunications equipment and systems.

Sonar Technicians, Surface (STG) operate (manipulate, control, evaluate, and interpret data) surface sonar and oceanographic equipment.

surface ship underwater fire control equipment, and associated equipment for the solution of antisubmarine warfare problems; perform organizational and intermediate maintenance on surface sonar and allied equipment.

SECTION 4

PROJECTED SUPPLY OF TECHNICAL RATINGS AT DIFFERENT EXPERIENCE LEVELS

ADDRESSING QUESTION 4

What is the projected availability of the required types of personnel? Are they likely to be in sufficient supply during the time frame of interest?

Figure 7 shows where this question is addressed in the conceptual design process. The data required to answer it have been excerpted from a more general report on Navy manpower availability prepared by NPRDC.*

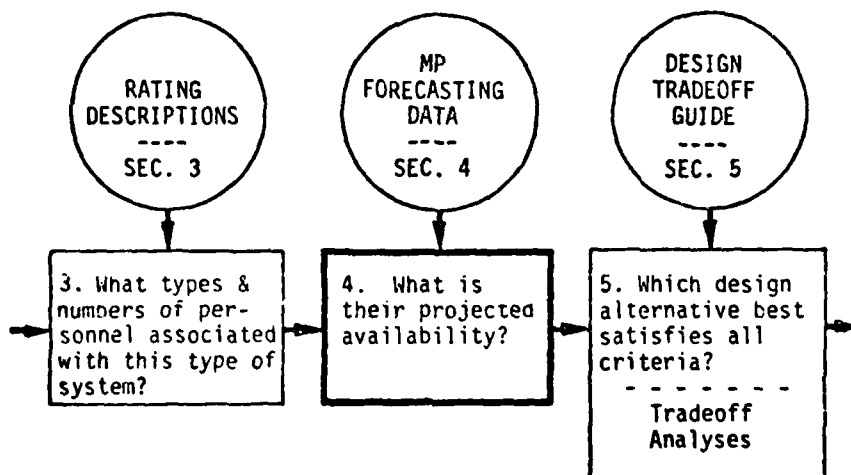


Figure 7. Addressing Question 4.

*Kochler, E. A. Manpower availability--Navy enlisted projections--FY78-FY84 (NPRDC SR 79-11). San Diego: Navy Personnel Research and Development Center, 1979.

These data, presented on the following pages, provide an explicit answer to Question 4. Graphs are presented for DS, ET, FTM, RM, and STG personnel (Figures 8-13) showing the following:

1. Number of personnel available at the end of fiscal years 1978-84.
2. Number of personnel needed to meet CNO estimated requirements.
3. The difference (surplus or shortfall) between available and required numbers at each level of experience (pay grade).

For example, if the designer anticipates that his system will be maintained by electronic technicians (ETs), inspection of pages 4-5 and 4-6 reveals that although there will be a surplus of 3rd class ETs (pay grade E-4), a severe shortage of 2nd class (E-5) and 1st class (E-6) ETs is forecast. The clear implication of these data is that the system should be designed, to the fullest extent possible, to the skill levels possessed by 3rd class ETs. To determine what these skill levels are, he will need to refer to Section 6.

CURRENT SHORTAGES ARE EXPECTED TO CONTINUE

There is a projected shortfall of experienced technicians of virtually every type associated with surface ship electronic systems. These shortages are expected to continue.

The persistent shortages in experienced personnel reflected in these graphs are expected to continue beyond 1984. Thus, the designer should view any currently projected shortfall as one that is likely to continue even though a system now in design may not be operational until well beyond 1984.

PROJECTED PERSONNEL SUPPLY

	<u>Page</u>
DS (Data Systems Technician)	4-4
ET (Electronic Technician)	4-5, 4-6
FTM (Fire Control Technician, Surface Missile)	4-7
RM (Radioman)	4-8
STG (Sonar Technician, Surface)	4-9

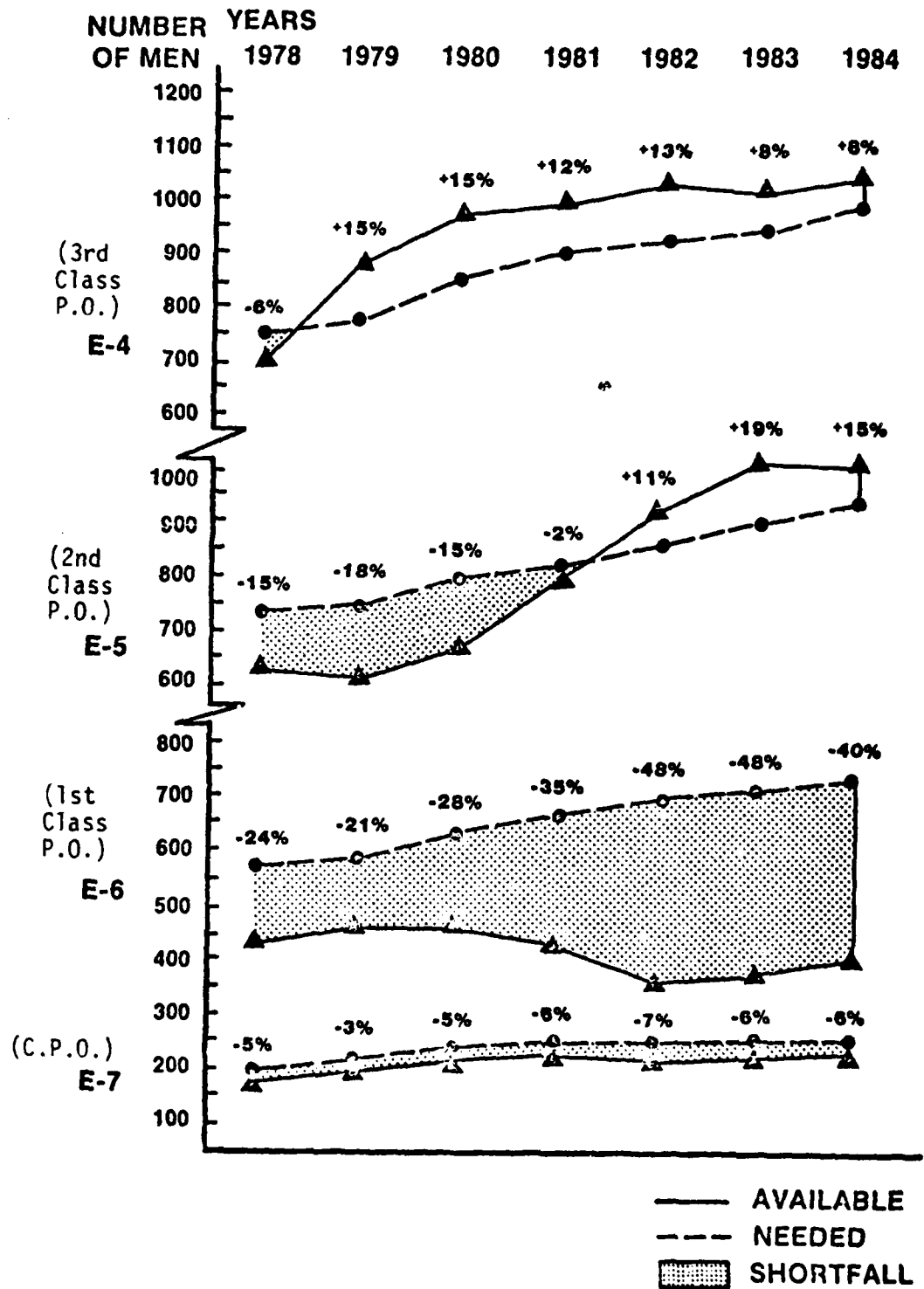


Figure 8. DS (Data Systems Technician).

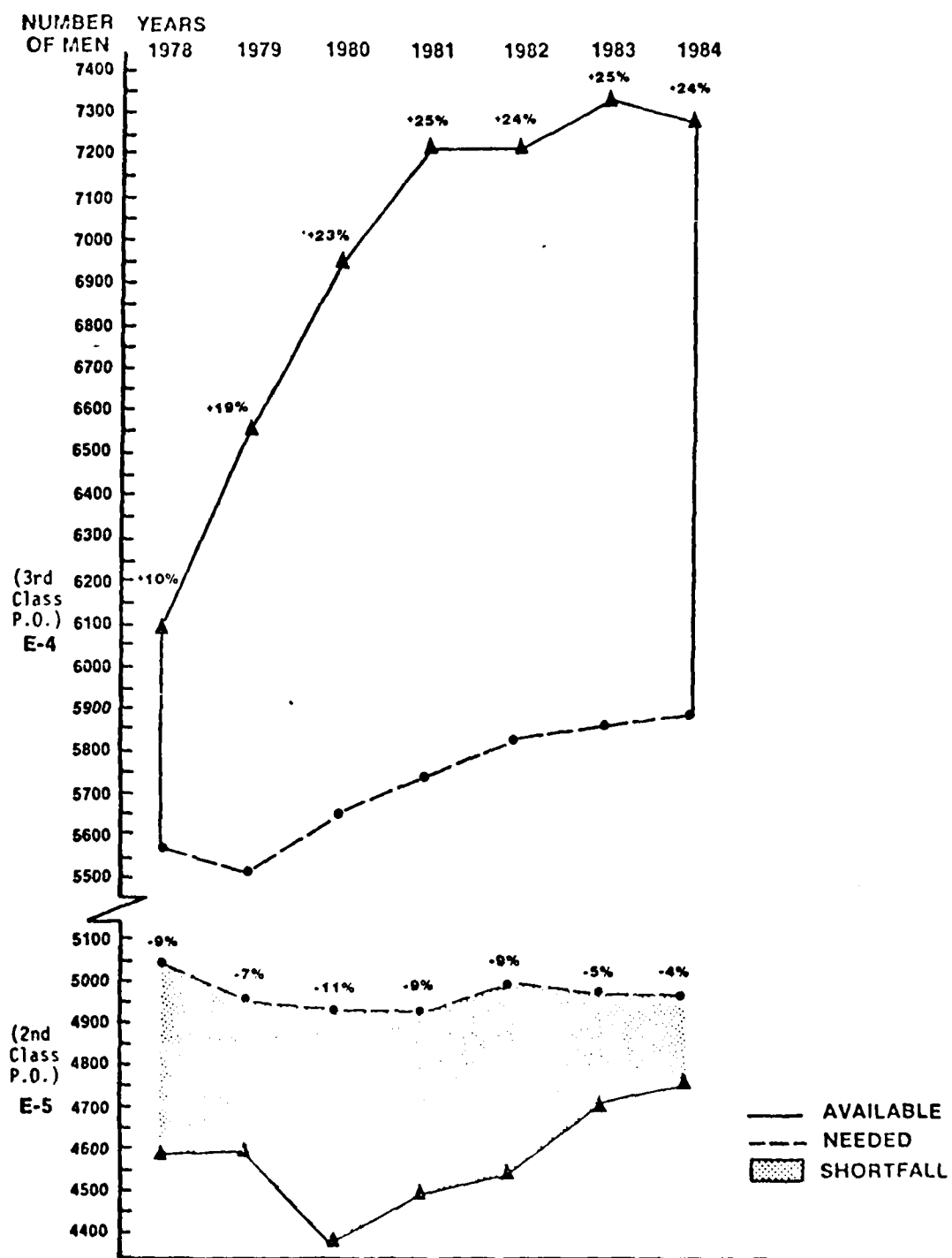


Figure 9. ET (Electronics Technician).

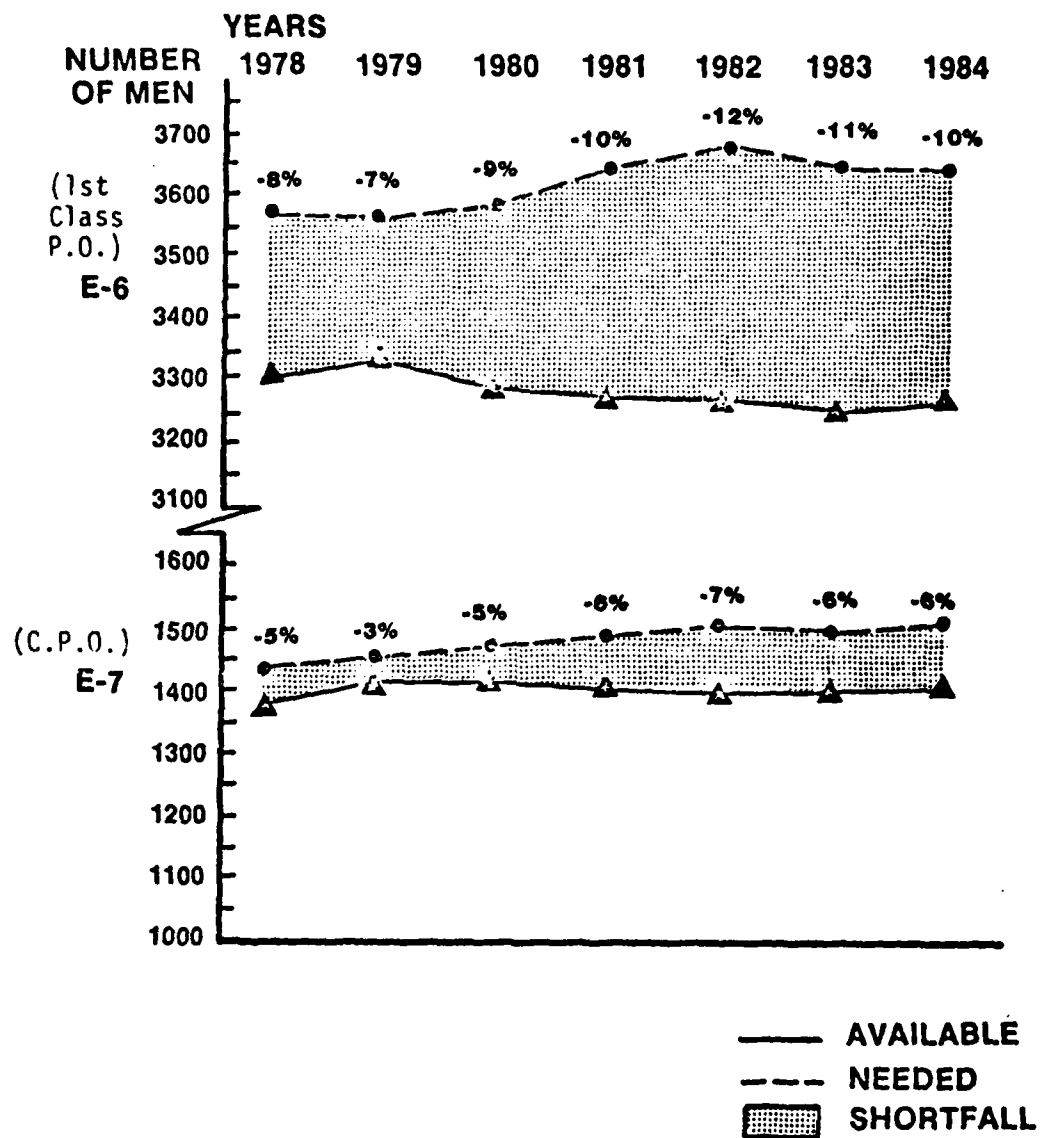


Figure 10. ET (Electronics Technician).

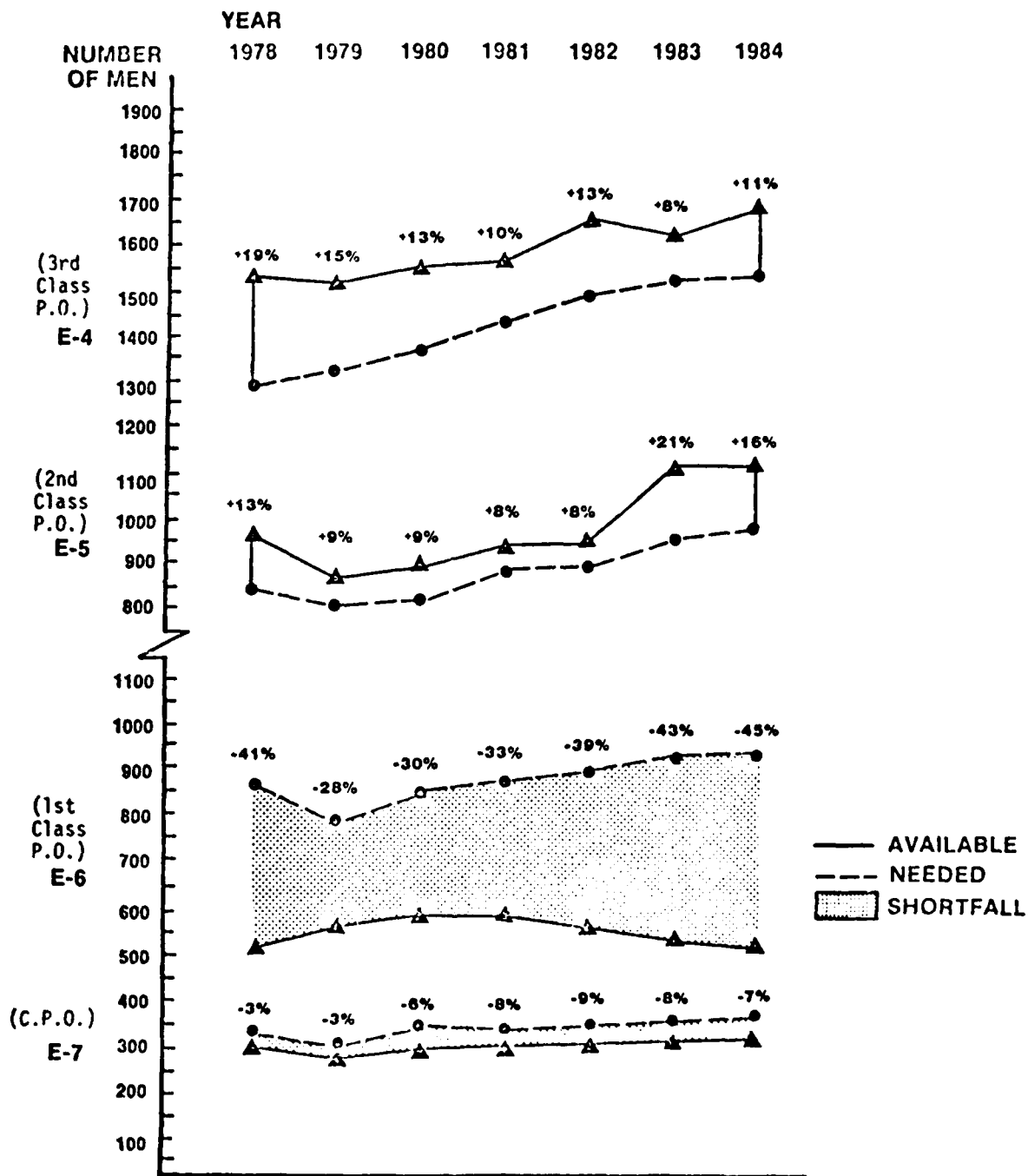


Figure 11. FTM (Fire Control Technician, Surface Missile).

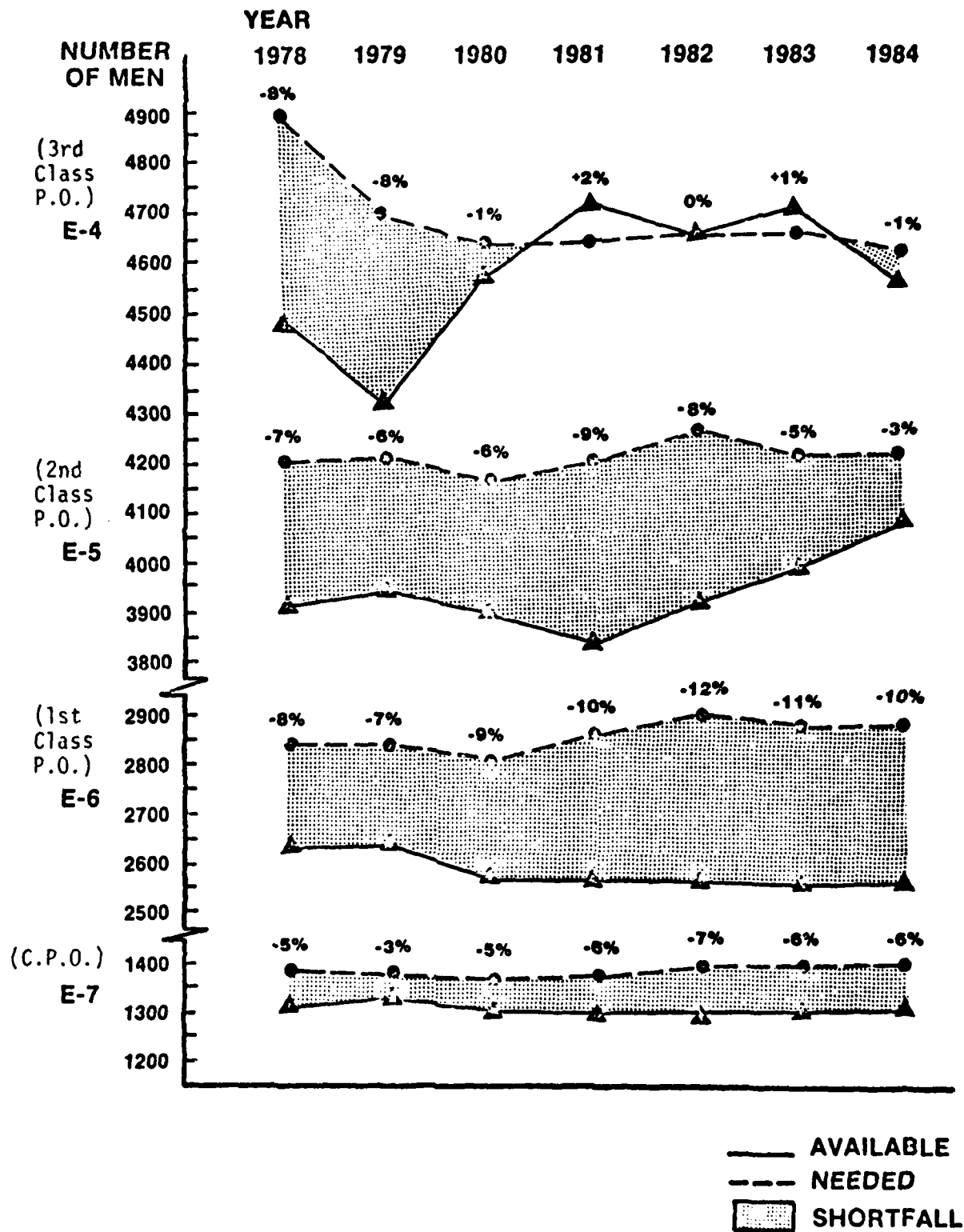


Figure 12. RM (Radioman).

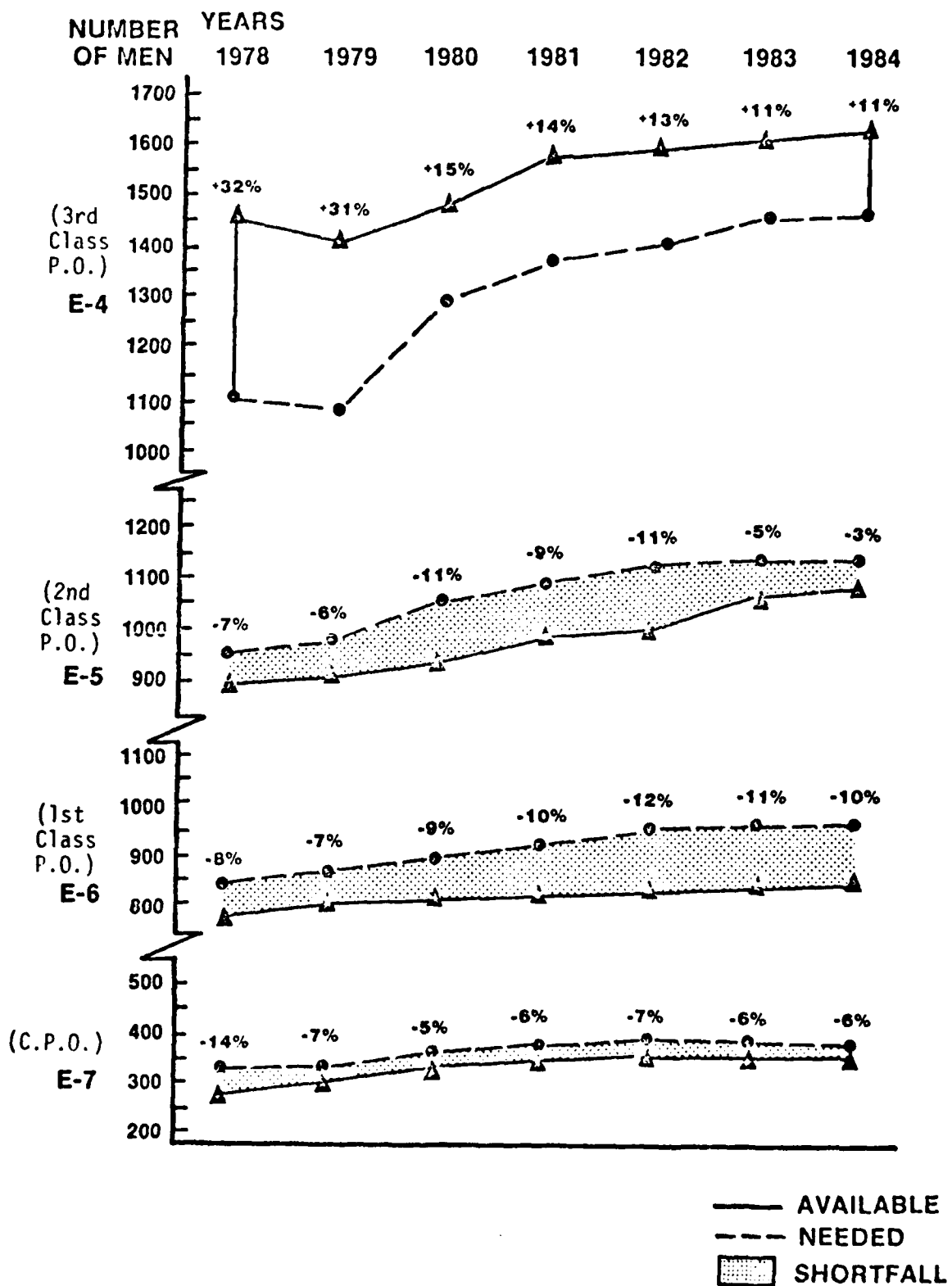


Figure 13. STG (Sonar Technician, Surface).

SECTION 5

EVALUATION OF ALTERNATIVES

ADDRESSING QUESTION 5

In view of the answers to Questions 1 through 4, which general design alternative best satisfies not only manpower and training criteria but cost, potential benefit, and technical risk considerations?

The purpose of this section is to aid the designer in conducting early tradeoff analyses involving human resources and other design criteria. Figure 14 shows where in the process this occurs.

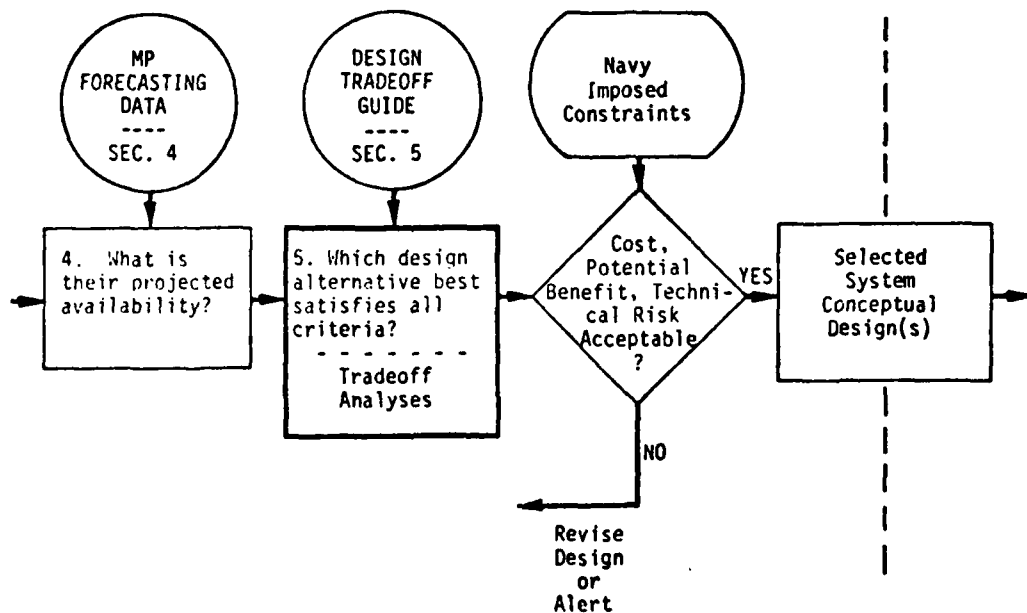


Figure 14. Addressing Question 5.

CONDUCTING THE TRADEOFFS

How are the design tradeoffs conducted?

The tradeoff technique described in this section makes use of the data in the evaluative profiles shown in Sections 1 and 2. This is not meant to imply that the designer or program manager will take into account only the information presented in those sections. For example, personnel supply at different skill levels (Section 4) certainly should be considered. Independent estimates of the technical feasibility of successfully implementing various design concepts may be made and other externally generated considerations very likely will be brought to bear.

However, the method provided here is a very easy way to evaluate the impact of all of the 21 design concepts defined in Section 1 that apply to the design under consideration, as they interact in relation to the 14 criteria identified in Section 2.

USE OF THE WORKSHEETS

Five worksheets are used to list those design concepts that apply to each system design being evaluated.

These worksheets, examples of which follow, are titled:

1. Maintenance Factors (1)
2. Maintenance Factors (2)
3. Operating Factors
4. General Criteria
5. System Design Evaluation Summary

The first four worksheets contain an "Impact Index" for different design concepts that may be applicable to one or more designs under

consideration. These indices are the same values that appeared in Sections 1 and 2. Positive values reflect a favorable impact on the system criterion in question, negative values an unfavorable impact.

ENTERING THE IMPACT INDICES

For each system design, one of which may be a baseline system, the analyst simply enters the Impact Index for each concept that applies.

For example, consider two systems that had the following design features:

	Design	
	A	B
1. Equipment layout to facilitate maintenance	✓	✓
2. LRUs--No spares		
3. LRUs--Spares with onboard repair	✓	
4. LRUs--Spares with remote repair		
5. LRUs--Spares with throwaway maintenance		✓
6. "Overdesign" for reliability & maintenance		
7. Embedded computers		✓
8. Automatic performance monitoring		✓
9. Built-in test equipment	✓	✓
10. Built-in troubleshooting logic aids		✓
11. Automatic fault localization		
12. Standard hardware components	✓	✓
13. Standard hardware--Cards/LRUs		✓
14. Standard hardware--Functional units		
15. Standard hardware--Subsystems		
16. Operational simplicity	✓	
17. Built-in operator performance aids		✓
18. Automatic decision making		
19. Automatic information transmit & display		✓
20. Built-in training capability		✓
21. Combined operator/maintainer functions		

Filling out each worksheet in turn, the analyst enters the Impact Index for each applicable design concept as it applies to each evaluative criterion on that worksheet. An example of a filled-in Worksheet 1 for the above two systems is shown on page 5-7. Completed Worksheets 2, 3, and 4 are shown on subsequent pages.

SUMMATION OF INDICES

The indices entered on each worksheet are algebraically summed and transferred to the System Design Evaluation Summary.

The values in each column of each worksheet are summed algebraically to arrive at a total impact score for each criterion variable. Then, the final step is to transfer these scores to the System Design Evaluation Summary sheet.

The results of this process for our two example systems are shown on page 5-11. In the example, it is evident that Design A is generally evaluated superior to Design B on the basis of most maintainability criteria, but Design B is rated greatly superior on operational criteria. However, Design B's advantage in this respect is seen as coming at a considerably higher initial acquisition cost. Reexamination of Worksheet 4 reveals that the high initial acquisition cost stems from not one but several different concepts employed in Design B. The next step in an iterative process would be to see whether one or more different concepts might be substituted in the interest of lower cost without seriously impacting the operational advantage.

TOWARD A SINGLE OVERALL EVALUATIVE INDEX

Can all the scores on the System Design Evaluation Summary be summed into a single index?

It is tempting to perform a second algebraic summation of all of the values entered on the System Design Evaluation Summary sheet. This

would permit the merits of the two systems to be compared on the basis of a single overall index. It should be noted that this procedure can be defended only if the analyst views all 14 evaluative criteria as equally important to the total design objective. If he does not, the 14 criteria must be differentially weighted on the basis of some externally imposed system of values before the summation takes place.

WORKSHEET 1
MAINTENANCE FACTORS (1)

	A. SKILL LEVEL REQUIRED				B. SYSTEM-SPECIFIC TRAINING REQUIRED				C. MAINTENANCE MAN-HOURS REQUIRED				D. MTBF			
	Impact Index	Design A	Design B	Design C	Impact Index	Design A	Design B	Design C	Impact Index	Design A	Design B	Design C	Impact Index	Design A	Design B	Design C
1. Equipment layout to facilitate maintenance	+8	8	8		+6	6	6		+23	23	23		0	0	0	
2. LRUs--No spares	-1				-5				0*				0			
3. LRUs--Spares with onboard repair	-2*	-2			-6	-6			0*	0			0	0		
4. LRUs--Spares with remote repair	+14				+12				+18				0			
5. LRUs--Spares with throwaway maintenance	+16		16		+14		14		+18		18		0		0	
6. "Over-design" for reliability & maintenance	0				0				+17				+32			
7. Embedded computers	-15		-15		-13		-13		-12		-12		-4*		-4	
8. Automatic performance monitoring	+4		4		-3*		-3		+6		6		-5*		-5	
9. Built-in test equipment	+11	11	11		+5	5	5		+16	16	16		-6	-6	-6	
10. Built-in troubleshooting logic aids	+15				+16				+24				-5			
11. Automatic fault localization	+21				+20				+31				-8			
12. Standard hardware components	+4	4	4		+4	4	4		+4	4	4		+3	3	3	
13. Standard hardware--Cards/LRUs	+7		7		+7		7		+5		5		+3		3	
14. Standard hardware--Functional units	+7				+8				+6				+3			
15. Standard hardware--Subsystems	+6				+8				+7				+3			
16. Operational simplicity	+5	5			+7	7			+3	3			+11			
17. Built-in operator performance aids	-7		-7		-8		-8		-5		-5		-7		-7	
18. Automatic decision making	-15				-20				-11				-13			
19. Automatic information transmit & display	-13		-13		-11		-11		-11		-11		-11		-11	
20. Built-in training capability	-11		-11		-10		-10		-6		-6		-9		-9	
21. Combined operator/maintainer functions	-4				-12				0*				0			
	Σ	26	4		Σ	16	-9		Σ	46	38		Σ	-3	-36	

WORKSHEET 2 MAINTENANCE FACTORS (2)

	E. MTR			F. TOOLS, TEST EQUIPMENT & FACILITIES			G. SUPPLY & SUPPORT COSTS		
	Impact Index	Design A	Design B	Design C	Impact Index	Design A	Design B	Design C	
1. Equipment layout to facilitate maintenance	+22	22	22		+3	3	3	0	
2. LRUS--No spares	+2*				-1			+2*	
3. LRUS--Spares with onboard repair	+12	12			-3	-3		+2*	
4. LRUS--Spares with remote repair	+17				0*			-11	
5. LRUS--Spares with throwaway maintenance	+17		17		+12		12	-20	
6. "Overdesign" for reliability & maintenance	0				+1			+4*	
7. Embedded computers	-6		-6		-6		-6	-12	
8. Automatic performance monitoring	+7		7		+2*		2	-7	
9. Built-in test equipment	+23	23	23		+15	15	15	-4*	
10. Built-in troubleshooting logic aids	+28				+7			-2	
11. Automatic fault localization	+40				+12			-3*	
12. Standard hardware components	+6	6	6		+7	7	7	+14	
13. Standard hardware--Cards/LRUS	+9		9		+8		8	+15	
14. Standard hardware--Functional units	+9				+9			+14	
15. Standard hardware--Subsystems	+8				+9			+15	
16. Operational simplicity	+6	6			+2	2		+6	
17. Built-in operator performance aids	-2		-2		-5		-5	-10	
18. Automatic decision making	-5				-5			-14	
19. Automatic information transmit & display	-6		-6		-6		-6	-8	
20. Built-in training capability	-2		-2		-5		-5	-10	
21. Combined operator/maintainer functions	0				0			0	
	Σ	69	68		Σ	24	25	Σ	
								18	
								-42	

WORKSHEET 3 OPERATING FACTORS

	H. OPERATOR SKILL & EXPERIENCE REQUIRED				I. SYSTEM-SPECIFIC OPERATOR TRAINING REQ.				J. TOTAL NUMBER OF OPERATORS REQUIRED				K. SYSTEM OPERABILITY			
	Impact Index	Design A	Design B	Design C	Impact Index	Design A	Design B	Design C	Impact Index	Design A	Design B	Design C	Impact Index	Design A	Design B	Design C
1. Equipment layout to facilitate maintenance	0	0	0		0	0	0		0	0	0		0	0	0	
2. LRUs--No spares	0				0				0				0			
3. LRUs--Spares with onboard repair	0	0			0	0			0	0			0	0		
4. LRUs--Spares with remote repair	0				0				0				0			
5. LRUs--Spares with throwaway maintenance	0		0		0		0		0		0		0		0	
6. "Overdesign" for reliability & maintenance	0				0				0				0			
7. Embedded computers	0		0		0		0		+3		3		+4		4	
8. Automatic performance monitoring	+6		6		+6		6		+2		2		+6		6	
9. Built-in test equipment	0	0	0		0	0	0		0	0	0		0	0	0	
10. Built-in troubleshooting logic aids	0				0				0				0			
11. Automatic fault localization	0				0				0				0			
12. Standard hardware components	0	0	0		0	0	0		0	0	0		0	0	0	
13. Standard hardware--Cards/LRUs	0		0		0		0		0		0		0		0	
14. Standard hardware--Functional units	0				0				0				0			
15. Standard hardware--Subsystems	+4				+3				0				0			
16. Operational simplicity	+18	18			+24	24			+11	11			+21	21		
17. Built-in operator performance aids	+16		16		+18		18		+9		9		+22		22	
18. Automatic decision making	+22				+20				+16				+26			
19. Automatic information transmit & display	+6*		6		+4*		4		+19		19		+20		20	
20. Built-in training capability	+6		6		+11		11		0		0		+10		10	
21. Combined operator/maintainer functions	-23				-29				-5*				0			
	Σ	18	34		Σ	24	39		Σ	11	33		Σ	21	52	

WORKSHEET 4
GENERAL CRITERIA

	L. OVERALL OPERATIONAL CAPABILITY & EFFECTIVENESS				M. INITIAL SYSTEM ACQUISITION COSTS				N. OPERATIONAL LIFETIME COSTS			
	Impact Index	Design A	Design B	Design C	Impact Index	Design A	Design B	Design C	Impact Index	Design A	Design B	Design C
1. Equipment layout to facilitate maintenance	+7	7	7		-4	-4	-4		+4	-1	-4	
2. LRUs--No spares	0*				-2*				0			
3. LRUs--Spares with onboard repair	+5	5			-3	-3			0	0		
4. LRUs--Spares with remote repair	+5				-3				-3*			
5. LRUs--Spares with throwaway maintenance	+7		7		-4		-4		-8		-8	
6. "Overdesign" for reliability & maintenance	+16				-20				+20			
7. Embedded computers	+8		8		-15		-15		-5		-5	
8. Automatic performance monitoring	+22		22		-19		-19		-3*		-3	
9. Built-in test equipment	+12	12	12		-21	-21	-21		+3*	3	3	
10. Built-in troubleshooting logic aids	+15				-20				+2*			
11. Automatic fault localization	+21				-27				+3*			
12. Standard hardware components	+3	3	3		+8	8	8		+9	9	9	
13. Standard hardware--Cards/LRUs	+4		4		+8		8		+11		11	
14. Standard hardware--Functional units	+5				+10				+12			
15. Standard hardware--Subsystems	+5				+10				+12			
16. Operational simplicity	+7*	7			+9	9			+5	5		
17. Built-in operator performance aids	+17		17		-19		-19		-11		-11	
18. Automatic decision making	+26				-29				-12			
19. Automatic information transmit & display	+25		25		-23		-23		-7		-7	
20. Built-in training capability	+13		13		-20		-20		-7		-7	
21. Combined operator/maintainer functions	0				0				0			
	Σ	34	118		Σ	-11	-109		Σ	21	-14	

WORKSHEET 5
SYSTEM DESIGN EVALUATION SUMMARY

	Design A	Design B	Design C
A. Maintainer skill & experience level required	26	4	
B. System-specific maint. training required	16	-9	
C. Maintenance man-hours required	46	38	
D. MTBF	-3	-36	
E. MTTR	69	68	
F. Tools, test equip., facilities required	24	25	
G. Supply and support costs	18	-42	
H. Operator skill & experience required	18	34	
I. System-specific oper. training required	24	39	
J. Total number of operators required	11	33	
K. System operability	21	52	
L. Overall oper. capability & effectiveness	34	118	
M. Initial system acquisition costs	-11	-109	
N. Operational lifetime costs	21	-14	

EXTRA WORKSHEETS

WORKSHEET 1 MAINTENANCE FACTORS (1)

	A. SKILL LEVEL REQUIRED				B. SYSTEM-SPECIFIC TRAINING REQUIRED				C. MAINTENANCE MAN- HOURS REQUIRED				D. MTBF			
	Impact Index	Design A	Design B	Design C	Impact Index	Design A	Design B	Design C	Impact Index	Design A	Design B	Design C	Impact Index	Design A	Design B	Design C
1. Equipment layout to facilitate maintenance	+8				+6				+23				0			
2. LRUs--No spares	-1				-5				0*				0			
3. LRUs--Spares with onboard repair	-2*				-6				0*				0			
4. LRUs--Spares with remote repair	+14				+12				+18				0			
5. LRUs--Spares with throwaway maintenance	+16				+14				+18				0			
6. "Overdesign" for reliability & maintenance	0				0				+17				+32			
7. Embedded computers	-15				-13				-12				-4*			
8. Automatic performance monitoring	+4				-3*				+6				-5*			
9. Built-in test equipment	+11				+5				+16				-6			
10. Built-in troubleshooting logic aids	+15				+16				+24				-5			
11. Automatic fault localization	+21				+20				+31				-8			
12. Standard hardware components	+4				+4				+4				+3			
13. Standard hardware--Cards/LRUs	+7				+7				+5				+3			
14. Standard hardware--Functional units	+7				+8				+6				+3			
15. Standard hardware--Subsystems	+6				+8				+7				+3			
16. Operational simplicity	+5				+7				+3				+11			
17. Built-in operator performance aids	-7				-8				-5				-7			
18. Automatic decision making	-15				-20				-11				-13			
19. Automatic information transmit & display	-13				-11				-11				-11			
20. Built-in training capability	-11				-10				-6				-9			
21. Combined operator/maintainer functions	-4				-12				0*				0			
	Σ				Σ				Σ				Σ			

WORKSHEET 2 MAINTENANCE FACTORS (2)

	E. MTTR			F. TOOLS, TEST EQUIPMENT & FACILITIES			G. SUPPLY & SUPPORT COSTS		
	Design A	Design B	Design C	Design A	Design B	Design C	Design A	Design B	Design C
1. Equipment layout to facilitate maintenance	+22			+3			0		
2. LRUs--No spares	+2*			-1			+2*		
3. LRUs--Spares with onboard repair	+12			-3			+2*		
4. LRUs--Spares with remote repair	+17			0*			-11		
5. LRUs--Spares with throwaway maintenance	+17			+12			-20		
6. "Overdesign" for reliability & maintenance	0			+1			+4*		
7. Embedded computers	-6			-6			-12		
8. Automatic performance monitoring	+7			+2*			-7		
9. Built-in test equipment	+23			+15			-4*		
10. Built-in troubleshooting logic aids	+28			+7			-2		
11. Automatic fault localization	+40			+12			-3*		
12. Standard hardware components	+6			+7			+14		
13. Standard hardware--Cards/LRUs	+9			+8			+15		
14. Standard hardware--Functional units	+9			+9			+14		
15. Standard hardware--Subsystems	+8			+9			+15		
16. Operational simplicity	+6			+2			+6		
17. Built-in operator performance aids	-2			-5			-10		
18. Automatic decision making	-5			-5			-14		
19. Automatic information transmit & display	-6			-6			-8		
20. Built-in training capability	-2			-5			-10		
21. Combined operator/maintainer functions	0			0			0		
	Σ			Σ			Σ		

WORKSHEET 3 OPERATING FACTORS

	H. OPERATOR SKILL & EXPERIENCE REQUIRED				I. SYSTEM-SPECIFIC OPERATOR TRAINING REQ.				J. TOTAL NUMBER OF OPERATORS REQUIRED				K. SYSTEM OPERABILITY			
	Impact Index	Design A	Design B	Design C	Impact Index	Design A	Design B	Design C	Impact Index	Design A	Design B	Design C	Impact Index	Design A	Design B	Design C
1. Equipment layout to facilitate maintenance	0				0				0				0			
2. LRUs--no spares	0				0				0				0			
3. LRUs--Spares with onboard repair	0				0				0				0			
4. LRUs--Spares with remote repair	0				0				0				0			
5. LRUs--Spares with throwaway maintenance	0				0				0				0			
6. "Overdesign" for reliability & maintenance	0				0				0				0			
7. Embedded computers	0				0				+3				+4			
8. Automatic performance monitoring	+6				+6				+2				+6			
9. Built-in test equipment	0				0				0				0			
10. Built-in troubleshooting logic aids	0				0				0				0			
11. Automatic fault localization	0				0				0				0			
12. Standard hardware components	0				0				0				0			
13. Standard hardware--Cards/LRUs	0				0				0				0			
14. Standard hardware--Functional units	0				0				0				0			
15. Standard hardware--Subsystems	+4				+3				0				0			
16. Operational simplicity	+18				+24				+11				+21			
17. Built-in operator performance aids	+16				+18				+9				+22			
18. Automatic decision making	+22				+20				+16				+26			
19. Automatic information transmit & display	+6*				+4*				+19				+20			
20. Built-in training capability	+6				+11				0				+10			
21. Combined operator/maintainer functions	-23				-29				-5*				0			
	Σ				Σ				Σ				Σ			

WORKSHEET 4
GENERAL CRITERIA

	L. OVERALL OPERATIONAL CAPABIL. & EFFECTIVENESS				M. INITIAL SYSTEM ACQUISITION COSTS				N. OPERATIONAL LIFETIME COSTS			
	Project Index	Design A	Design B	Design C	Project Index	Design A	Design B	Design C	Project Index	Design A	Design B	Design C
1. Equipment layout to facilitate maintenance	+7				-4				+4			
2. LRUs--No spares	0*				-2*				0			
3. LRUs--Spares with onboard repair	+5				-3				0			
4. LRUs--Spares with remote repair	+5				-3				-3*			
5. LRUs--Spares with throwaway maintenance	+7				-4				-8			
6. "Overdesign" for reliability & maintenance	+16				-20				+20			
7. Embedded computers	+8				-15				-5			
8. Automatic performance monitoring	+22				-19				-3*			
9. Built-in test equipment	+12				-21				+3*			
10. Built-in troubleshooting logic aids	+15				-20				+2*			
11. Automatic fault localization	+21				-27				+3*			
12. Standard hardware components	+3				+8				+9			
13. Standard hardware--Cards/LRUs	+4				+8				+11			
14. Standard hardware--Functional units	+5				+10				+12			
15. Standard hardware--Subsystems	+5				+10				+12			
16. Operational simplicity	+7*				+9				+5			
17. Built-in operator performance aids	+17				-19				-11			
18. Automatic decision making	+26				-29				-12			
19. Automatic information transmit & display	+25				-23				-7			
20. Built-in training capability	+13				-20				-7			
21. Combined operator/maintainer functions	0				0				0			
	Σ				Σ				Σ			

WORKSHEET 5
SYSTEM DESIGN EVALUATION SUMMARY

	Design A	Design B	Design C
A. Maintainer skill & experience level required			
B. System-specific maint. training required			
C. Maintenance man-hours required			
D. MTBF			
E. MTTR			
F. Tools, test equip., facilities required			
G. Supply and support costs			
H. Operator skill & experience required			
I. System-specific oper. training required			
J. Total number of operators required			
K. System operability			
L. Overall oper. capability & effectiveness			
M. Initial system acquisition costs			
N. Operational lifetime costs			

SECTION 6

TAXONOMIES OF TASKS AND ASSOCIATED SKILL LEVELS

ADDRESSING QUESTION 6

What is the impact of the preferred system design on specific operator and maintainer tasks?

To answer Question 6 it is necessary to move from the conceptual level of analysis, occurring very early in the design process, to a more detailed task and skill level analysis. In the sequence of steps involved in using human resources data as a design factor, we are at the point shown in Figure 15.

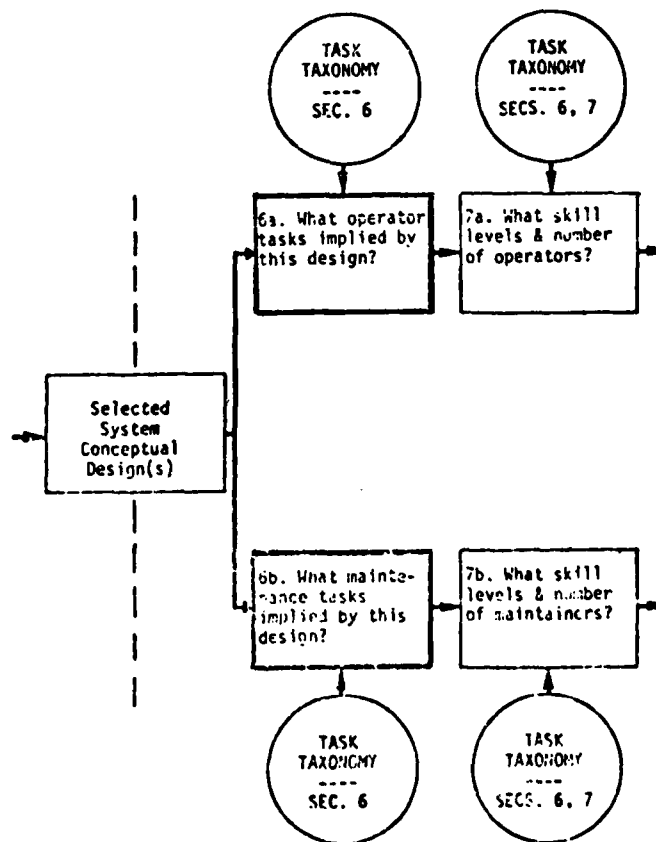


Figure 15. Addressing Question 6.

EXISTING SYSTEMS SERVE AS THE REFERENCE

Each task level analysis can be facilitated by reference to tasks performed in operational systems of the same general type as that being designed.

Conducting the necessary task analyses early in the conceptual and engineering phases of system development typically suffers from a lack of detailed information concerning specific tasks to be performed by the operators and maintainers. However, systems designed to perform similar functions involve similar human activities, and it is therefore possible to use task performance data from earlier systems as a point of departure.

SIMILARITIES AND DIFFERENCES

The task analysis should focus on similarities and differences in the tasks to be performed.

The newly proposed design probably will include:

- Some tasks that are unique to the new system.
- Many tasks that are similar, if not identical to those performed in older systems of the same type.

Identification of the new tasks must necessarily depend upon knowledge of the new engineering design features, so this requirement can be addressed here only in the sense that the task taxonomies provide the basis for identifying which tasks are "old" and which are consequences of the new design. It is important to note, however, that new tasks are the source of new training requirements and quite possibly new NECs. Thus their proliferation is to be discouraged except where they involve simplification or elimination of old tasks, particularly those older tasks that were especially difficult or time consuming to perform (Section 7).

DIFFICULTY LEVELS FOR PERSONNEL OF DIFFERENT EXPERIENCE

The task taxonomies provide the designer with a means of determining the task difficulty levels and corresponding personnel skill levels for most tasks of the type that his system will generate.

The subsections that follow contain comprehensive inventories of the tasks performed aboard ship by DS, ET(N), ET(R), FTM, RM, and STG personnel. At the beginning of each subsection, an index is provided that shows where task data relating to general operation/maintenance activities can be found as well as task data associated with specific subsystems.

Skill data are also presented in the form of profiles showing the level of proficiency associated with typical Fleet personnel at the 3rd, 2nd, and 1st class petty officer grades. These skill profiles reflect the averaged judgments of substantial numbers of senior chief petty officers with recent, extensive supervisory experience with shipboard personnel in their rating specialty. The descriptors employed on the proficiency profiles have the following meanings:

- LIMITED: Can do simple parts of the task. Needs to be told or shown how to do most of the task.
- PARTIAL: Can do most parts of the task. Needs help only on the hardest parts. May not perform the task with the desired speed or accuracy.
- COMPETENT: Can do all parts of the task. Needs only a spot check of completed work. Generally meets required standards for speed and accuracy.
- SUPERIOR: Superior in accurately and quickly performing the task. No checkup needed. Can instruct others how to do the task.

ALL TASKS SHOULD BE CONSIDERED

The designer should consider the impact of his design on all applicable operator and maintainer tasks.

For example, if the system under development is a data processing system that calls for the skills of Data Systems Technicians, the designer should turn first to the DS section and identify from the index (page 6-7) the general tasks performed by these personnel that are applicable to his system as well as the subsystem tasks that apply. (In doing this, he should pay particular attention to any proposed subsystems whose tasks may not be covered by the taxonomy since these will probably generate new training requirements.)

The index of DS tasks shows that tasks associated with "General Operation" are to be found on page 6-8. Turning to that page, the designer will find 7 general operations tasks listed together with skill level profiles for 3rd, 2nd, and 1st class petty officers. It will be seen that all three grades of petty officers are viewed as "competent" for the first 3 tasks, but that only 1st class petty officers are considered "competent" for the last task which involves initiating communications links.

In this manner, the designer can determine the experience level required for competency in each task applicable to the system under development.

PREDECESSOR SYSTEMS ARE IDENTIFIED

The systems on which the skill level profiles are based are identified.

Each task in the inventory was considered by senior technicians as it is performed in systems for which they had primary responsibility.

Usually the tasks apply to several different systems though they may not be performed in quite the same way in each system.

To the right of each task description the systems used for reference in judging the associated required skill levels are listed. Thus, for the first task listed for DSs on page 6-8, the systems considered included:

UYK-5	UYA-4
UYK-20	UYK-7
LHA	NTDS-3
NTDS-CV	USQ-20

Statistical tests were made of the differences in judged difficulty levels for each task as performed in the several different systems. These were, for the most part, insignificant. Where they were significantly different, the task is listed separately for each system as appropriate.

Each judge also indicated whether or not he felt each task was particularly time consuming. These results, in the form of the percentage of raters who judged each task to be time consuming, are shown to the right side of the profile along with the applicable system identifiers. Unanimity of opinion on this point was unlikely since different systems provided different frames of reference. However, there was relatively strong agreement that some tasks are generally more time consuming than others. For convenience, these and all particularly difficult tasks have been listed separately in Section 7.

Some of the task-skill level judgments were made by too few supervisors to ensure reliable results. Those based on just 3, 4, or 5 raters have been marked with an *, but the skill profile is nevertheless shown. Those tasks for which there were only 1 or 2 judges are listed in the inventory for the sake of completeness but no skill profiles are presented.

USING THE TAXONOMIES

The taxonomies should be used as a checkoff list.

The designer should use the information presented in these taxonomies as a checklist against which to assess the scope and probable difficulty levels of the tasks to be performed by the operators and maintainers of his system. He should pay particular attention to:

- New tasks, not appearing in the list, which have significant implications for new training requirements.
- Listed tasks that are particularly difficult.
- Listed tasks that are particularly time consuming.

His general design objective should be to minimize the number of tasks in each of the above categories and to maximize the likelihood of "competent" performance by 3rd class petty officers.

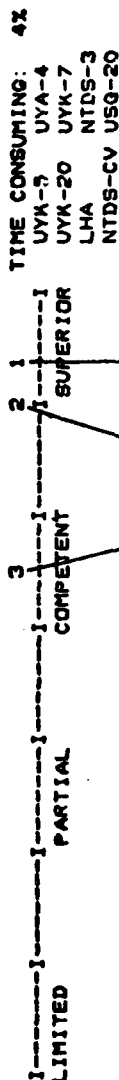
Further use of the data in the task taxonomies is described in the next section which is concerned with particularly difficult and time consuming tasks.

INDEX OF TASKS PERFORMED BY DSS

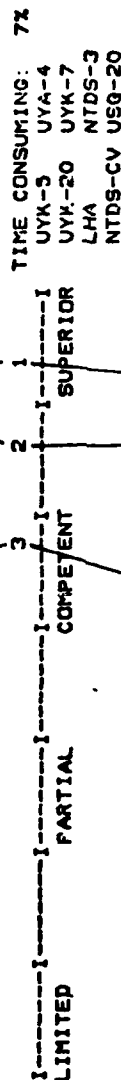
GENERAL OPERATION	PAGE	6-8
GENERAL SOFTWARE MAINTENANCE		6-8
GENERAL HARDWARE MAINTENANCE		6-9
A-TO-D & D-TO-A CONVERTERS		6-10
CARD READER		6-11
CARD PUNCH		6-12
CHILLED WATER SYSTEM		6-12
CIRCUIT CARD TEST SET		6-13
COMPUTER ELECTRONICS		6-14
DISK FILE		6-15
DATA ENTRY KEYSET CONSOLE		6-16
DATA TERMINAL SET		6-16
DISPLAY CONSOLE		6-17
HIGH SPEED PRINTER		6-18
MAGNETIC TAPE CONTROLLER		6-19
MAGNETIC TAPE TRANSPORT		6-20
PAPER TAPE PUNCH		6-20
PAPER TAPE READER		6-21
PULSE AMPLIFIER-SYMBOL GENERATOR		6-22
TELETYPE		6-23
VIDEO SIMULATOR		6-24

DB: GENERAL OPERATION

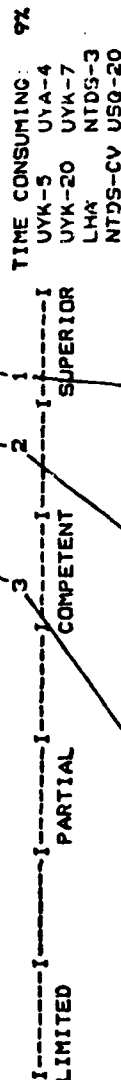
PERFORM POWER UP/DOWN PROCEDURES
ON DATA PROCESSING EQUIPMENT



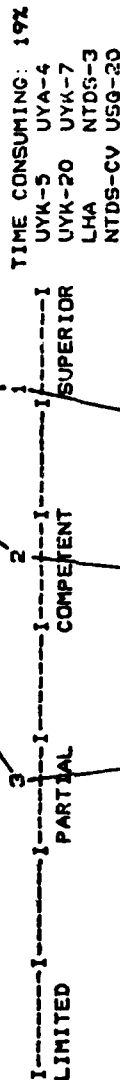
LOAD PRINTER PAPER IN DATA
PROCESSING EQUIPMENT



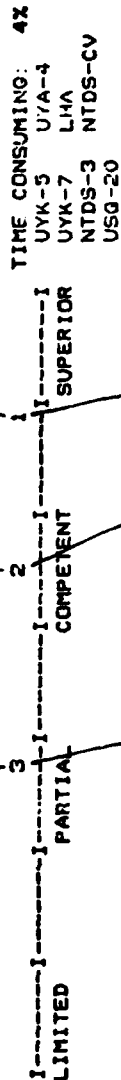
LOAD MAGNETIC TAPE/DISK PACKS
IN DATA PROCESSING EQUIPMENT



LOAD/RUN DIAGNOSTIC/TEST PROGRAMS



LOAD OPERATION PROGRAM FROM
SYSTEM MONITORING PANEL (SMP)



PLACE EQUIPMENT ON/OFF LINE
USING SMP

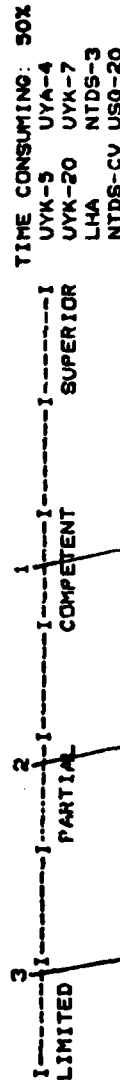


INITIATE COMMUNICATIONS LINKS SUCH
AS LINK 11, LINK 4A, LINK 14



DB: GENERAL SOFTWARE MAINTENANCE

WRITE/REWRITE PROGRAMS (MAINTENANCE,
OPERATIONAL)



TEST NEW PROGRAMS (MAINTENANCE,
OPERATIONAL)

TIME CONSUMING: 33%
UYK-5 UYA-4
UYK-20 UYK-7
LHA NTDS-3
NTDS-CV USQ-20

DEBUG PROGRAMS (MAINTENANCE,
OPERATIONAL)

TIME CONSUMING: 48%
UYK-5 UYA-4
UYK-20 UYK-7
LHA NTDS-3
NTDS-CV USQ-20

MAKE AUTHORIZED CHANGES TO PROGRAMS

TIME CONSUMING: 11%
UYK-5 UYA-4
UYK-20 UYK-7
LHA NTDS-3
NTDS-CV USQ-20

DS: GENERAL HARDWARE MAINTENANCE

RESEARCH TECHNICAL PUBLICATIONS TO FIND
APPROPRIATE SCHEMATICS/LOGIC DIAGRAMS/
TACLES/TROUBLESHOOTING CHARTS/MAINTENANCE
INFORMATION/PART NUMBERS FOR SPECIFIC
PIECES OF EQUIPMENT

TIME CONSUMING: 19%
UYK-5 UYA-4
UYK-20 UYK-7
LHA NTDS-3
NTDS-CV USQ-20

IDENTIFY STANDARD ELECTRONIC/MECHANICAL
SYMBOLS AS USED ON SCHEMATICS, LOGIC
DIAGRAMS, FLOW CHARTS, ETC.

TIME CONSUMING: 0%
UYK-5 UYA-4
UYK-20 UYK-7
LHA NTDS-3
NTDS-CV USQ-20

MODIFY EQUIPMENT IN ACCORDANCE WITH
SHIPALTS, ORDALTS, FIELD CHANGE ORDERS
AND ELECTRONIC INFORMATION BULLETINS (EIBS)

TIME CONSUMING: 40%
UYK-5 UYA-4
UYK-20 UYK-7
LHA NTDS-3
NTDS-CV USQ-20

CHANGE SYSTEM CONFIGURATION BY
PATCHING OR BY SWITCHBOARD CHANGES

TIME CONSUMING: 3%
UYK-5 UYA-4
UYK-20 UYK-7
LHA NTDS-3
NTDS-CV USQ-20

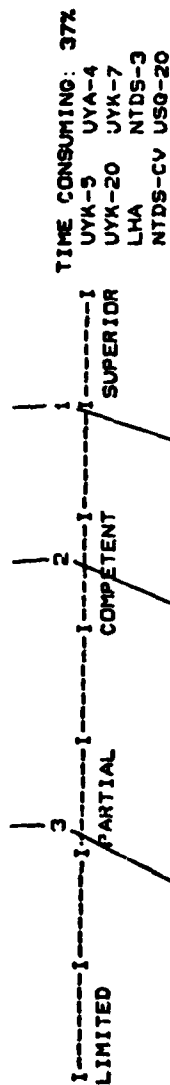
ANALYZE EQUIPMENT FRONT PANEL
INDICATORS FOR FAULT DETECTION

TIME CONSUMING: 0%
UYK-5 UYA-4
UYK-20 UYK-7
LHA NTDS-3
NTDS-CV USQ-20

USE TEST EQUIPMENT TO INJECT
SIGNALS AND/OR TAKE READINGS

TIME CONSUMING: 2%
UYK-5 UYA-4
UYK-20 UYK-7
LHA NTDS-3
NTDS-CV USQ-20

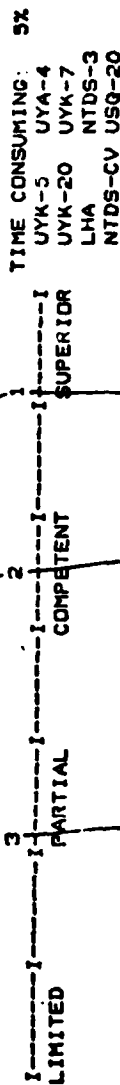
ASSEMBLE/REPAIR CABLES AND TEST LEADS,
SUCH AS CONNECTORS, PROBES, ETC.



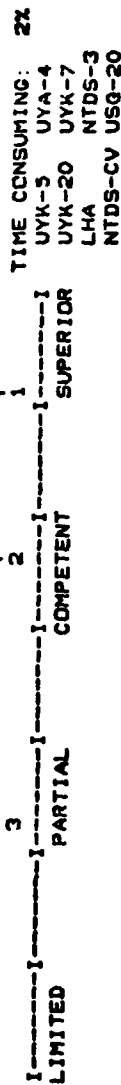
ALIGN/ADJUST MECHANICAL LINKAGES AND
GEAR TRAINS



LOCALIZE/ISOLATE EQUIPMENT MALFUNCTION
TO A SUBSYSTEM

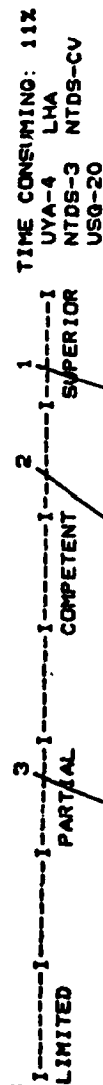


LOCALIZE/ISOLATE EQUIPMENT
MALFUNCTION TO A UNIT

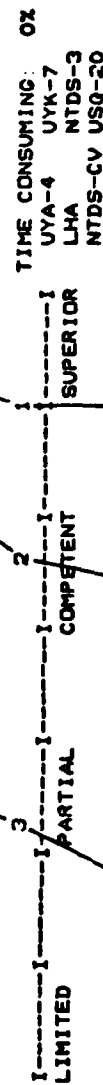


DB: A-TO-D & D-TO-A CONVERTERS

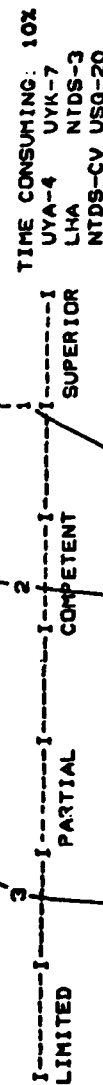
CLEAN/LUBRICATE A TO D AND D TO A CONVERTERS



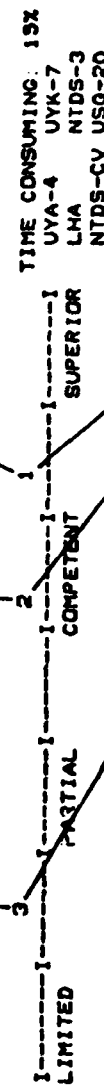
TEST/INSPECT A TO D AND D TO A CONVERTERS



LOCALIZE/ISOLATE A TO D AND D TO A
CONVERTERS MALFUNCTION TO THE MODULE/CARD
LEVEL



LOCALIZE/ISOLATE A TO D AND D TO A
CONVERTERS MALFUNCTION TO THE COMPONENT
LEVEL, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.



REMOVE/REPLACE A TO D AND D TO A
CONVERTERS MODULES/CARDS



REMOVE/REPLACE A TO D AND D TO A CONVERTERS
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

CALIBRATE/ALIGN/ADJUST A TO D AND D TO A
CONVERTERS

DS. CARD READER

CLEAN/LUBRICATE CARD READER

TEST/INSPECT CARD READER

LOCALIZE/ISOLATE CARD READER MALFUNCTION
TO THE MODULE/CARD LEVEL

LOCALIZE/ISOLATE CARD READER MALFUNCTION
TO THE COMPONENT LEVEL, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.

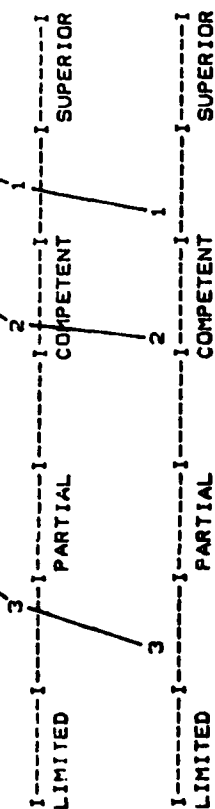
REMOVE/REPLACE CARD READER MODULES/CARDS

REMOVE/REPLACE CARD READER COMPONENTS,
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

CALIBRATE/ALIGN/ADJUST CARD READER

TIME CONSUMING 15%
UYK-4 UYK-20
UYK-7 LHA
NTDS-3 NTDS-CV
USQ-20

TIME CONSUMING 31%
UYK-4 UYK-7
LHA NTDS-3
NTDS-CV USQ-20



TIME CONSUMING 13%
UYK-5 UYK-20
LHA NTDS-CV
USQ-20



TIME CONSUMING 14%
UYK-5 UYK-20
LHA NTDS-CV
USQ-20



TIME CONSUMING 18%
UYK-5 UYK-20
LHA NTDS-CV
USQ-20



TIME CONSUMING 23%
UYK-5 UYK-20
LHA NTDS-CV
USQ-20



TIME CONSUMING 0%
UYK-5 UYK-20
LHA NTDS-CV
USQ-20



TIME CONSUMING 14%
UYK-5 UYK-20
LHA NTDS-CV
USQ-20

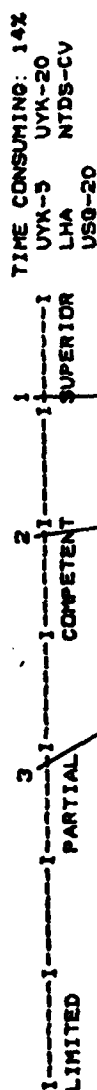


TIME CONSUMING 47%
UYK-5 UYK-20
LHA NTDS-CV
USQ-20

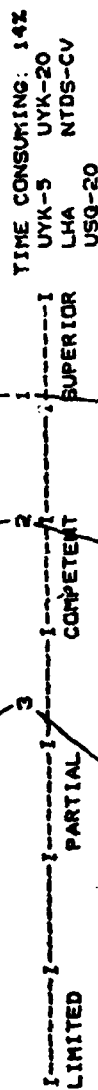


DS: CARD PUNCH

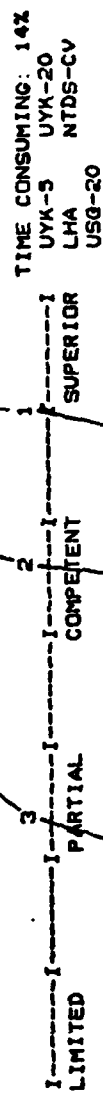
CLEAN/LUBRICATE CARD PUNCH



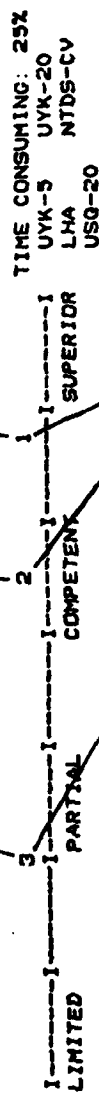
TEST/INSPECT CARD PUNCH



LOCALIZE/ISOLATE CARD PUNCH MALFUNCTION TO THE MODULE/CARD LEVEL



LOCALIZE/ISOLATE CARD PUNCH MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



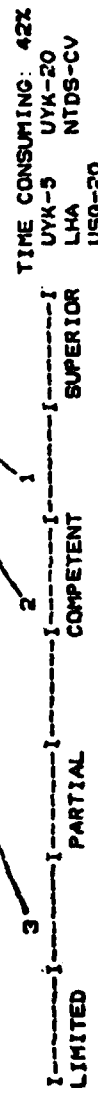
REMOVE/REPLACE CARD PUNCH MODULES/CARDS



REMOVE/REPLACE CARD PUNCH MODULES/CARDS



CALIBRATE/ALIGN/ADJUST CARD PUNCH



DS: CHILLED WATER SYSTEM

CLEAN COOLING CHILLED WATER SYSTEM



TEST/INSPECT COOLING CHILLED WATER SYSTEM

TIME CONSUMING: 21%
UYA-4 LHA
NTDS-3 NTDS-CV
USQ-20

LOCALIZE/ISOLATE COOLING CHILLED WATER SYSTEM MALFUNCTION TO A UNIT

TIME CONSUMING: 5%
UYA-4 LHA
NTDS-3 NTDS-CV
USQ-20

LOCALIZE/ISOLATE COOLING CHILLED WATER SYSTEM MALFUNCTION TO THE PART LEVEL

TIME CONSUMING: 11%
UYA-4 LHA
NTDS-3 NTDS-CV
USQ-20

REMOVE/REPLACE COOLING CHILLED WATER SYSTEM PARTS

TIME CONSUMING: 42%
UYA-4 LHA
NTDS-3 NTDS-CV
USQ-20

CALIBRATE/ALIGN/ADJUST COOLING CHILLED WATER SYSTEM

TIME CONSUMING: 7%
UYA-4 LHA
NTDS-3 NTDS-CV
USQ-20

DS: CIRCUIT CARD TEST SET

CLEAN CIRCUIT CARD TEST SET

TIME CONSUMING: 17%
UYA-4 UYK-20
LHA NTDS-3
NTDS-CV

TEST/INSPECT CIRCUIT CARD TEST SET

TIME CONSUMING: 16%
UYA-4 UYK-20
LHA NTDS-3
NTDS-CV

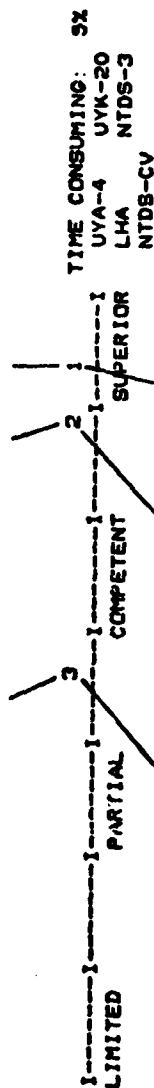
LOCALIZE/ISOLATE CIRCUIT CARD TEST SET MALFUNCTION TO THE MODULE/CARD LEVEL

TIME CONSUMING: 0%
UYA-4 UYK-20
LHA NTDS-3
NTDS-CV

LOCALIZE/ISOLATE CIRCUIT CARD TEST SET MALFUNCTION TO THE COMPONENT LEVEL, SUCH

TIME CONSUMING: 5%
UYA-4 UYK-20
LHA NTDS-3

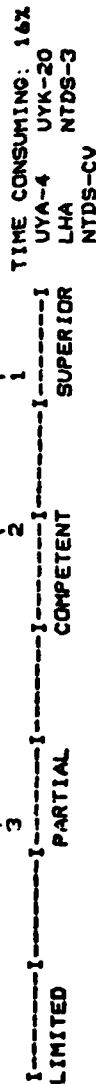
REMOVE/REPLACE CIRCUIT CARD TEST SET
MODULES/CARDS



REMOVE/REPLACE CIRCUIT CARD TEST SET
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

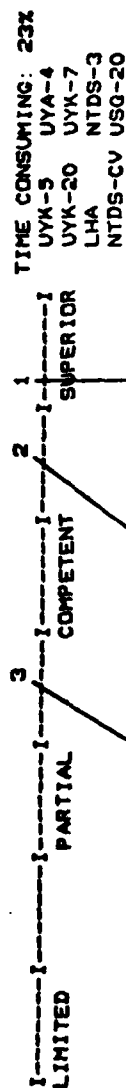


CALIBRATE/ALIGN/ADJUST CIRCUIT CARD TEST SET

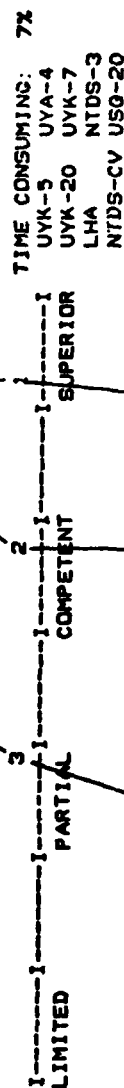


DS: COMPUTER ELECTRONICS

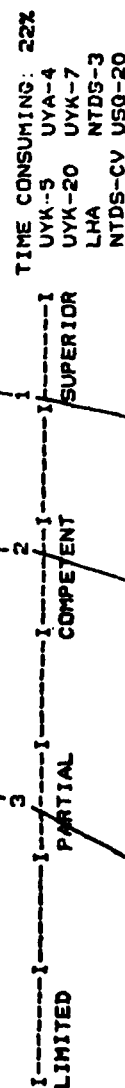
CLEAN DIGITAL COMPUTER ELECTRONICS



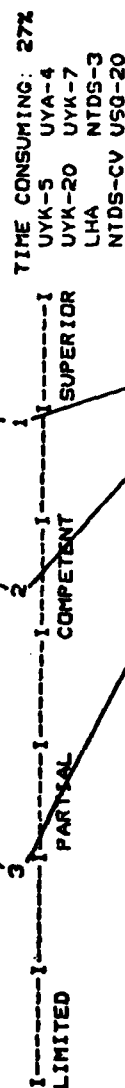
TEST/INSPECT DIGITAL COMPUTER ELECTRONICS



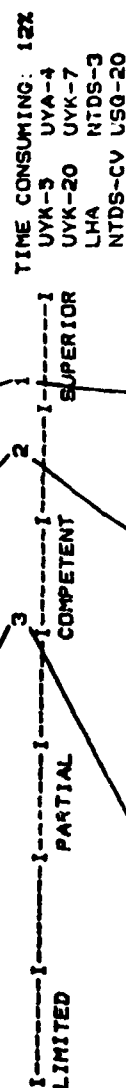
LOCALIZE/ISOLATE DIGITAL COMPUTER
ELECTRONICS MALFUNCTION TO THE
MODULE/CARD LEVEL



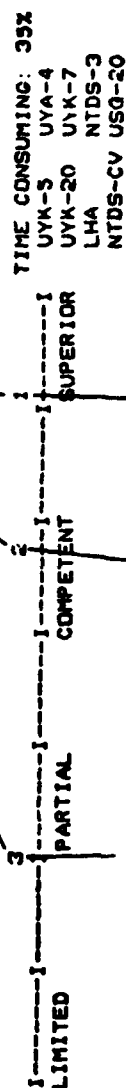
LOCALIZE/ISOLATE DIGITAL COMPUTER
ELECTRONICS MALFUNCTION TO THE COMPONENT
LEVEL, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.



REMOVE/REPLACE DIGITAL COMPUTER
ELECTRONICS MODULES/CARDS



REMOVE/REPLACE DIGITAL COMPUTER
ELECTRONICS COMPONENTS, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.



CALIBRATE/ALIGN/ADJUST DIGITAL COMPUTER ELECTRONICS

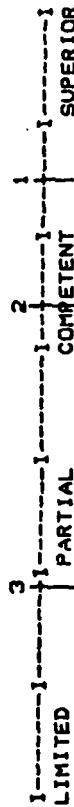
TIME CONSUMING: 33%
UYK-5 UYA-4
UYK-20 UYK-7
LHA NTDS-3
NTDS-CV USQ-20



DS: DISK FILE

CLEAN/LUBRICATE DISK FILE

TIME CONSUMING: 11%
UYK-5 UYK-20
LHA NTDS-CV
USQ-20



TEST/INSPECT DISK FILE

TIME CONSUMING: 11%
UYK-5 UYK-20
LHA NTDS-CV
USQ-20



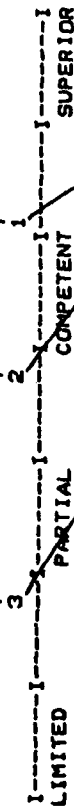
LOCALIZE/ISOLATE DISK FILE MALFUNCTION TO THE MODULE/CARD LEVEL

TIME CONSUMING: 11%
UYK-5 UYK-20
LHA NTDS-CV
USQ-20



LOCALIZE/ISOLATE DISK FILE MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, I.C'S, ETC.

TIME CONSUMING: 11%
UYK-5 UYK-20
LHA NTDS-CV
USQ-20



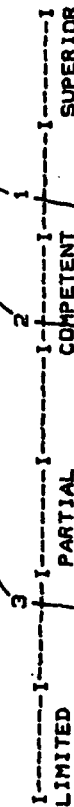
REMOVE/REPLACE DISK FILE MODULES/CARDS

TIME CONSUMING: 0%
UYK-5 UYK-20
LHA NTDS-CV
USQ-20



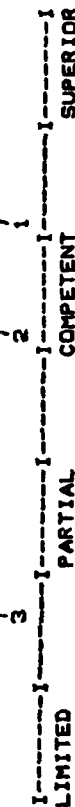
REMOVE/REPLACE DISK FILE COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, I.C'S, ETC.

TIME CONSUMING: 11%
UYK-5 UYK-20
LHA NTDS-CV
USQ-20



CALIBRATE/ALIGN/ADJUST DISK FILE

TIME CONSUMING: 33%
UYK-5 UYK-20
LHA NTDS-CV
USQ-20



DS: DATA ENTRY KEYSET CONSOLE

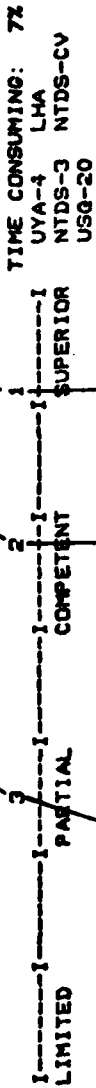
CLEAN DATA ENTRY KEYSET CONSOLE



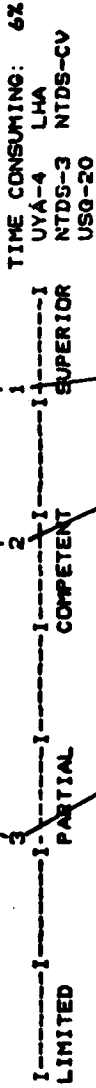
TEST/INSPECT DATA ENTRY KEYSET CONSOLE



LOCALIZE/ISOLATE DATA ENTRY KEYSET CONSOLE MALFUNCTION TO THE MODULE/CARD LEVEL



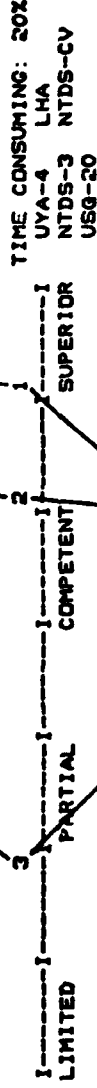
LOCALIZE/ISOLATE DATA ENTRY KEYSET CONSOLE MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



REMOVE/REPLACE DATA ENTRY KEYSET CONSOLE MODULES/CARDS



REMOVE/REPLACE DATA ENTRY KEYSET CONSOLE COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



CALIBRATE/ALIGN/ADJUST DATA ENTRY KEYSET CONSOLE

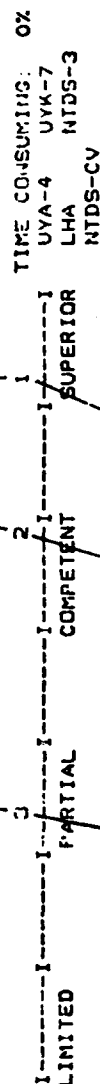


DS: DATA TERMINAL SET

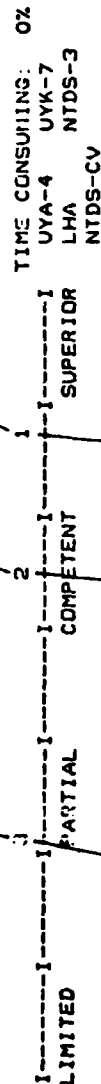
CLEAN/LUBRICATE DATA TERMINAL SET



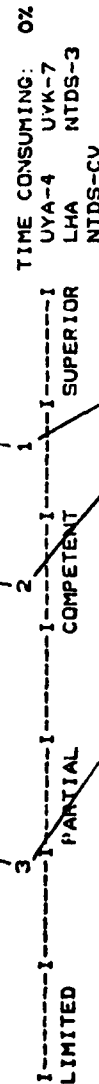
TEST/INSPECT DATA TERMINAL SET



LOCALIZE-ISOLATE DATA TERMINAL SET MALFUNCTION TO THE MODULE/CARD LEVEL



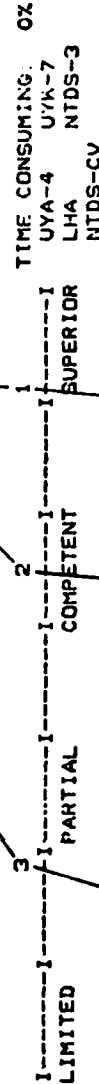
LOCALIZE-ISOLATE DATA TERMINAL SET MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



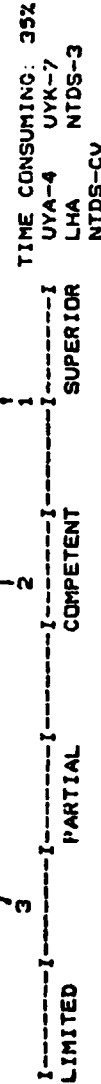
REMOVE/REPLACE DATA TERMINAL SET MODULES/CARDS



REMOVE/REPLACE DATA TERMINAL SET COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



CALIBRATE/ALIGN/ADJUST DATA TERMINAL SET



DS: DISPLAY CONSOLE

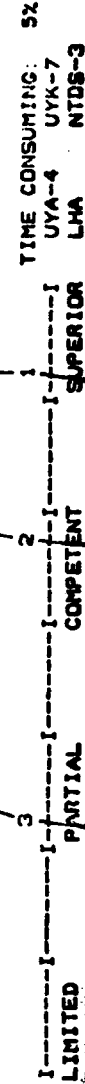
CLEAN DISPLAY CONSOLE



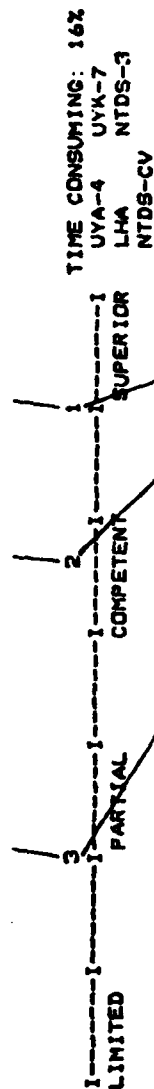
TEST/INSPECT DISPLAY CONSOLE



LOCALIZE-ISOLATE DISPLAY CONSOLE MALFUNCTION TO THE MODULE/CARD LEVEL



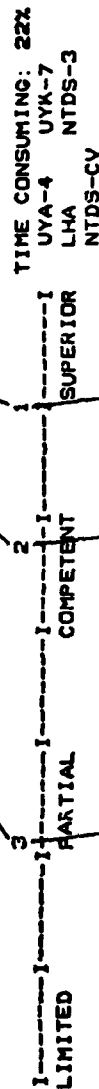
LOCALIZE/ISOLATE DISPLAY CONSOLE
MALFUNCTION TO THE COMPONENT LEVEL, SUCH
AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



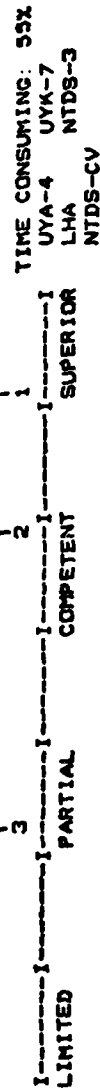
REMOVE/REPLACE DISPLAY CONSOLE
MODULES/CARDS



REMOVE/REPLACE DISPLAY CONSOLE COMPONENTS,
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



CALIBRATE/ALIGN/ADJUST DISPLAY CONSOLE



DS: HIGH SPEED PRINTER

CLEAN/LUBRICATE HIGH SPEED PRINTER



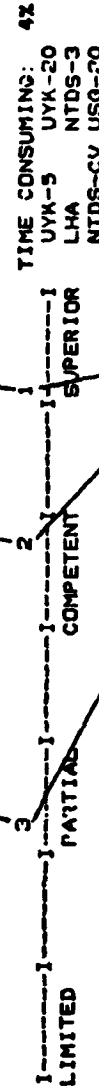
TEST/INSPECT HIGH SPEED PRINTER



LOCALIZE/ISOLATE HIGH SPEED PRINTER
MALFUNCTION TO THE MODULE/CARD LEVEL



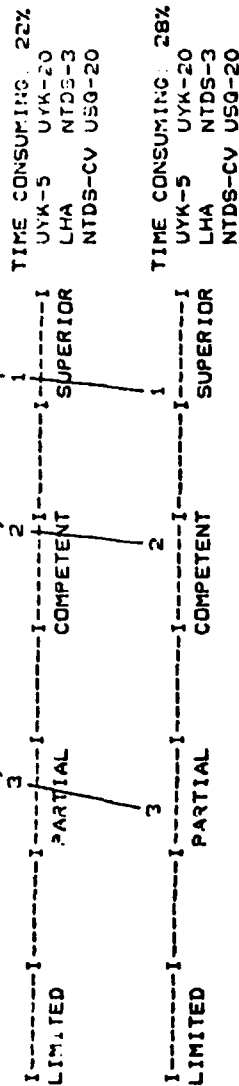
LOCALIZE/ISOLATE HIGH SPEED PRINTER
MALFUNCTION TO THE COMPONENT LEVEL, SUCH
AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



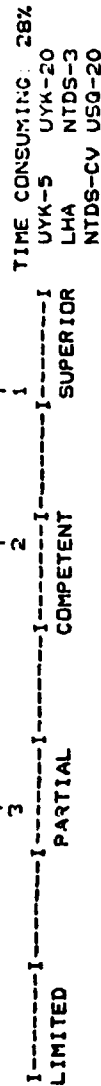
REMOVE/REPLACE HIGH SPEED PRINTER
MODULES/CARDS



REMOVE/REPLACE HIGH SPEED PRINTER
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

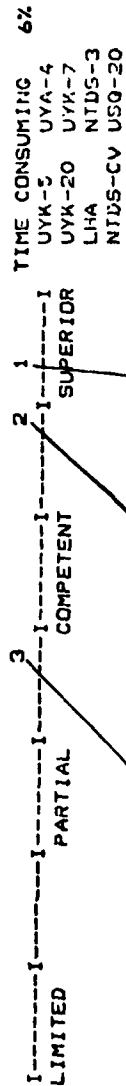


CALIBRATE/ALIGN/ADJUST HIGH SPEED PRINTER

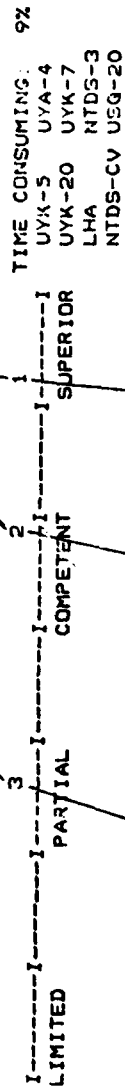


DS: MAGNETIC TAPE CONTROLLER

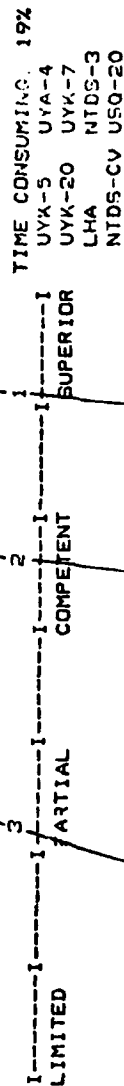
CLEAN MAGNETIC TAPE CONTROLLER



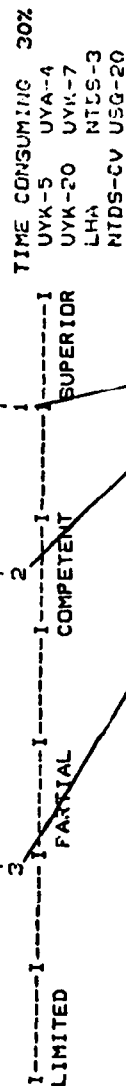
TEST/INSPECT MAGNETIC TAPE CONTROLLER



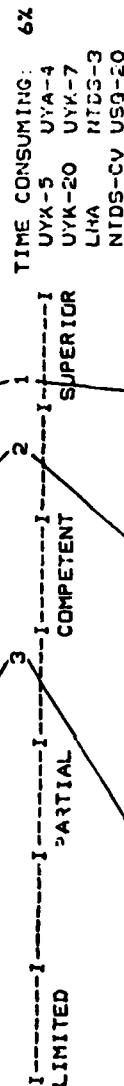
LOCALIZE/ISOLATE MAGNETIC TAPE
CONTROLLER MALFUNCTION TO THE
MODULE/CARD LEVEL



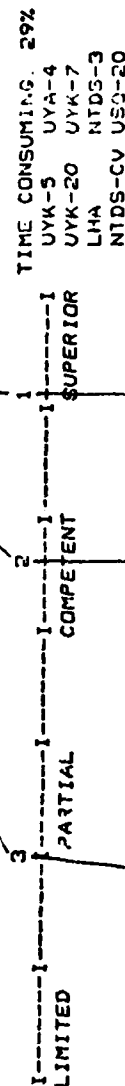
LOCALIZE/ISOLATE MAGNETIC TAPE CONTROLLER
MALFUNCTION TO THE COMPONENT LEVEL, SUCH
AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



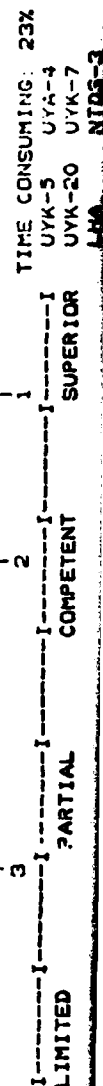
REMOVE/REPLACE MAGNETIC TAPE CONTROLLER
MODULES/CARDS



REMOVE/REPLACE MAGNETIC TAPE CONTROLLER
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

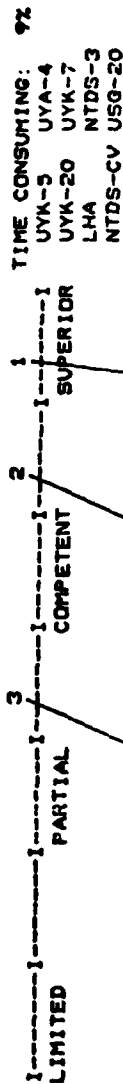


CALIBRATE/ALIGN/ADJUST MAGNETIC TAPE
CONTROLLER

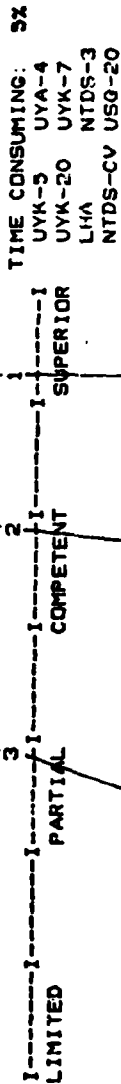


DS: MAGNETIC TAPE TRANSPORT

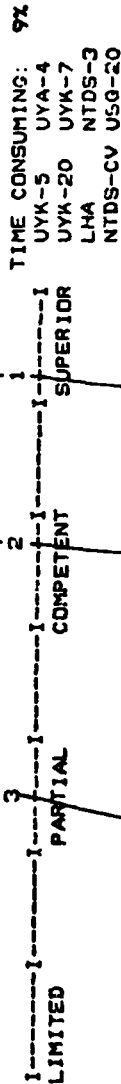
CLEAN/LUBRICATE MAGNETIC TAPE TRANSPORT



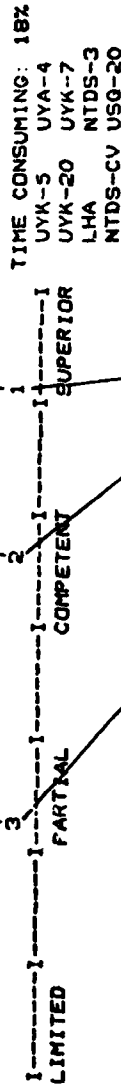
TEST/INSPECT MAGNETIC TAPE TRANSPORT



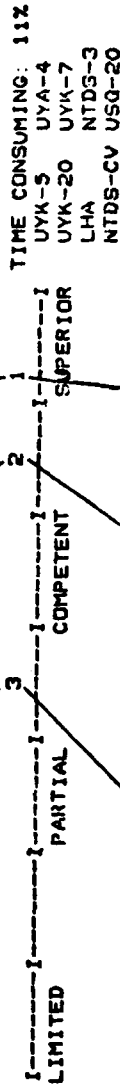
LOCALIZE/ISOLATE MAGNETIC TAPE TRANSPORT
MALFUNCTION TO THE MODULE/CARD LEVEL



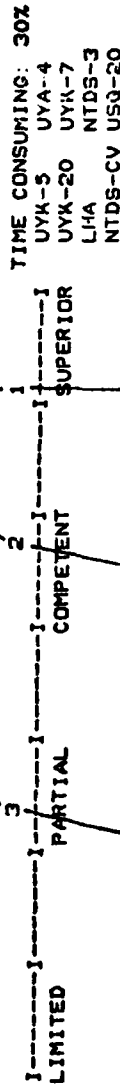
LOCALIZE/ISOLATE MAGNETIC TAPE TRANSPORT
MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS
SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



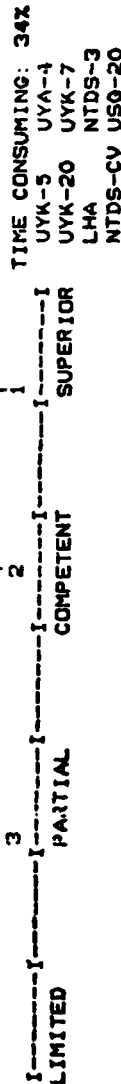
REMOVE/REPLACE MAGNETIC TAPE TRANSPORT
MODULES/CARDS



REMOVE/REPLACE MAGNETIC TAPE TRANSPORT
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, ICS, ETC.

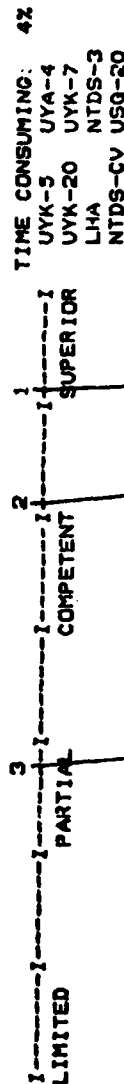


CALIBRATE/ALIGN/ADJUST MAGNETIC TAPE
TRANSPORT



DS: PAPER TAPE PUNCH

CLEAN/LUBRICATE PAPER TAPE PUNCH

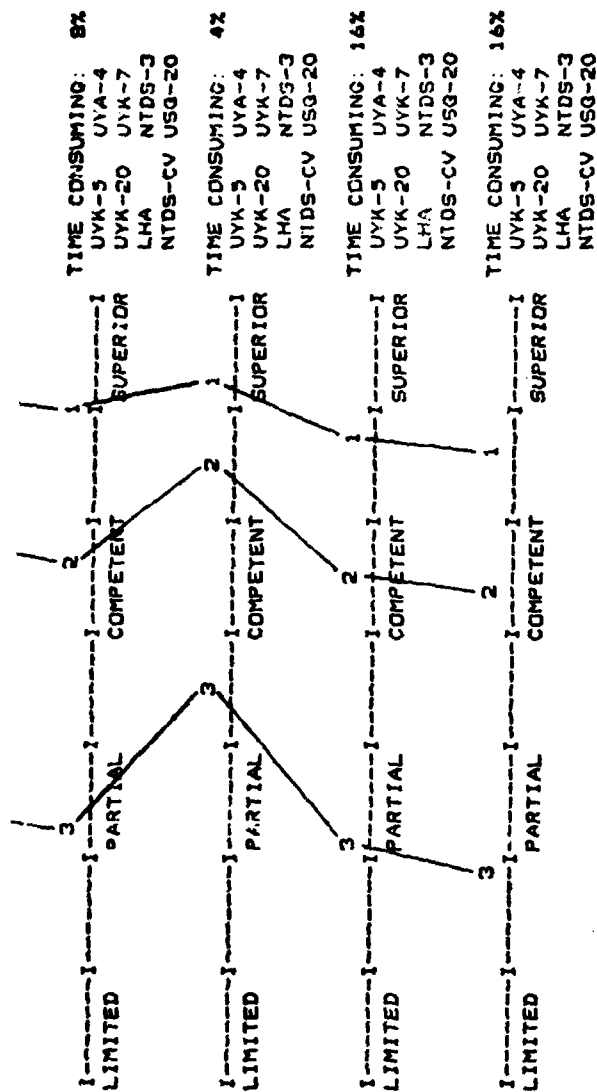


LOCALIZE/ISOLATE PAPER TAPE READER
MALFUNCTION TO THE COMPONENT LEVEL,
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

REMOVE/REPLACE PAPER TAPE READER
MODULES/CARDS

REMOVE/REPLACE PAPER TAPE READER
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

CALIBRATE/ALIGN/ADJUST PAPER TAPE READER



DS: PULSE AMPLIFIER-SYMBOL GENERATOR

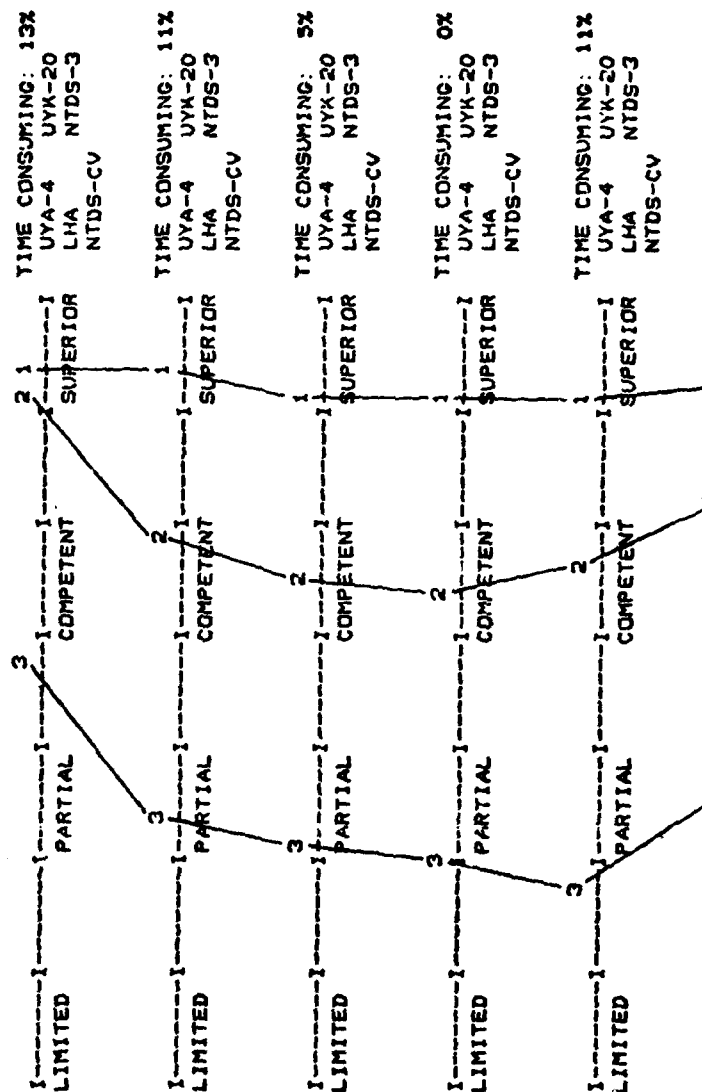
CLEAN/LUBRICATE PULSE AMPLIFIER-
SYMBOL GENERATOR

TEST/INSPECT PULSE AMPLIFIER-SYMBOL
GENERATOR

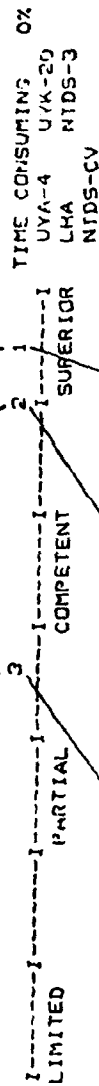
LOCALIZE/ISOLATE PULSE AMPLIFIER-SYMBOL
GENERATOR

LOCALIZE/ISOLATE PULSE AMPLIFIER-SYMBOL
GENERATOR MALFUNCTION TO THE
MODULE/CARD LEVEL

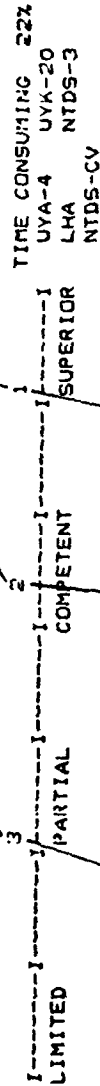
LOCALIZE/ISOLATE PULSE AMPLIFIER-SYMBOL
GENERATOR MALFUNCTION TO THE COMPONENT
LEVEL, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.



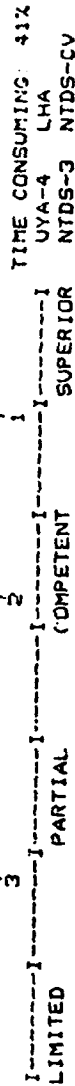
REMOVE/REPLACE PULSE AMPLIFIER-SYMBOL
GENERATOR MODULES/CARDS



REMOVE/REPLACE PULSE AMPLIFIER-SYMBOL
GENERATOR COMPONENTS, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.

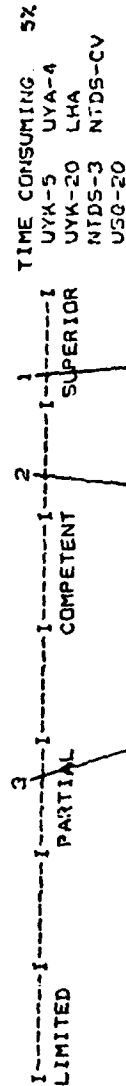


CALIBRATE/ALIGN/ADJUST PULSE
AMPLIFIER-SYMBOL GENERATOR

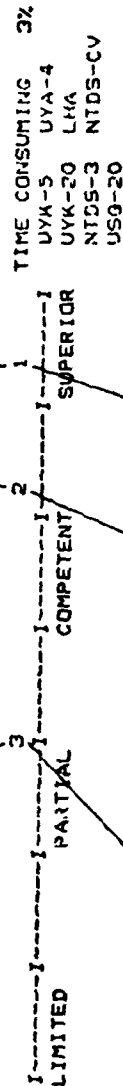


DS: TELETYPE

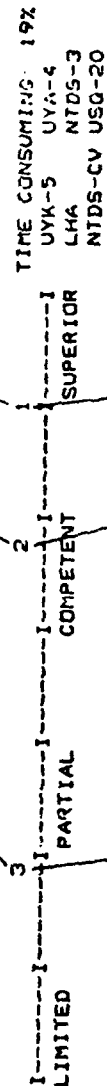
CLEAN/LUBRICATE TELETYPE



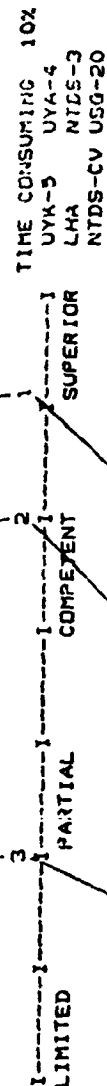
TEST/INSPECT TELETYPE



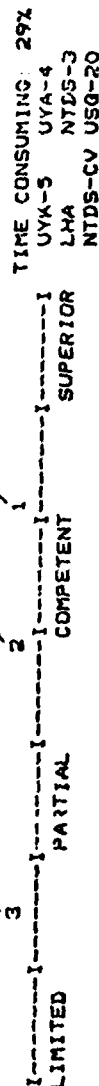
LOCALIZE/ISOLATE TELETYPE MALFUNCTION
TO THE COMPONENT LEVEL, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.



REMOVE/REPLACE TELETYPE COMPONENTS, SUCH
AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

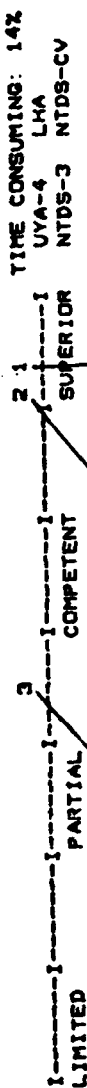


CALIBRATE/ALIGN/ADJUST TELETYPE

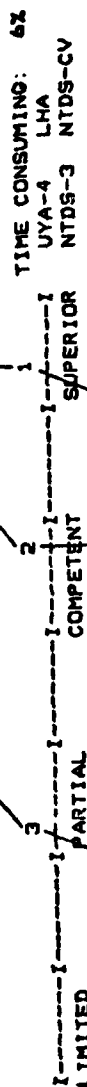


DS: VIDEO SIMULATOR

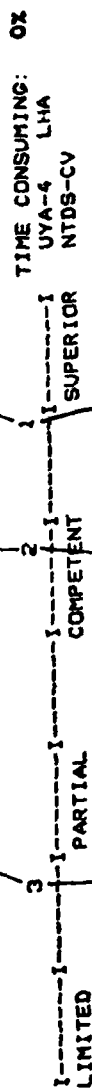
CLEAN VIDEO SIMULATOR



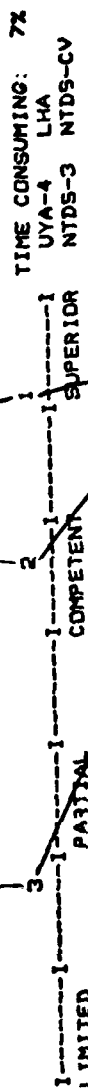
TEST/INSPECT VIDEO SIMULATOR



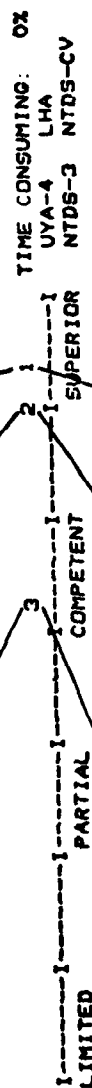
LOCALIZE/ISOLATE VIDEO SIMULATOR MALFUNCTION TO THE MODULE/CARD LEVEL



LOCALIZE/ISOLATE VIDEO SIMULATOR MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



REMOVE/REPLACE VIDEO SIMULATOR MODULES/CARDS



REMOVE/REPLACE VIDEO SIMULATOR COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



CALIBRATE/ALIGN/ADJUST VIDEO SIMULATOR



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ET(N): GENERAL MAINTENANCE

RESEARCH TECHNICAL PUBLICATIONS TO
FIND APPROPRIATE SCHEMATICS/LOGIC
DIAGRAMS/TABLES/TROUBLESHOOTING CHARTS/
MAINTENANCE INFORMATION/PART NUMBERS FOR
SPECIFIC PIECES OF EQUIPMENT

IDENTIFY STANDARD ELECTRONIC/
MECHANICAL SYMBOLS AS USED ON
SCHEMATICS, LOGIC DIAGRAMS, FLOW
CHARTS, ETC.

MODIFY EQUIPMENT IN ACCORDANCE
WITH SHIPALTS, ORDALTS, FIELD
CHANGE ORDERS AND ELECTRONIC
INFORMATION BULLETINS (EIBS)

CHANGE SYSTEM CONFIGURATION BY
PATCHING OR BY SWITCHBOARD
CHANGES

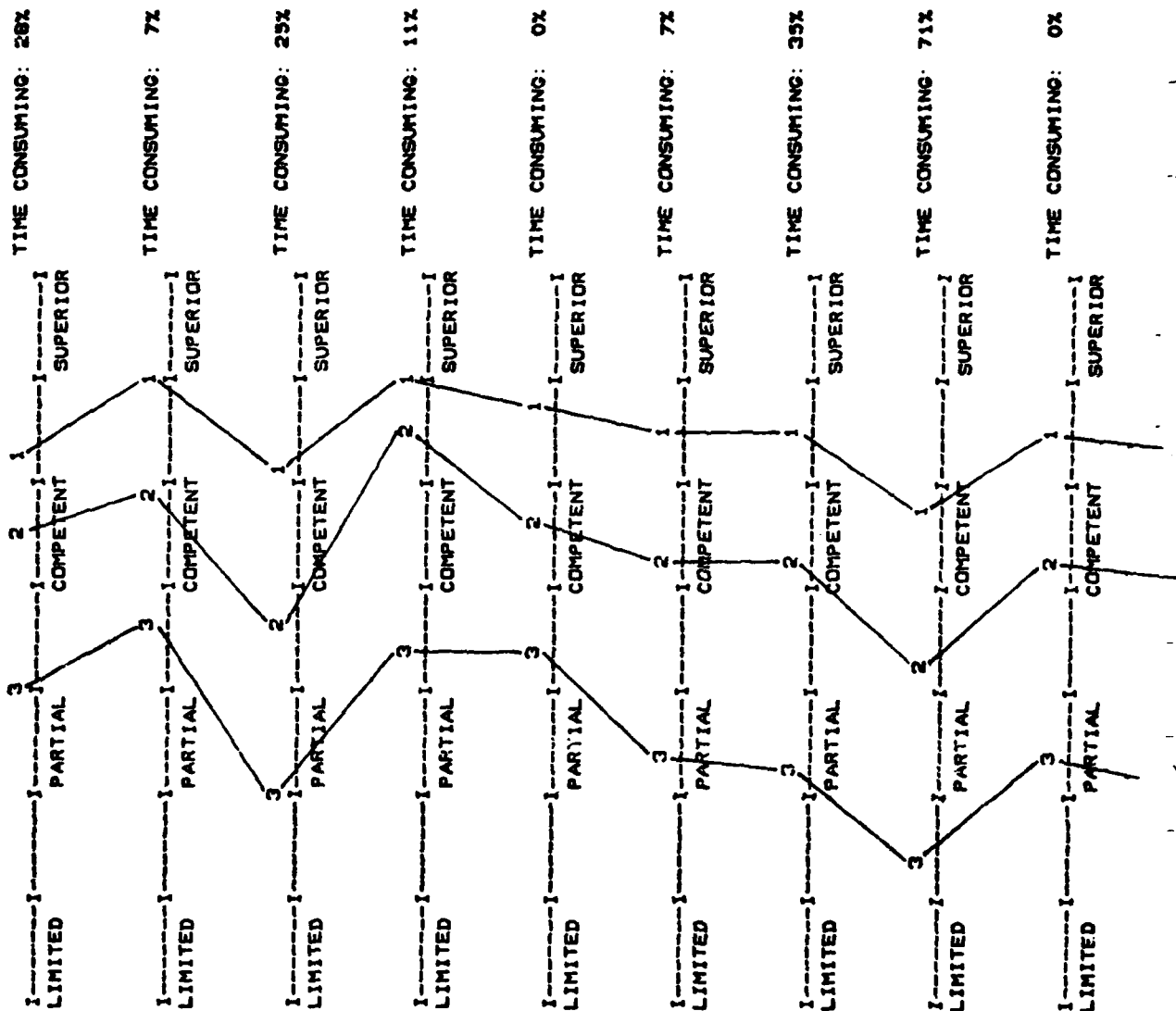
ANALYZE EQUIPMENT FRONT PANEL
INDICATORS FOR FAULT DETECTION

USE TEST EQUIPMENT TO INJECT
SIGNALS AND/OR TAKE READINGS

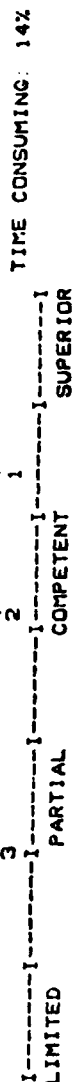
ASSEMBLE/REPAIR CABLES AND TEST
LEADS, SUCH AS CONNECTORS,
PROBES, ETC.

ALIGN/ADJUST MECHANICAL LINKAGES
AND GEAR TRAINS

LOCALIZE/ISOLATE EQUIPMENT
MALFUNCTION TO A SUBSYSTEM

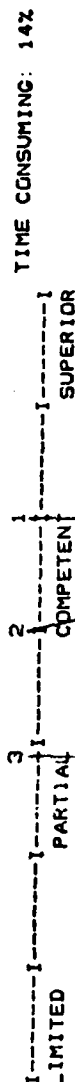


LOCALIZE/ISOLATE EQUIPMENT
MALFUNCTION TO A UNIT

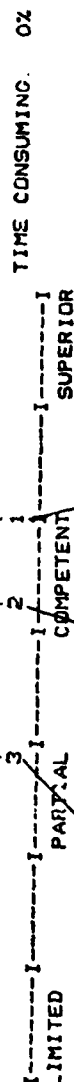


ET(N): ANTENNA SYSTEMS, COMMUNICATIONS

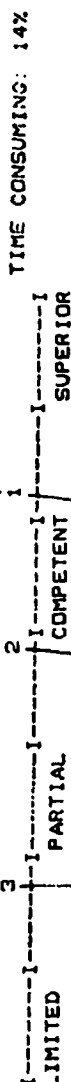
CLEAN/LUBRICATE COMMUNICATION
ANTENNA SYSTEMS



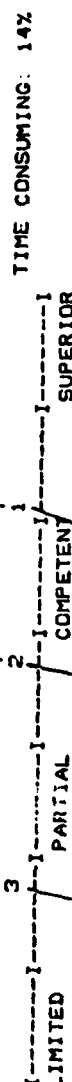
TEST/INSPECT COMMUNICATION
ANTENNA SYSTEMS



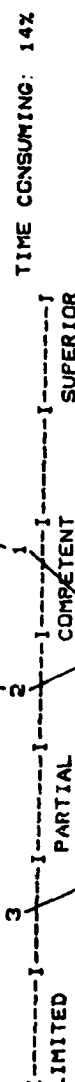
LOCALIZE/ISOLATE COMMUNICATION
ANTENNA SYSTEMS MALFUNCTION
TO A SUBSYSTEM



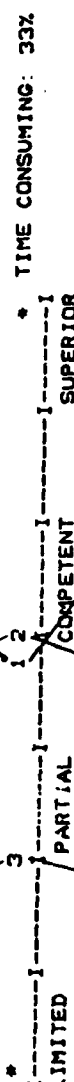
LOCALIZE/ISOLATE COMMUNICATION
ANTENNA SYSTEMS MALFUNCTION TO
A UNIT



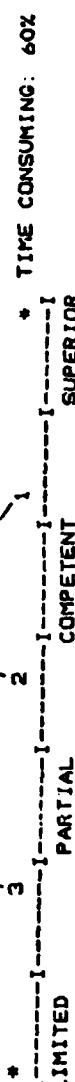
LOCALIZE/ISOLATE COMMUNICATION
ANTENNA SYSTEMS MALFUNCTION TO
THE COMPONENT LEVEL



REMOVE/REPLACE COMMUNICATION
ANTENNA SYSTEMS COMPONENTS, SUCH
AS SWITCHES, RESISTORS, CAPACITORS
TRANSISTORS, ICS, ETC.



CALIBRATE/ALIGN/ADJUST COMMUNICATION
ANTENNA SYSTEMS

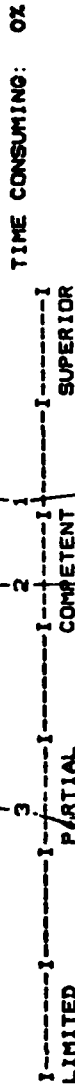


ET(N): AUDIO

LOCALIZE/ISOLATE AUDIO MALFUNCTION
TO A UNIT



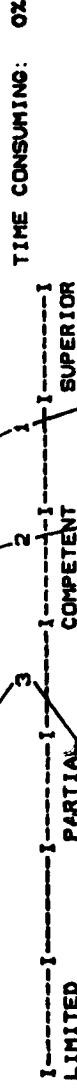
LOCALIZE/ISOLATE AUDIO MALFUNCTION
TO THE MODULE/CARD LEVEL



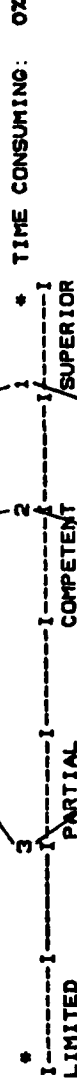
LOCALIZE/ISOLATE AUDIO MALFUNCTION TO
THE COMPONENT LEVEL, SUCH AS SWITCHES,
RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



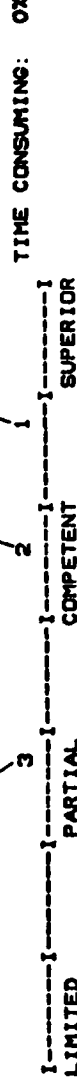
REMOVE/REPLACE AUDIO MODULES/CARDS



REMOVE/REPLACE AUDIO COMPONENTS,
SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.



CALIBRATE/ALIGN/ADJUST AUDIO



ET(N): COMMUNICATION EQUIPMENT, VHF/UHF

TEST/INSPECT VHF/UHF COMMUNICATION
EQUIPMENT



LOCALIZE/ISOLATE VHF/UHF COM-
MUNICATION EQUIPMENT MALFUNCTION
A UNIT



LOCALIZE/ISOLATE VHF/UHF COMMUNICATION EQUIPMENT MALFUNCTION TO THE MODULE/CARD LEVEL

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

LOCALIZE/ISOLATE VHF/UHF COMMUNICATION EQUIPMENT MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

REMOVE/REPLACE VHF/UHF COMMUNICATION EQUIPMENT

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

REMOVE/REPLACE VHF/UHF COMMUNICATION EQUIPMENT COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

CALIBRATE/ALIGN/ADJUST VHF/UHF COMMUNICATION EQUIPMENT

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

ET(N): COMMUNICATION PATCHING FACILITY

TEST/INSPECT COMM PATCHING FACILITY

* TIME CONSUMING: 0%
LIMITED PARTIAL COMPETENT SUPERIOR

LOCALIZE/ISOLATE COMM PATCHING FACILITY MALFUNCTION TO A UNIT

* TIME CONSUMING: 20%
LIMITED PARTIAL COMPETENT SUPERIOR

LOCALIZE/ISOLATE COMM PATCHING FACILITY MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

* TIME CONSUMING: 40%
LIMITED PARTIAL COMPETENT SUPERIOR

REMOVE/REPLACE COMM PATCHING FACILITY COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

* TIME CONSUMING: 20%
LIMITED PARTIAL COMPETENT SUPERIOR

* TIME CONSUMING: 20%

* LIMITED PARTIAL COMPETENT SUPERIOR

3 2 1

TEST/INSPECT COMMUNICATION REMOTES

* LIMITED * PARTIAL * COMPETENT * SUPERIOR
TIME CONSUMING: OZ

LOCALIZE/ISOLATE COMMUNICATION REMOTES MALFUNCTION TO A UNIT

* LIMITED * PARTIAL * COMPETENT * SUPERIOR
TIME CONSUMING: OZ

LOCALIZE/ISOLATE COMMUNICATION REMOTES MALFUNCTION TO THE MODULE/CARD LEVEL

* LIMITED * PARTIAL * COMPETENT * SUPERIOR
TIME CONSUMING: OZ

LOCALIZE/ISOLATE COMMUNICATION REMOTES MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

* LIMITED * PARTIAL * COMPETENT * SUPERIOR
TIME CONSUMING: 20Z

REMOVE/REPLACE COMMUNICATION REMOTES MODULES/CARDS

* LIMITED * PARTIAL * COMPETENT * SUPERIOR
TIME CONSUMING: OZ

REMOVE/REPLACE COMMUNICATION REMOTES COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

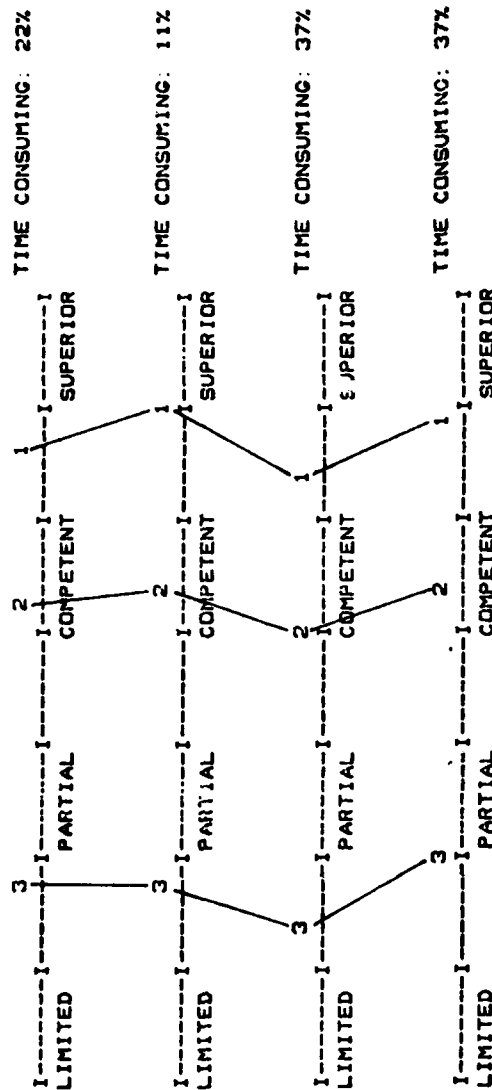
* LIMITED * PARTIAL * COMPETENT * SUPERIOR
TIME CONSUMING: 20Z

CALIBRATE/ALIGN/ADJUST COMMUNICATION REMOTES

* LIMITED * PARTIAL * COMPETENT * SUPERIOR
TIME CONSUMING: OZ

ET(N): COOLING SYSTEMS

TEST/INSPECT ELECTRONIC EQUIPMENT
COOLING SYSTEM



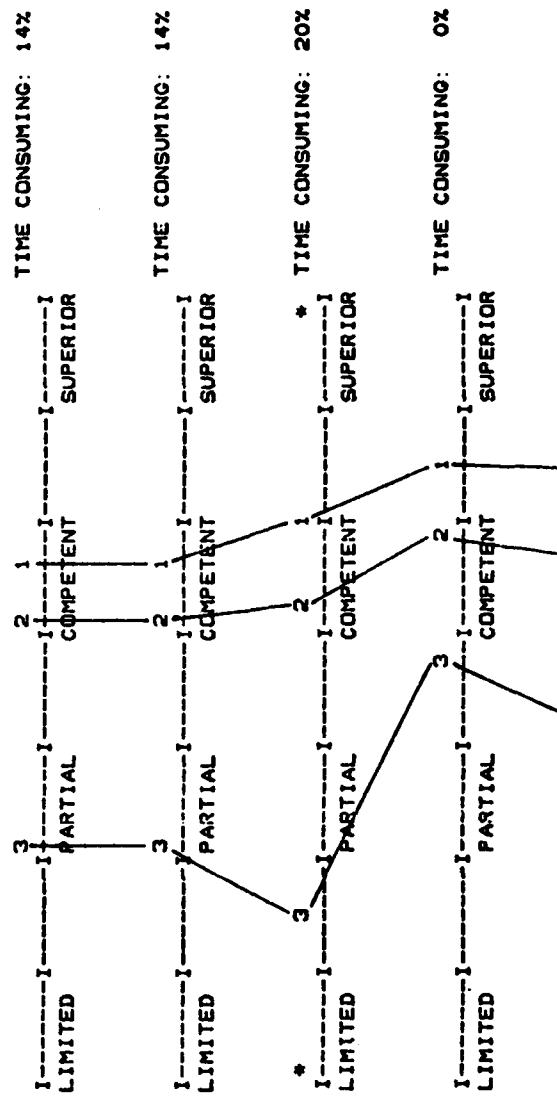
LOCALIZE/ISOLATE ELECTRONIC
EQUIPMENT COOLING SYSTEM MALFUNCTION
TO A UNIT

LOCALIZE/ISOLATE ELECTRONIC
EQUIPMENT COOLING SYSTEM MAL-
FUNCTION TO THE FAILED PART

REMOVE/REPLACE ELECTRONIC EQUIP-
MENT COOLING SYSTEM FAILED PART

ET(N): DEMODULATION

LOCALIZE/ISOLATE DEMODULATION
MALFUNCTION TO A UNIT

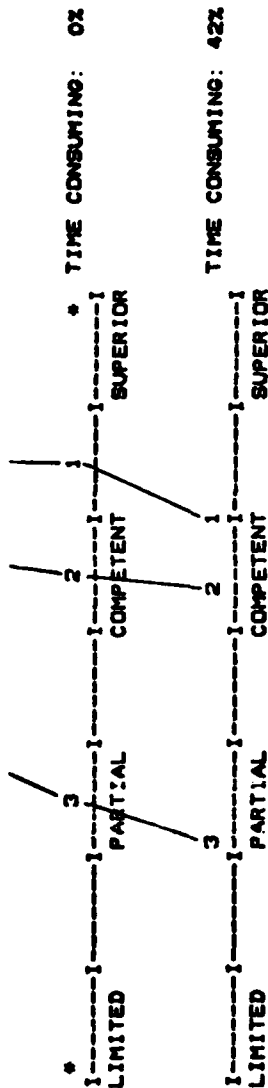


LOCALIZE/ISOLATE DEMODULATION
MALFUNCTION TO THE MODULE/CARD LEVEL

LOCALIZE/ISOLATE DEMODULATION
MALFUNCTION TO THE COMPONENT
LEVEL, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

REMOVE/REPLACE DEMODULATION
MODULES/CARDS

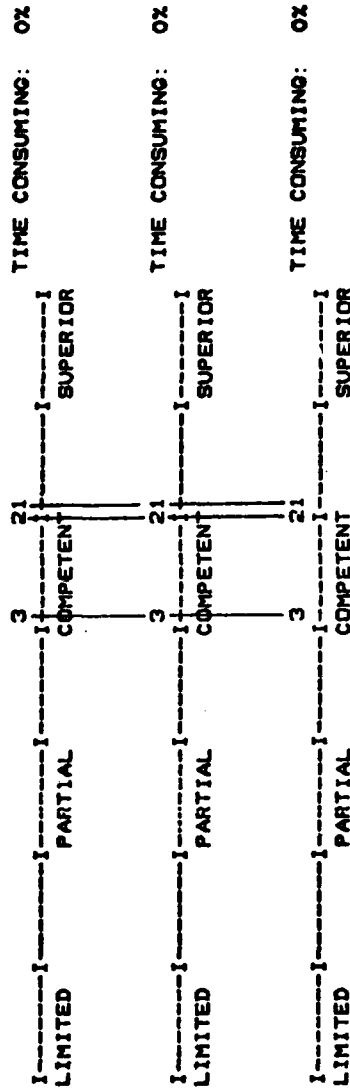
REMOVE/REPLACE DEMODULATION COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



CALIBRATE/ALIGN/ADJUST DEMODULATION

ET(N): HEADSETS/HANDSETS

TEST/INSPECT HEADSETS/HANDSETS



LOCALIZE/ISOLATE HEADSETS/HANDSETS MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

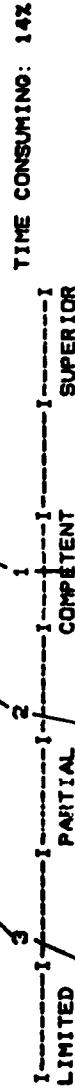
REMOVE/REPLACE HEADSETS/HANDSETS COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

ET(N): IF UNITS

LOCALIZE/ISOLATE IF MALFUNCTION TO A UNIT



LOCALIZE/ISOLATE IF MALFUNCTION TO THE MODULE/CARD LEVEL



LOCALIZE/ISOLATE IF MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

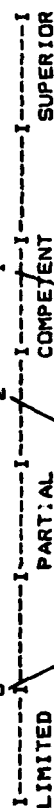
REMOVE/REPLACE IF MODULES/CARDS

TIME CONSUMING: 14%



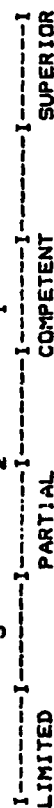
REMOVE/REPLACE IF COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

TIME CONSUMING: 33%



CALIBRATE/ALIGN/ADJUST IF

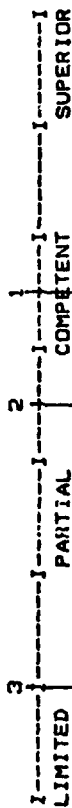
TIME CONSUMING: 37%



ET(N): MIXERS

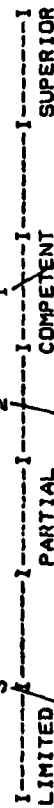
LOCALIZE/ISOLATE MIXERS (FREQ TRANSLATION) MALFUNCTION TO A UNIT

TIME CONSUMING: 16%



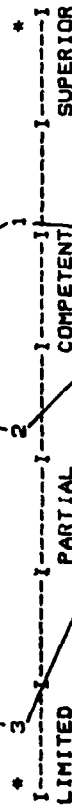
LOCALIZE/ISOLATE MIXERS (FREQ TRANSLATION) MALFUNCTION TO THE MODULE/CARD LEVEL

TIME CONSUMING: 16%



LOCALIZE/ISOLATE MIXERS (FREQ TRANSLATION) MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

TIME CONSUMING: 20%



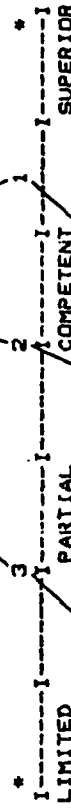
REMOVE/REPLACE MIXERS (FREQ TRANSLATION) MODULES/CARDS

TIME CONSUMING: 0%



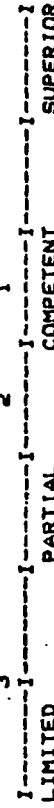
REMOVE/REPLACE MIXERS (FREQ TRANSLATION) COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

TIME CONSUMING: 0%



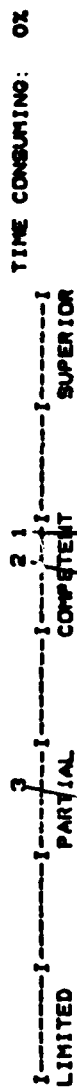
CALIBRATE/ALIGN/ADJUST MIXERS (FREQ TRANSLATION)

TIME CONSUMING: 66%

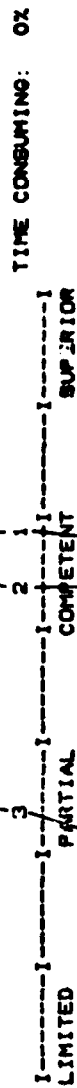


ET(N): MODULATION

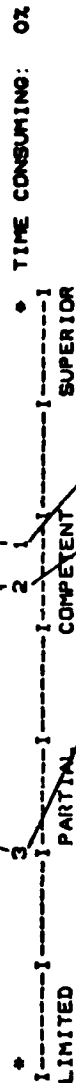
LOCALIZE/ISOLATE MODULATION
MALFUNCTION TO A UNIT



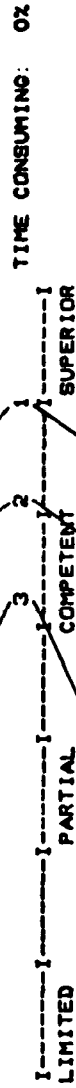
LOCALIZE/ISOLATE MODULATION MAL-
FUNCTION TO THE MODULE/CARD LEVEL



LOCALIZE/ISOLATE MODULATION MAL-
FUNCTION TO THE COMPONENT LEVEL,
SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.



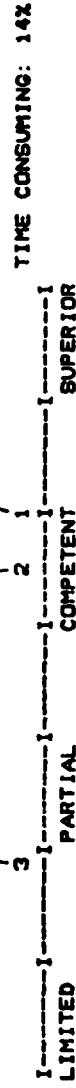
REMOVE/REPLACE MODULATION MODULES/
CARDS



REMOVE/REPLACE MODULATION COM-
PONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

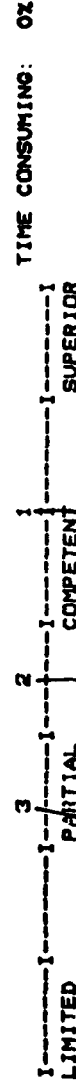


CALIBRATE/ALIGN/ADJUST MODULATION



ET(N): MOTOR GENERATORS

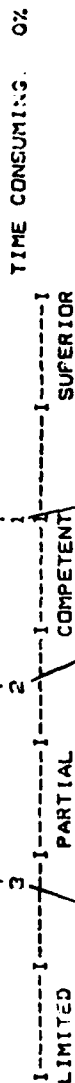
CLEAN/LUBRICATE MOTOR/GENERATORS



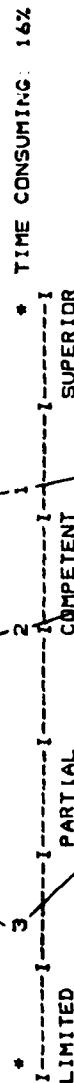
TEST/INSPECT MOTOR/GENERATORS



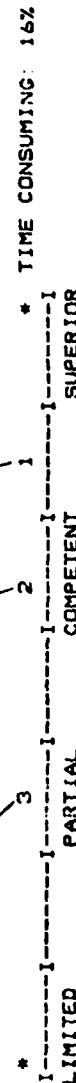
LOCALIZE/ISOLATE MOTOR/GENERATORS



REMOVE/REPLACE MOTOR/GENERATORS
FUNCTION TO THE FAILED PART

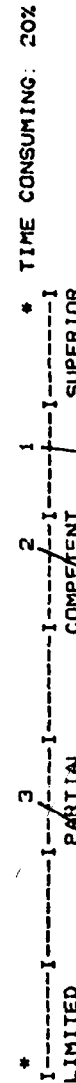


REMOVE/REPLACE MOTOR/GENERATORS
FAILED PART

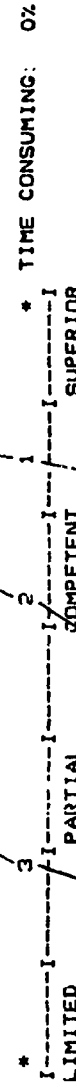


ET(N): RECEIVERS, VLF/LF/HF

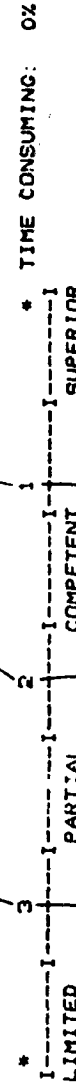
TEST/INSPECT VLF/LF/HF RECEIVERS



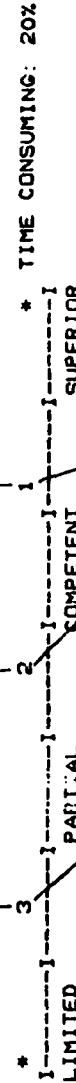
LOCALIZE/ISOLATE VLF/LF/HF
RECEIVERS MALFUNCTION TO A UNIT



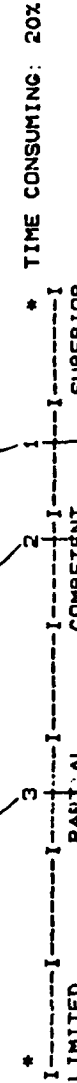
LOCALIZE/ISOLATE VLF/LF/HF
RECEIVERS MALFUNCTION TO THE
MODULE/CARD LEVEL



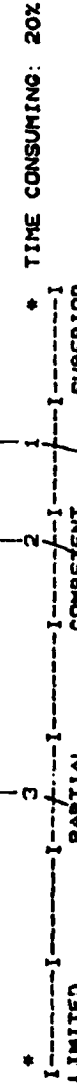
LOCALIZE/ISOLATE VLF/LF/HF
RECEIVERS MALFUNCTION TO THE COM-
PONENT LEVEL, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICs, ETC.

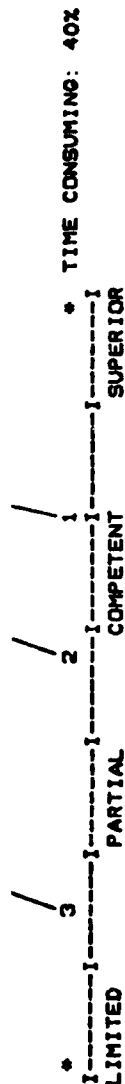


REMOVE/REPLACE VLF/LF/HF RECEIVERS
MODULES/CARDS



REMOVE/REPLACE VLF/LF/HF RECEIVERS
COMPONENTS, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICs, ETC.



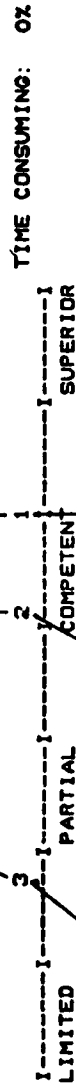


ET(N): RF UNITS

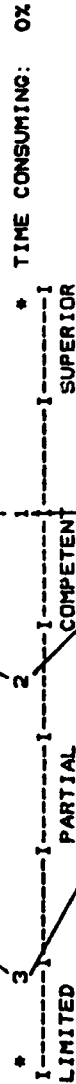
LOCALIZE/ISOLATE RF MALFUNCTION
TO A UNIT



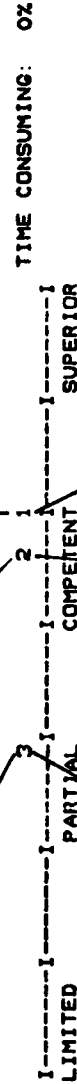
LOCALIZE/ISOLATE RF MALFUNCTION
TO THE MODULE/CARD LEVEL



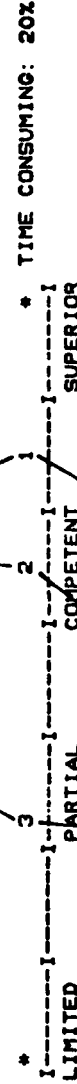
LOCALIZE/ISOLATE RF MALFUNCTION
TO THE COMPONENT LEVEL, SUCH AS
SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



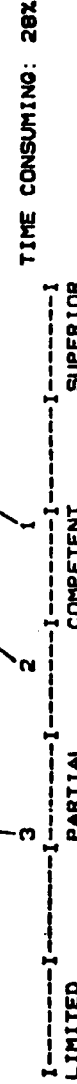
REMOVE/REPLACE RF MODULES CARDS



REMOVE/REPLACE RF COMPONENTS,
SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.



CALIBRATE/ALIGN/ADJUST RF



ET(N): SECURE EQUIPMENT

LOCALIZE/ISOLATE SECURE EQUIPMENT
SYSTEMS MALFUNCTION TO A SUBSYSTEM



LOCALIZE/ISOLATE SECURE EQUIPMENT
SYSTEMS MALFUNCTION TO A UNIT

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

LOCALIZE/ISOLATE SECURE EQUIPMENT
SYSTEMS MALFUNCTION TO THE MODULE/
CARD LEVEL

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

LOCALIZE/ISOLATE SECURE EQUIPMENT
SYSTEMS MALFUNCTION TO THE COM-
PONENT LEVEL, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

REMOVE/REPLACE SECURE EQUIPMENT
SYSTEMS MODULES/CARDS

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

REMOVE/REPLACE SECURE EQUIPMENT
SYSTEMS COMPONENTS, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

CALIBRATE/ALIGN/ADJUST SECURE
EQUIPMENT SYSTEMS

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

ET(N): SYNCHRO/SERVO AMPLIFIERS

TEST/INSPECT SYNCHRO/SERVO
AMPLIFIERS

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR
TIME CONSUMING: 20%

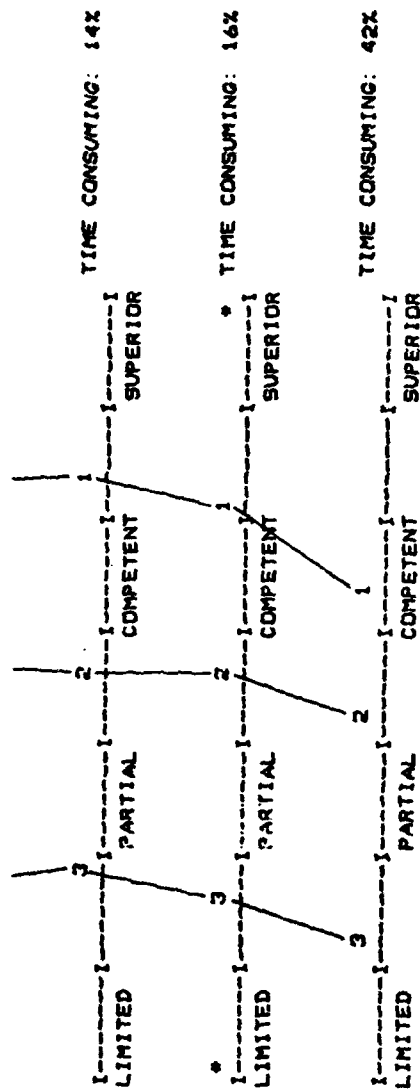
LOCALIZE/ISOLATE SYNCHRO/SERVO
AMPLIFIERS MALFUNCTION TO THE
MODULE/CARD LEVEL

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR
TIME CONSUMING: 14%

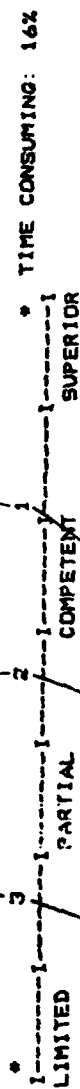
LOCALIZE/ISOLATE SYNCHRO/SERVO
AMPLIFIERS MALFUNCTION TO THE
COMPONENT LEVEL, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR
TIME CONSUMING: 16%

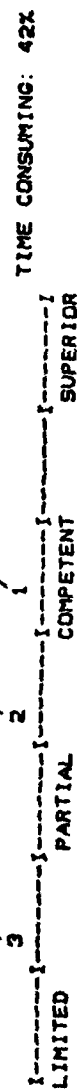
REMOVE/REPLACE SYNCHRO/SERVO
AMPLIFIERS MODULES/CARDS



REMOVE/REPLACE SYNCHRO/SERVO
AMPLIFIERS COMPONENTS, SUCH AS
SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

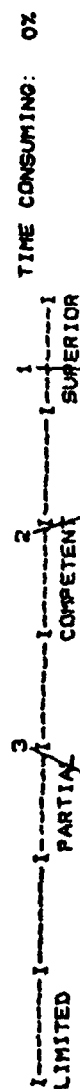


CALIBRATE/ALIGN/ADJUST SYNCHRO/
SERVO AMPLIFIERS

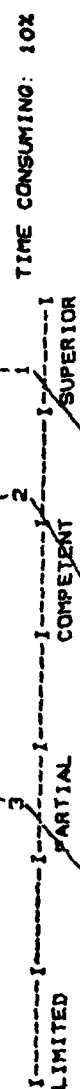


ET(N): TEST EQUIPMENT

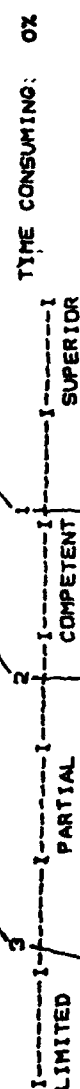
CLEAN/LUBRICATE TEST EQUIPMENT



TEST/INSPECT TEST EQUIPMENT



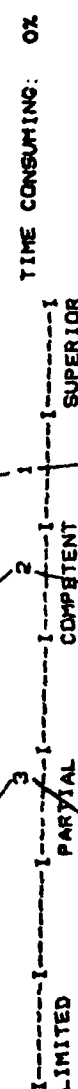
LOCALIZE/ISOLATE TEST EQUIPMENT
MALFUNCTION TO THE MODULE/CARD
LEVEL



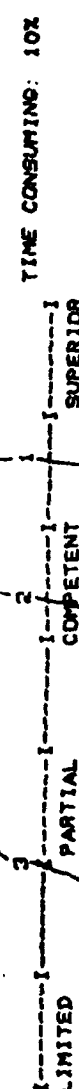
LOCALIZE/ISOLATE TEST EQUIPMENT
MALFUNCTION TO THE COMPONENT LEVEL,
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



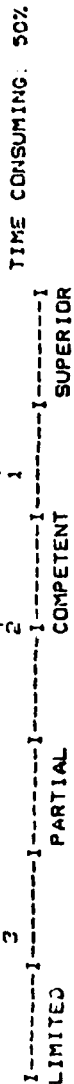
REMOVE/REPLACE TEST EQUIPMENT
MODULES/CARDS



REMOVE/REPLACE TEST EQUIPMENT
COMPONENTS, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.

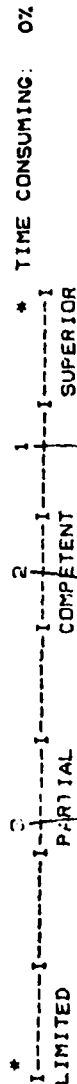


CALIBRATE/ALIGN/ADJUST TEST
EQUIPMENT

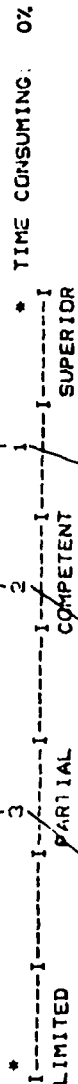


ET(N): TRANSMITTERS, VLF/LF/HF

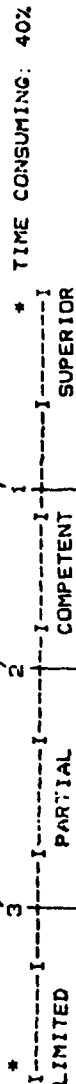
TEST/INSPECT VLF/LF/HF TRANS-
MITTERS



LOCALIZE/ISOLATE VLF/LF/HF
TRANSMITTERS MALFUNCTION TO A
UNIT



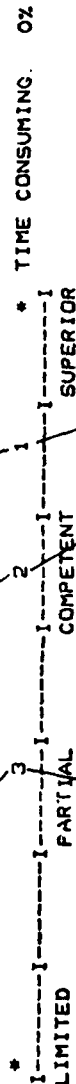
LOCALIZE/ISOLATE VLF/LF/HF
TRANSMITTERS MALFUNCTION TO THE
MODULE/CARD LEVEL



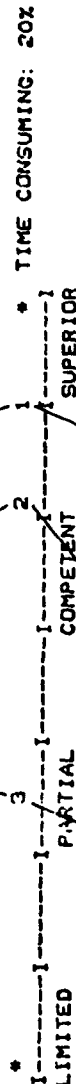
LOCALIZE/ISOLATE VLF/LF/HF
TRANSMITTERS MALFUNCTION TO THE
COMPONENT LEVEL, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC



REMOVE/REPLACE VLF/LF/HF TRANS-
MITTERS MODULES/CARDS



REMOVE/REPLACE VLF/LF/HF TRANS-
MITTERS COMPONENTS, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC



CALIBRATE/ALIGN/ADJUST VLF/LF/
HF TRANSMITTERS



ET(N): TTY COMPARATOR CONVERTER

TEST/INSPECT TTY COMPARATOR
CONVERTER GROUP

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

LOCALIZE/ISOLATE TTY COMPARATOR
CONVERTER GROUP MALFUNCTION TO
THE MODULE/CARD LEVEL

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

LOCALIZE/ISOLATE TTY COMPARATOR
CONVERTER GROUP MALFUNCTION TO
THE COMPONENT LEVEL

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

REMOVE/REPLACE TTY COMPARATOR
CONVERTER GROUP COMPONENTS

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

CALIBRATE/ALIGN/ADJUST TTY
COMPARATOR CONVERTER GROUP

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

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ET(R): GENERAL MAINTENANCE

RESEARCH TECHNICAL PUBLICATIONS TO
FIND APPROPRIATE SCHEMATICS/LOGIC
DIAGRAMS/TABLES/TROUBLESHOOTING CHARTS/
MAINTENANCE INFORMATION/PART NUMBERS FOR
SPECIFIC PIECES OF EQUIPMENT



IDENTIFY STANDARD ELECTRONIC/
MECHANICAL SYMBOLS AS USED ON
SCHEMATICS, LOGIC DIAGRAMS, FLOW
CHARTS, ETC.



MODIFY EQUIPMENT IN ACCORDANCE
WITH SHIPALTS, ORDALTS, FIELD
CHANGE ORDERS AND ELECTRONIC
INFORMATION BULLETINS (EIBS)



CHANGE SYSTEM CONFIGURATION BY
PATCHING OR BY SWITCHBOARD
CHANGES



ANALYZE EQUIPMENT FRONT PANEL
INDICATORS FOR FAULT DETECTION



USE TEST EQUIPMENT TO INJECT
SIGNALS AND/OR TAKE READINGS



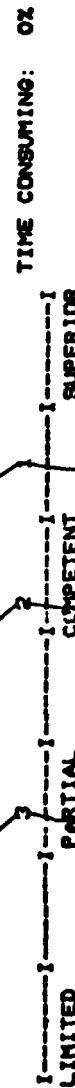
ASSEMBLE/REPAIR CABLES AND TEST
LEADS, SUCH AS CONNECTORS,
PROBES, ETC.



ALIGN/ADJUST MECHANICAL LINKAGES
AND GEAR TRAINS



LOCALIZE/ISOLATE EQUIPMENT
MALFUNCTION TO A SUBSYSTEM



LOCALIZE/ISOLATE EQUIPMENT
MALFUNCTION TO A UNIT

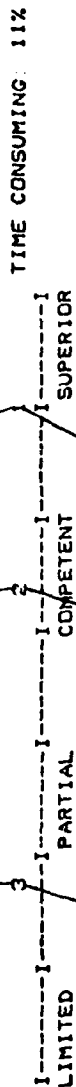


ET(R): COOLING SYSTEMS

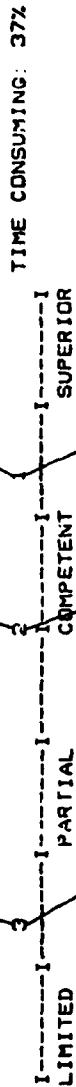
TEST/INSPECT ELECTRONIC EQUIPMENT
COOLING SYSTEM



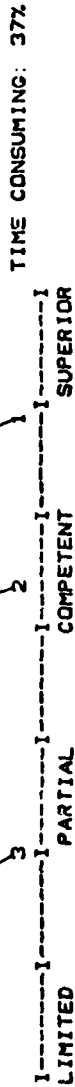
LOCALIZE/ISOLATE ELECTRONIC
EQUIPMENT COOLING SYSTEM MALFUNCTION
TO A UNIT



LOCALIZE/ISOLATE ELECTRONIC
EQUIPMENT COOLING SYSTEM MAL-
FUNCTION TO THE FAILED PART



REMOVE/REPLACE ELECTRONIC EQUIP-
MENT COOLING SYSTEM FAILED PART



ET(R): IFF SYSTEM

TEST/INSPECT IFF SYSTEM



LOCALIZE/ISOLATE IFF SYSTEM
MALFUNCTION TO A SUBSYSTEM



LOCALIZE/ISOLATE IFF SYSTEM
MALFUNCTION TO A UNIT



LOCALIZE/ISOLATE IFF SYSTEM MAL-
FUNCTION TO THE MODULE/CARD LEVEL

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

LOCALIZE/ISOLATE IFF SYSTEM MAL-
FUNCTION TO THE COMPONENT LEVEL,
SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

REMOVE/REPLACE IFF SYSTEM MODULES/
CARDS

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

REMOVE/REPLACE IFF SYSTEM COM-
PONENTS, SUCH AS SWITCHES, RE-
SISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

CALIBRATE/ALIGN/ADJUST IFF SYSTEM

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

ET(R): MOTOR GENERATORS

CLEAN/LUBRICATE MOTOR/GENERATORS

TIME CONSUMING: 0x
LIMITED PARTIAL 2 COMPETENT SUPERIOR

TEST/INSPECT MOTOR/GENERATORS

TIME CONSUMING: 0x
LIMITED PARTIAL 2 COMPETENT SUPERIOR

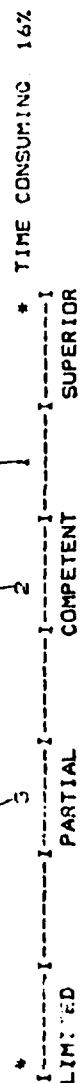
LOCALIZE/ISOLATE MOTOR/GENERATORS

TIME CONSUMING: 0x
LIMITED PARTIAL 2 COMPETENT SUPERIOR

LOCALIZE/ISOLATE MOTOR/GENERATORS
MALFUNCTION TO THE FAILED PART

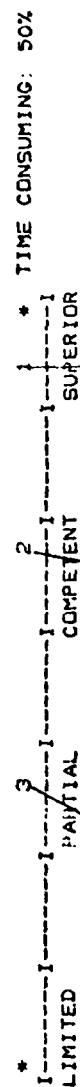
TIME CONSUMING: 16x
LIMITED PARTIAL 2 COMPETENT SUPERIOR

REMOVE/REPLACE MOTOR/GENERATORS
FAILED PART

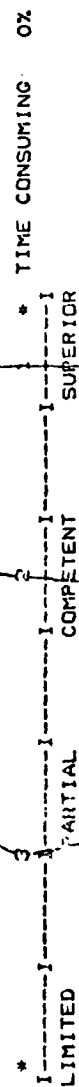


ET(R): RADAR ANTENNA/DRIVE SYSTEMS

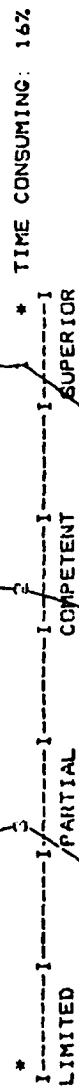
CLEAN/LUBRICATE RADAR ANTENNA/
DRIVE SYSTEM



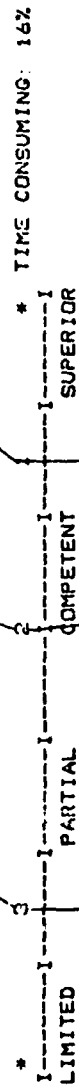
TEST/INSPECT RADAR ANTENNA/DRIVE
SYSTEM



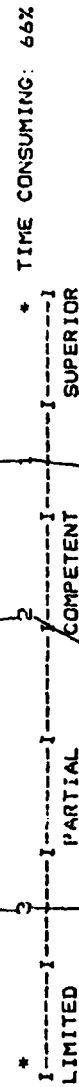
LOCALIZE/ISOLATE RADAR ANTENNA/
DRIVE SYSTEM MALFUNCTION TO A
UNIT



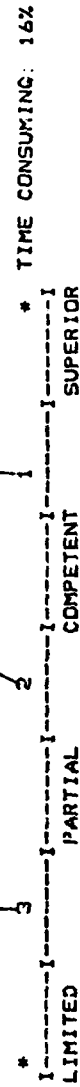
LOCALIZE/ISOLATE RADAR ANTENNA/
DRIVE SYSTEM MALFUNCTION TO THE
COMPONENT LEVEL



REMOVE/REPLACE RADAR ANTENNA/
DRIVE SYSTEM COMPONENTS

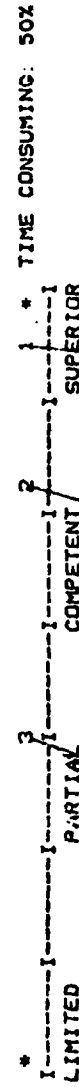


CALIBRATE/ALIGN/ADJUST RADAR
ANTENNA/DRIVE SYSTEM



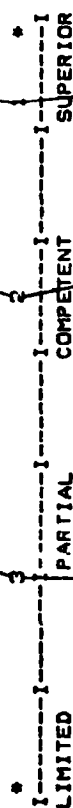
ET(R): RADAR INDICATOR/CONSOLE

CLEAN RADAR INDICATOR/CONSOLE



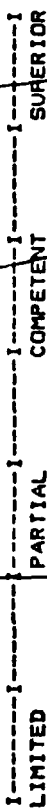
TEST/INSPECT RADAR INDICATOR/
CONSOLE

* TIME CONSUMING: 0%



LOCALIZE/ISOLATE RADAR INDICATOR/
CONSOLE MALFUNCTION TO A UNIT

INSUFFICIENT DATA TO DERIVE SCALE VALUES



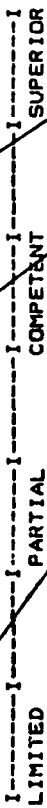
LOCALIZE-ISOLATE RADAR INDICATOR/
CONSOLE MALFUNCTION TO THE
MODULE/CARD LEVEL

* TIME CONSUMING: 25%



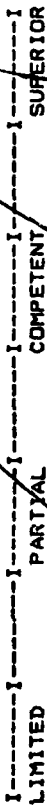
LOCALIZE/ISOLATE RADAR INDICATOR/
CONSOLE MALFUNCTION TO THE COM-
PONENT LEVEL, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

* TIME CONSUMING: 50%



REMOVE/REPLACE RADAR INDICATOR/
CONSOLE MODULES/CARDS

* TIME CONSUMING: 0%



REMOVE/REPLACE RADAR INDICATOR/
CONSOLE COMPONENTS, SUCH AS
SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

* TIME CONSUMING: 25%



CALIBRATE/ALIGN/ADJUST RADAR
INDICATOR/CONSOLE

* TIME CONSUMING: 50%



ET(R): RADAR POWER SUPPLY

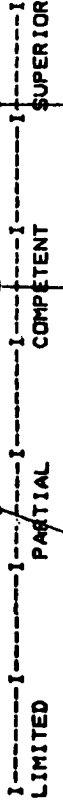
CLEAN RADAR POWER SUPPLY

* TIME CONSUMING: 0%

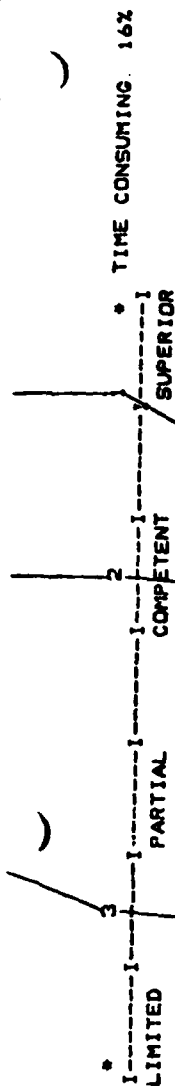


TEST/INSPECT RADAR POWER SUPPLY

* TIME CONSUMING: 0%



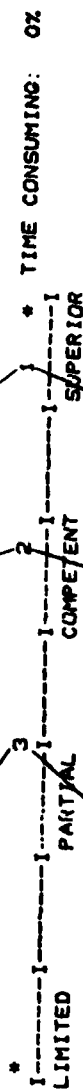
LOCALIZE/ISOLATE RADAR POWER
SUPPLY MALFUNCTION TO THE
MODULE/CARD LEVEL



LOCALIZE/ISOLATE RADAR POWER
SUPPLY MALFUNCTION TO THE COM-
PONENT LEVEL, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.



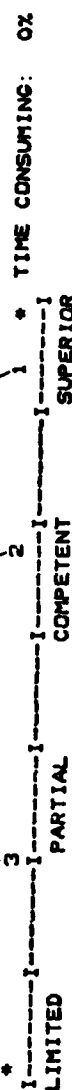
REMOVE/REPLACE RADAR POWER SUPPLY
MODULES/CARDS



REMOVE/REPLACE RADAR POWER SUPPLY
COMPONENTS, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.



CALIBRATE/ALIGN/ADJUST RADAR
POWER SUPPLY



ET(R): RADAR RECEIVERS

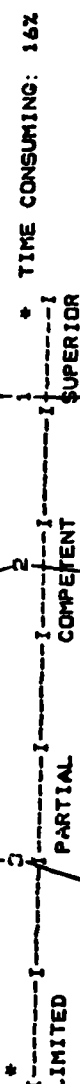
CLEAN RADAR RECEIVERS



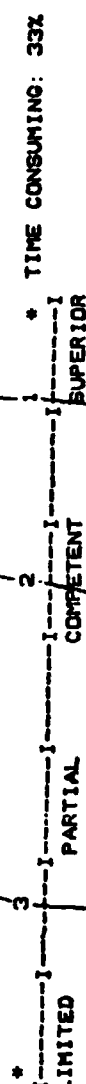
TEST/INSPECT RADAR RECEIVERS

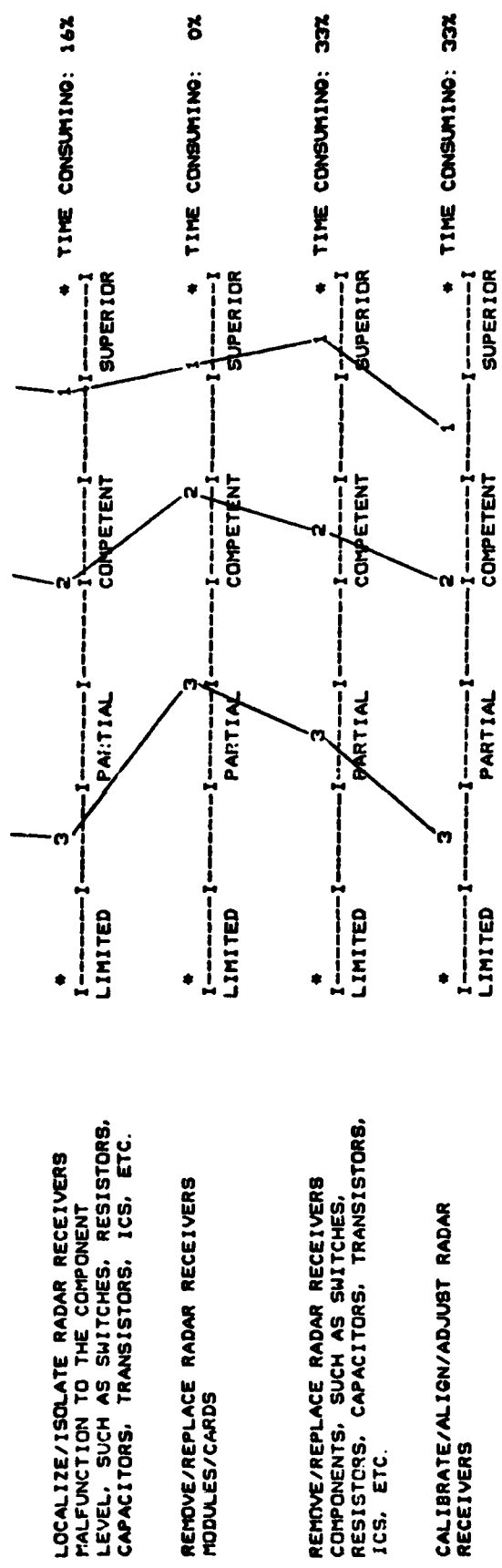


LOCALIZE/ISOLATE RADAR RECEIVERS
MALFUNCTION TO A UNIT

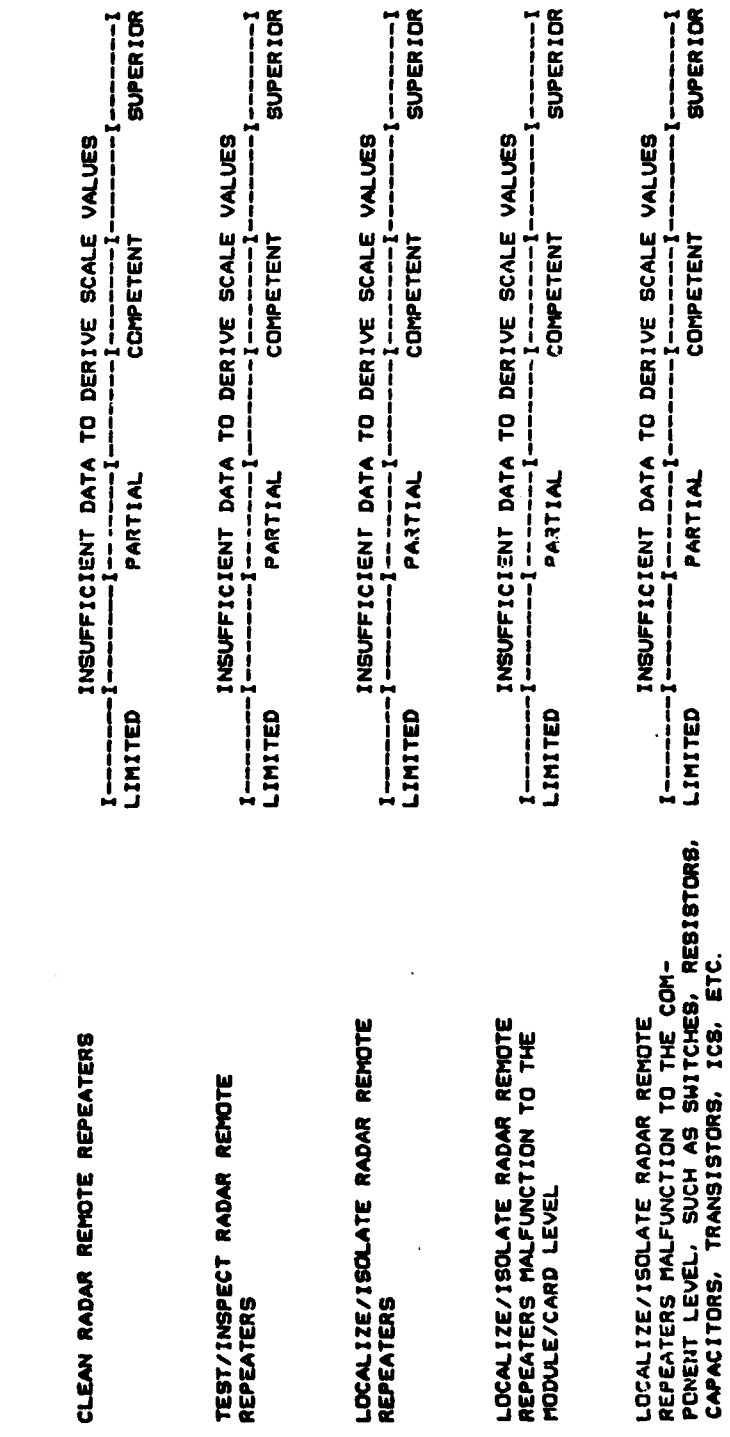


LOCALIZE/ISOLATE RADAR RECEIVERS
MALFUNCTION TO THE MODULE/CARD
LEVEL





ET(R): RADAR REMOTE REPEATERS



REMOVE/REPLACE RADAR REMOTE
REPEATERS MODULES/CARDS

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

REMOVE/REPLACE RADAR REMOTE
REPEATERS COMPONENTS, SUCH AS
SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

CALIBRATE/ALIGN/ADJUST RADAR
REMOTE REPEATERS

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

ET(R): RADAR SIGNAL DISTRIBUTION SYSTEM

CLEAN RADAR SIGNAL DISTRIBUTION
SYSTEM

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

TEST/INSPECT RADAR SIGNAL DIS-
TRIBUTION SYSTEM

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

LOCALIZE/ISOLATE RADAR SIGNAL
DISTRIBUTION SYSTEM MALFUNCTION
TO A UNIT

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

LOCALIZE/ISOLATE RADAR SIGNAL
DISTRIBUTION SYSTEM MALFUNCTION
TO THE MODULE/CARD LEVEL

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

LOCALIZE/ISOLATE RADAR SIGNAL
DISTRIBUTION SYSTEM MALFUNCTION
TO THE COMPONENT LEVEL, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.

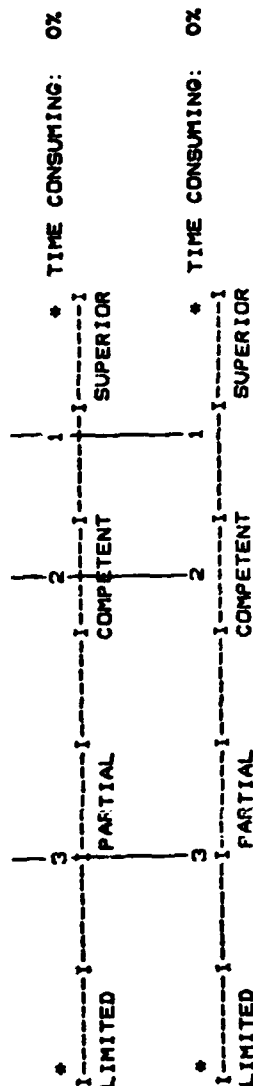
INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

REMOVE/REPLACE RADAR SIGNAL DIS-
TRIBUTION SYSTEM MODULES/CARDS

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED PARTIAL COMPETENT SUPERIOR

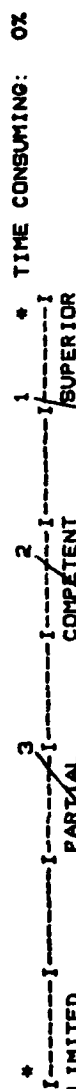
REMOVE/REPLACE RADAR SIGNAL DISTRIBUTION SYSTEM COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

CALIBRATE/ALIGN/ADJUST RADAR SIGNAL DISTRIBUTION SYSTEM



ET(R): RADAR TRANSMITTERS

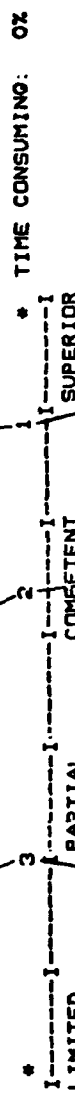
CLEAN RADAR TRANSMITTERS



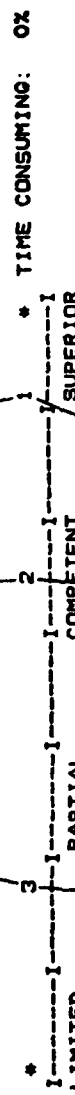
TEST/INSPECT RADAR TRANSMITTERS



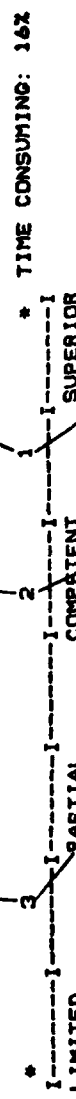
LOCALIZE/ISOLATE RADAR TRANSMITTERS



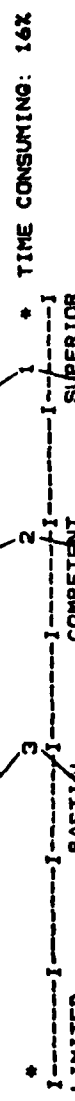
LOCALIZE/ISOLATE RADAR TRANSMITTERS MALFUNCTION TO THE MODULE/CARD LEVEL



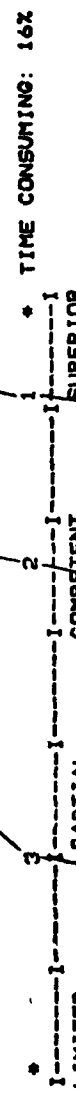
LOCALIZE/ISOLATE RADAR TRANSMITTERS MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

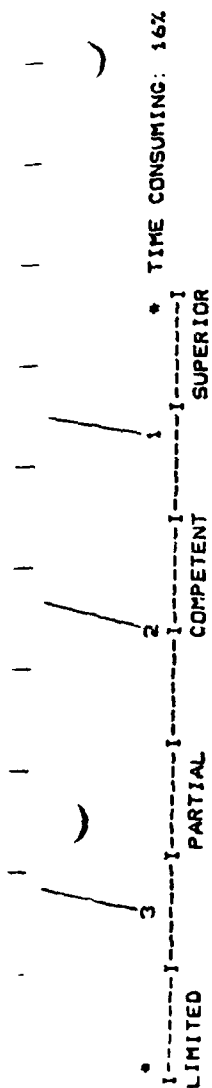


REMOVE/REPLACE RADAR TRANSMITTERS MODULES/CARDS

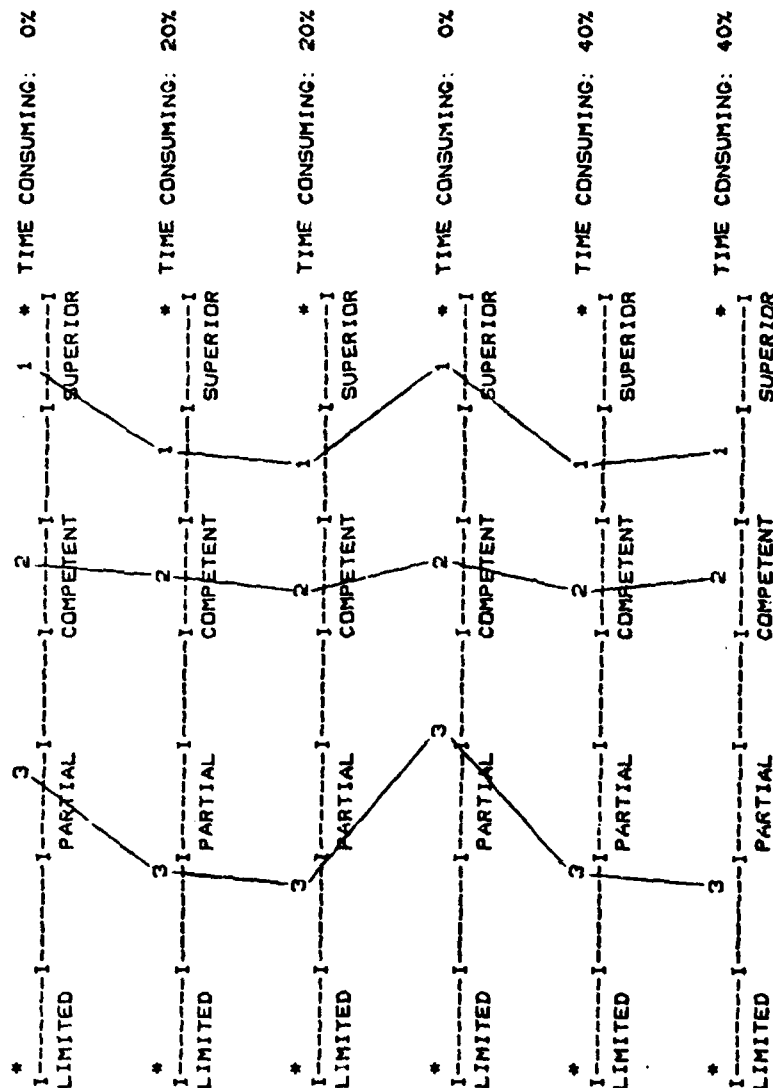


REMOVE/REPLACE RADAR TRANSMITTERS COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.





MACH-V VIDEO INDICATING DISPLAY



CC-0

ISOLATE RADAR VIDEO
ISOLATE DISPLAY MALFUNCTION
ISOLATE CARD LEVEL

REMOVE/REPLACE RADAR VIDEO
INDICATING DISPLAY MODULES/
CARDS

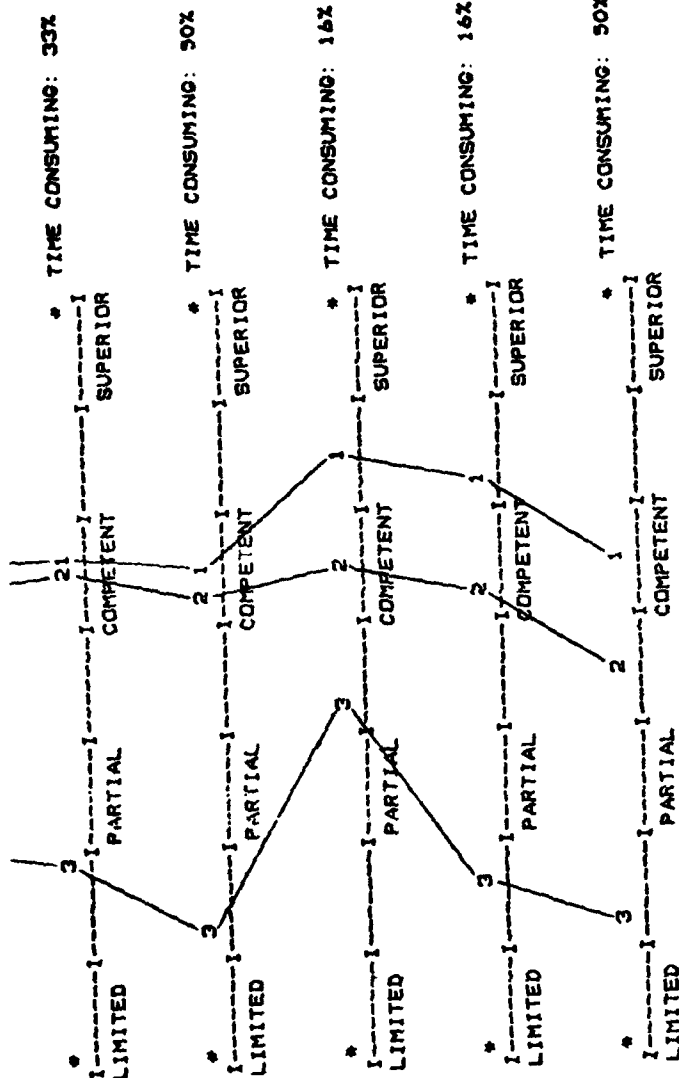
REMOVE/REPLACE RADAR VIDEO
INDICATING DISPLAY COMPONENTS, SUCH
AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

CALIBRATE/ALIGN/ADJUST RADAR
VIDEO INDICATING DISPLAY

ET(R): RADAR VIDEO PROCESSING UNIT



TEST/INSPECT RADAR VIDEO PROCESSING UNIT



LOCALIZE/ISOLATE RADAR VIDEO PROCESSING UNIT MALFUNCTION TO THE MODULE/CARD LEVEL

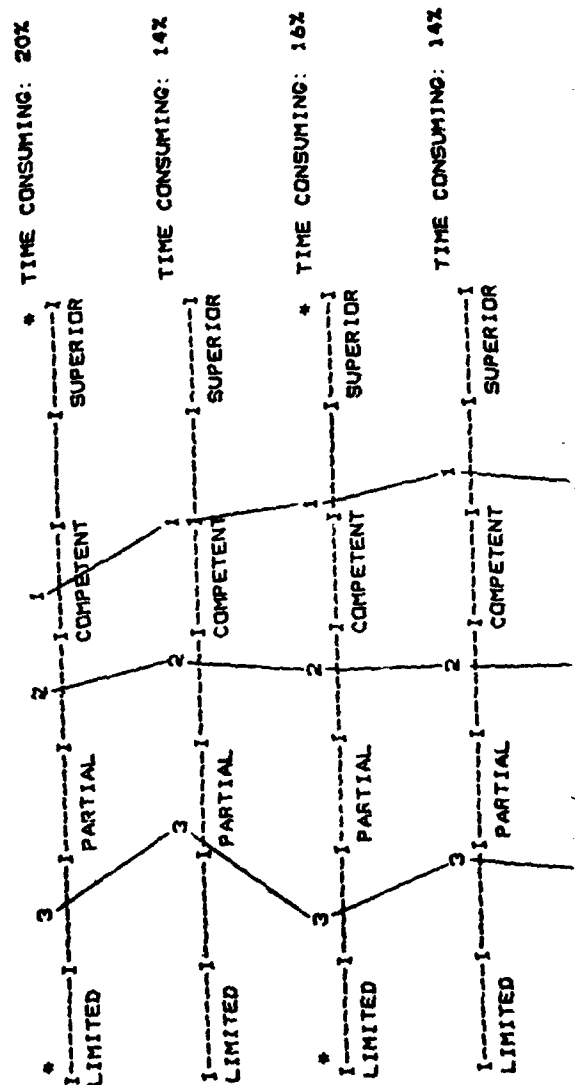
LOCALIZE/ISOLATE RADAR VIDEO PROCESSING UNIT MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

REMOVE/REPLACE RADAR VIDEO PROCESSING UNIT MODULES/CARDS

REMOVE/REPLACE RADAR VIDEO PROCESSING UNIT COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

CALIBRATE/ALIGN/ADJUST RADAR VIDEO PROCESSING UNIT

ET(R): SYNCHRO/SERVO AMPLIFIERS



TEST/INSPECT SYNCHRO/SERVO AMPLIFIERS

LOCALIZE/ISOLATE SYNCHRO/SERVO AMPLIFIERS MALFUNCTION TO THE MODULE/CARD LEVEL

LOCALIZE/ISOLATE SYNCHRO/SERVO AMPLIFIERS MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

REMOVE/REPLACE SYNCHRO/SERVO AMPLIFIERS MODULES/CARDS

REMOVE/REPLACE SYNCHRO/SERVO
AMPLIFIER COMPONENTS, SUCH AS
SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

CALIBRATE/ALIGN/ADJUST SYNCHRO/
SERVO AMPLIFIERS

ET(R): TEST EQUIPMENT

CLEAN/LUBRICATE TEST EQUIPMENT

TEST/INSPECT TEST EQUIPMENT

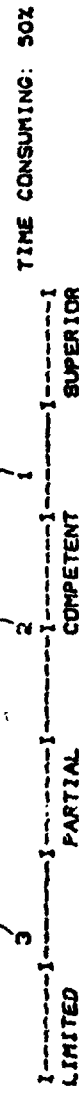
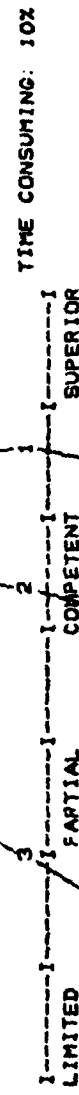
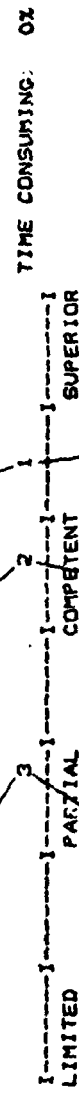
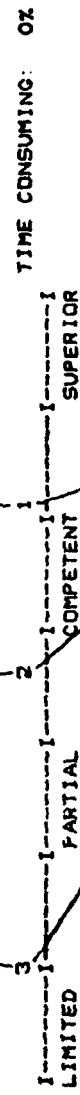
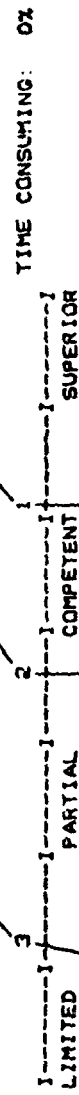
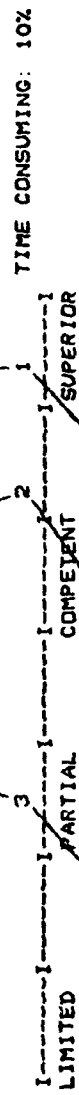
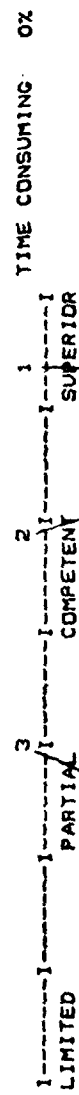
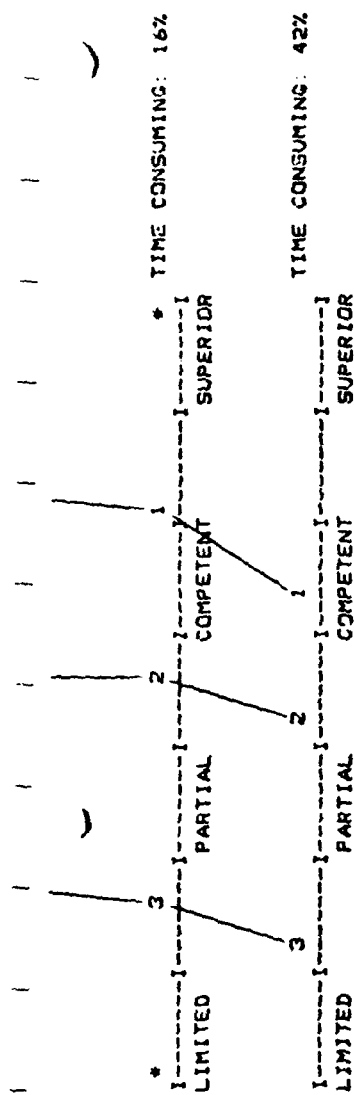
LOCALIZE/ISOLATE TEST EQUIPMENT
MALFUNCTION TO THE MODULE/CARD
LEVEL

LOCALIZE/ISOLATE TEST EQUIPMENT
MALFUNCTION TO THE COMPONENT LEVEL,
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

REMOVE/REPLACE TEST EQUIPMENT
MODULES/CARDS

REMOVE/REPLACE TEST EQUIPMENT
COMPONENTS, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.

CALIBRATE/ALIGN/ADJUST TEST
EQUIPMENT



INDEX OF TASKS PERFORMED BY FT(M)s

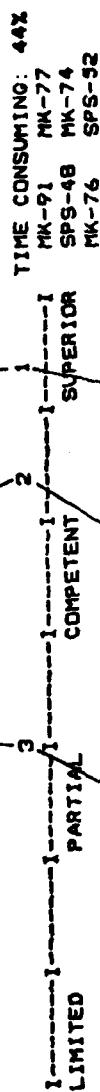
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FT(M): GENERAL OPERATION

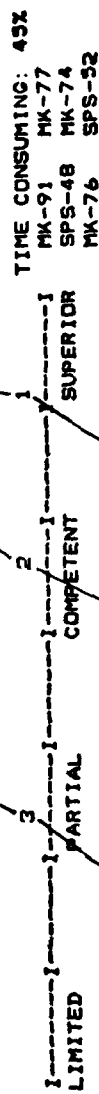
ACQUIRE/TRACK RADAR BEACON SIGNALS



SYSTEMS OPERATION TESTS (DSOT)



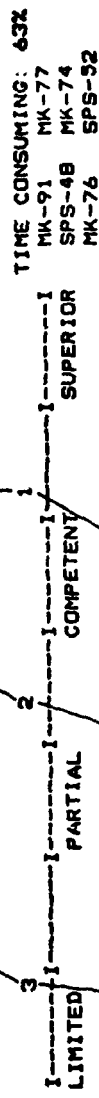
CONDUCT SUBSYSTEMS LEVEL DSOT



CONDUCT COMBAT SYSTEMS LEVEL DSOT



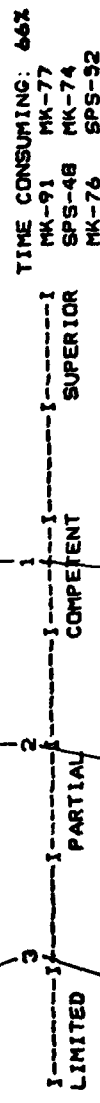
COORDINATE WEAPON SYSTEMS TESTS



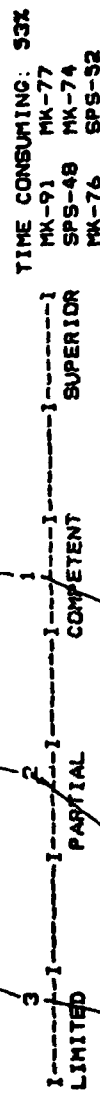
ANALYZE/ANNOTATE SYSTEMS TEST DATA



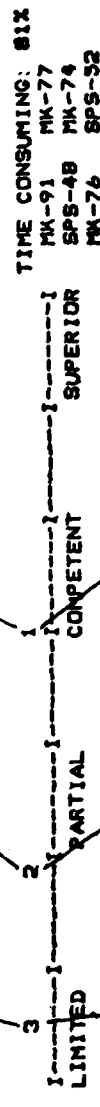
CHECK BATTERY ALIGNMENT (BORESIGHT)



DETERMINE BATTERY ALIGNMENT ERROR



MAKE ALIGNMENT CORRECTIONS TO GUN MOUNTS/MISSILE LAUNCHERS



CONDUCT HORIZON CHECKS

TIME CONSUMING: 44%
MK-74 MK-76
SPS-52

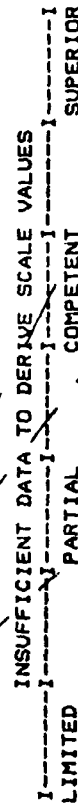


TRACK TARGETS BY AURAL MEANS

TIME CONSUMING: 0%
MK-91



TRACK TARGETS BY AURAL MEANS



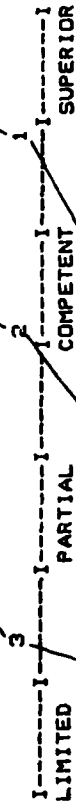
TRACK TARGETS BY AURAL MEANS

TIME CONSUMING: 0%
MK-74



ANALYZE TARGETS BY AURAL MEANS

TIME CONSUMING: 6%
MK-91 SPS-48
MK-74 SPS-52



INITIATE ELECTRONIC COUNTER COUNTERMEASURES (ECCM) ACTION FROM AURAL ANALYSIS

TIME CONSUMING: 13%
MK-91 SPS-48
MK-74 SPS-52



INSERT DATA INTO COMPUTERS MANUALLY

TIME CONSUMING: 31%
MK-91 MK-77
SPS-48 MK-74
MK-76 SPS-52



FT(M): GENERAL MAINTENANCE

RESEARCH TECHNICAL PUBLICATIONS TO
FIND APPROPRIATE SCHEMATICS/LOGIC
DIAGRAMS/TABLES/TROUBLESHOOTING CHARTS
MAINTENANCE INFORMATION/PART NUMBERS
FOR SPECIFIC PIECES OF EQUIPMENT

TIME CONSUMING: 35%
MK-91 MK-77
SPS-48 MK-74
MK-76 SPS-52



IDENTIFY STANDARD ELECTRONIC/
MECHANICAL SYMBOLS AS USED ON
SCHEMATICS, LOGIC DIAGRAMS, FLOW
CHARTS, ETC.

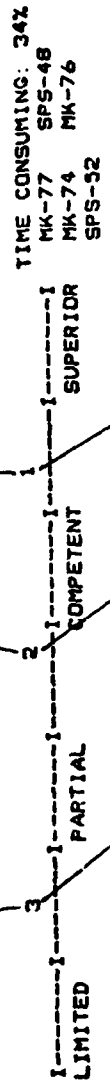
TIME CONSUMING: 8%
MK-91 MK-77
SPS-48 MK-74
MK-76 SPS-52



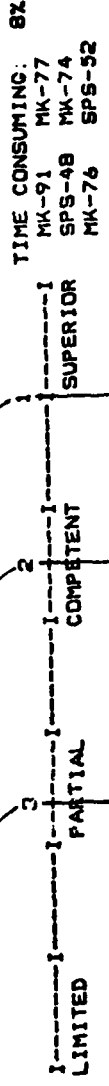
MODIFY EQUIPMENT IN ACCORDANCE WITH SHIPALTS, ORDALTS, FIELD CHANGE ORDERS AND ELECTRONIC INFORMATION BULLETINS (EIBS)



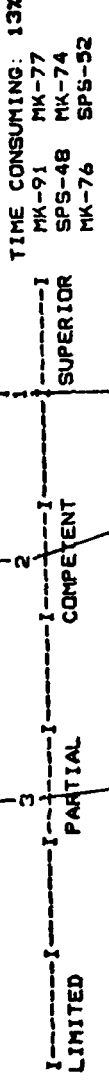
CHANGE SYSTEM CONFIGURATION BY PATCHING OR BY SWITCHBOARD CHANGES



ANALYZE EQUIPMENT FRONT PANEL INDICATORS FOR FAULT DETECTION



USE TEST EQUIPMENT TO INJECT SIGNALS AND/OR TAKE READINGS



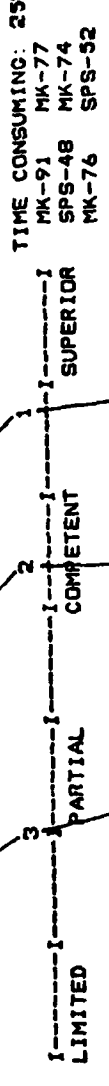
ASSEMBLE/REPAIR CABLES AND TEST LEADS, SUCH AS CONNECTORS, PROBES, ETC.



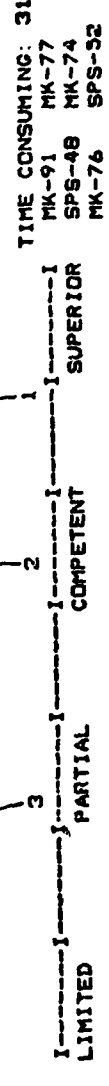
ALIGN/ADJUST MECHANICAL LINKAGES AND GEAR TRAINS



LOCALIZE/ISOLATE EQUIPMENT MALFUNCTION TO A SUBSYSTEM

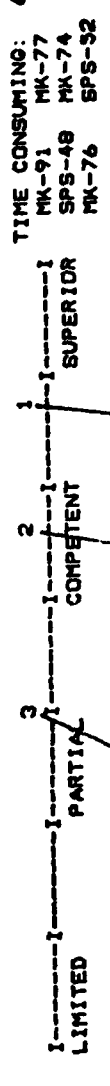


LOCALIZE/ISOLATE EQUIPMENT MALFUNCTION TO A UNIT

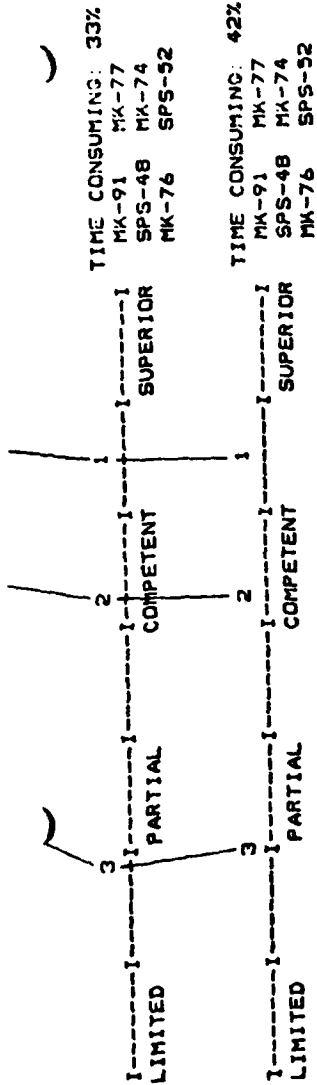


FT(N): BEARING-RANGE INDICATORS

TEST/INSPECT BEARING-RANGE INDICATORS



LOCALIZE/ISOLATE BEARING-RANGE
INDICATORS MALFUNCTION TO THE
COMPONENT LEVEL

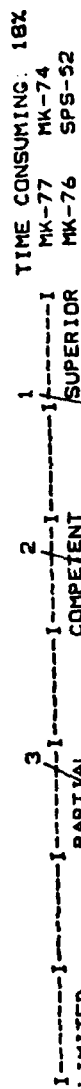


CALIBRATE/ALIGN/ADJUST BEARING-
RANGE INDICATORS

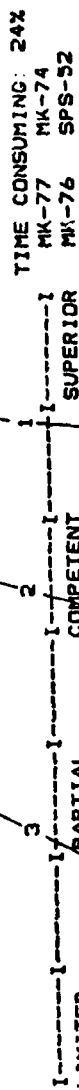


FT(M): CONTINUOUS WAVE ILLUMINATION

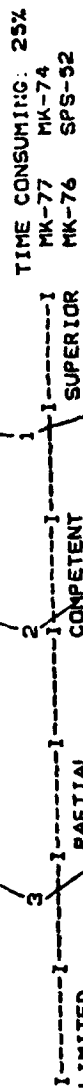
CLEAN/LUBRICATE CONTINUOUS
WAVE ILLUMINATION



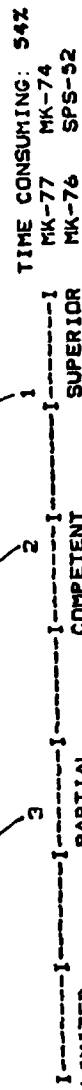
TEST/INSPECT CONTINUOUS WAVE
ILLUMINATION (CWI)



LOCALIZE/ISOLATE CONTINUOUS WAVE
ILLUMINATION (CWI) MALFUNCTION
TO THE COMPONENT LEVEL

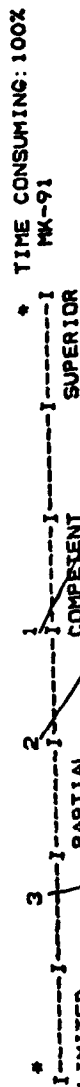


REMOVE/REPLACE CONTINUOUS WAVE
ILLUMINATION (CWI) COMPONENTS

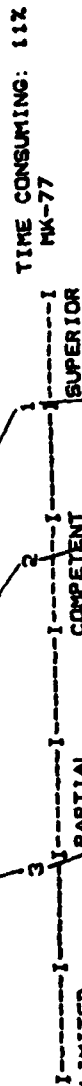


FT(M): DESSICATED AIR/COOLANT SYSTEMS

CLEAN DESSICATED AIR/COOLANT
SYSTEMS



CLEAN DESSICATED AIR/COOLANT
SYSTEMS



CLEAN DESSICATED AIR/COOLANT
SYSTEMS

* LIMITED 3 1 2 1 1 * TIME CONSUMING: 80%
COMPETENT SPS-48
SUPERIOR

CLEAN DESSICATED AIR/COOLANT
SYSTEMS

LIMITED 3 1 2 1 1 TIME CONSUMING: 0%
COMPETENT MK-74
SUPERIOR

CLEAN DESSICATED AIR/COOLANT
SYSTEMS

LIMITED 3 1 2 1 1 TIME CONSUMING: 57%
COMPETENT MK-76
SUPERIOR

CLEAN DESSICATED AIR/COOLANT
SYSTEMS

INSUFFICIENT DATA TO DERIVE SCALE VALUES
LIMITED 3 1 2 1 1
COMPETENT SUPERIOR

TEST/INSPECT DESSICATED AIR/
COOLANT SYSTEMS

LIMITED 3 1 2 1 1 TIME CONSUMING: 14%
COMPETENT MK-91 MK-77
SUPERIOR SPS-48 MK-74
MK-76 SPS-52

REMOVE/REPLACE DESSICATED AIR/
COOLANT SYSTEMS COMPONENTS

LIMITED 3 1 2 1 1 TIME CONSUMING: 57%
COMPETENT MK-91 MK-77
SUPERIOR SPS-48 MK-74
MK-76 SPS-52

CALIBRATE/ALIGN/ADJUST DESSICATED
AIR COOLANT SYSTEMS

LIMITED 3 1 2 1 1 TIME CONSUMING: 39%
COMPETENT MK-91 MK-77
SUPERIOR SPS-48 MK-74
MK-76 SPS-52

FT(M): FIRE CONTROL COMPUTERS

CLEAN/LUBRICATE FIRE CONTROL
COMPUTERS

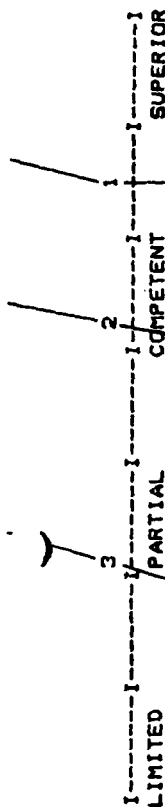
LIMITED 3 1 2 1 1 TIME CONSUMING: 25%
COMPETENT MK-91 MK-77
SUPERIOR SPS-48 MK-74
MK-76 SPS-52

TEST/INSPECT FIRE CONTROL COM-
PUTERS

LIMITED 3 1 2 1 1 TIME CONSUMING: 14%
COMPETENT MK-91 MK-77
SUPERIOR SPS-48 MK-74
MK-76 SPS-52

LOCALIZE/ISOLATE FIRE CONTROL
COMPUTERS MALFUNCTION TO A UNIT

TIME CONSUMING: 20%
MK-91 MK-77
SPS-48 MK-74
MK-76 SPS-52



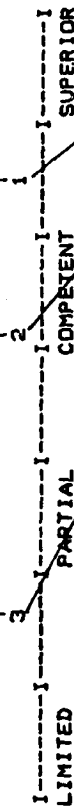
LOCALIZE/ISOLATE FIRE CONTROL
COMPUTERS MALFUNCTION TO THE
MODULE/CARD LEVEL

TIME CONSUMING: 36%
MK-91 MK-77
SPS-48 MK-74
MK-76 SPS-52



LOCALIZE/ISOLATE FIRE CONTROL
COMPUTERS MALFUNCTION TO THE
COMPONENT LEVEL, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.

TIME CONSUMING: 37%
MK-91 MK-77
SPS-48 MK-74
MK-76 SPS-52



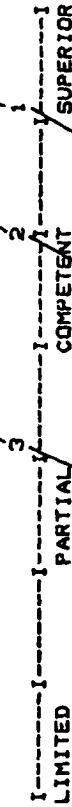
REMOVE/REPLACE FIRE CONTROL
COMPUTERS MODULES/CARDS

TIME CONSUMING: 3%
MK-91 MK-77
SPS-48 MK-74
MK-76 SPS-52



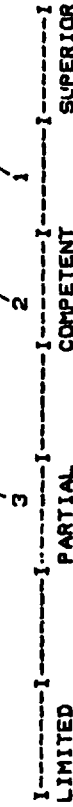
REMOVE/REPLACE FIRE CONTROL COM-
PUTERS COMPONENTS, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.

TIME CONSUMING: 20%
MK-91 MK-77
SPS-48 MK-74
MK-76 SPS-52



CALIBRATE/ALIGN/ADJUST FIRE
CONTROL COMPUTERS

TIME CONSUMING: 35%
MK-91 MK-77
SPS-48 MK-74
MK-76 SPS-52



FT(M): FIRE CONTROL DIRECTORS

CLEAN/LUBRICATE FIRE CONTROL
DIRECTORS

TIME CONSUMING: 46%
MK-91 MK-77
SPS-48 MK-74
MK-76 SPS-52



TEST/INSPECT FIRE CONTROL
DIRECTORS

TIME CONSUMING: 15%
MK-91 MK-77
SPS-48 MK-74
MK-76 SPS-52



LOCALIZE/ISOLATE FIRE CONTROL
DIRECTORS MALFUNCTION TO A UNIT

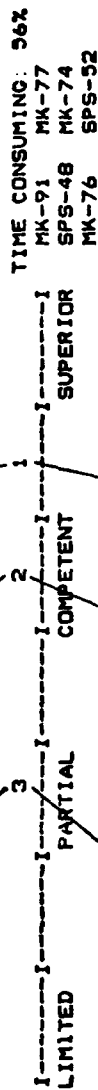
TIME CONSUMING: 30%
MK-91 MK-77
SPS-48 MK-74
MK-76 SPS-52



LOCALIZE/ISOLATE FIRE CONTROL
DIRECTORS MALFUNCTION TO THE
COMPONENT LEVEL.



REMOVE/REPLACE FIRE CONTROL
DIRECTORS COMPONENTS



CALIBRATE/ALIGN/ADJUST FIRE
CONTROL DIRECTORS



FT(M): RADAR ANTENNAS/DRIVE SYSTEMS

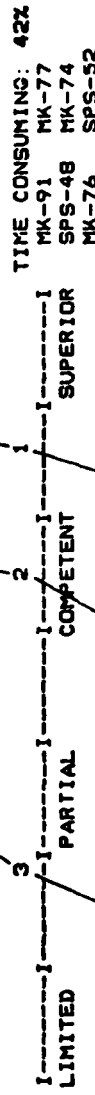
CLEAN/LUBRICATE RADAR ANTENNAS/
DRIVE SYSTEMS



TEST/INSPECT RADAR ANTENNAS/
DRIVE SYSTEMS



LOCALIZE/ISOLATE RADAR ANTENNAS/
DRIVE SYSTEMS MALFUNCTION TO THE
COMPONENT LEVEL



REMOVE/REPLACE RADAR ANTENNAS/
DRIVE SYSTEMS COMPONENTS

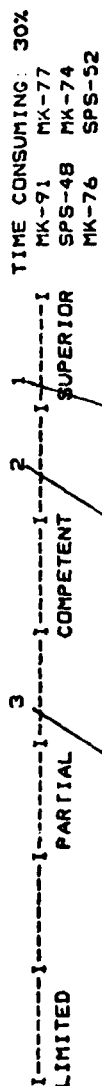


CALIBRATE/ALIGN/ADJUST RADAR
ANTENNAS/DRIVE SYSTEMS

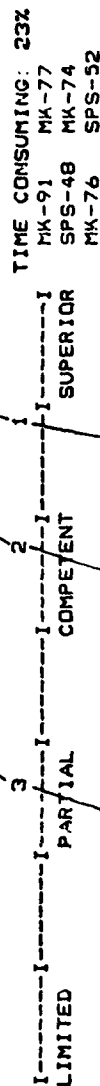


FT(M): RADAR CONSOLES

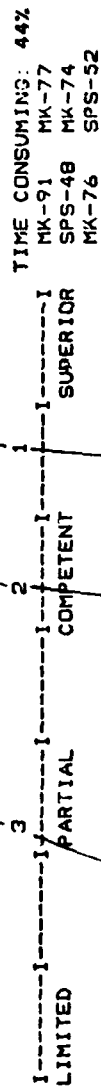
CLEAN/LUBRICATE RADAR CONSOLES



TEST/INSPECT RADAR CONSOLES



LOCALIZE/ISOLATE RADAR CONSOLES
MALFUNCTION TO THE MODULE/CARD
LEVEL



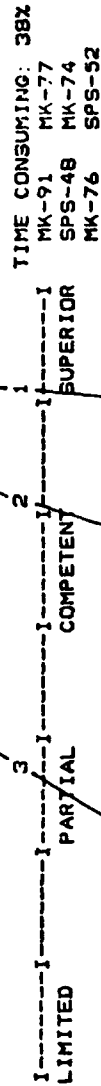
LOCALIZE/ISOLATE RADAR CONSOLES
MALFUNCTION TO THE COMPONENT LEVEL,
SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.



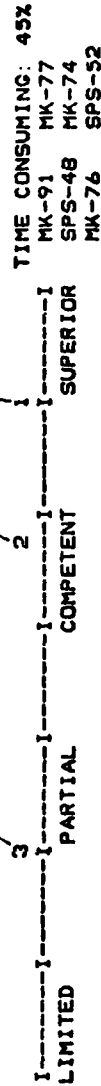
REMOVE/REPLACE CONSOLES
MODULES/CARDS



REMOVE/REPLACE RADAR CONSOLES
COMPONENTS, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.

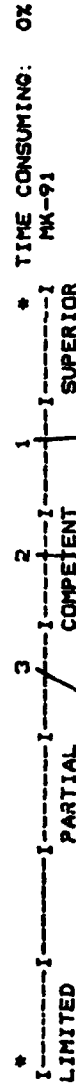


CALIBRATE/ALIGN/ADJUST RADAR
CONSOLES

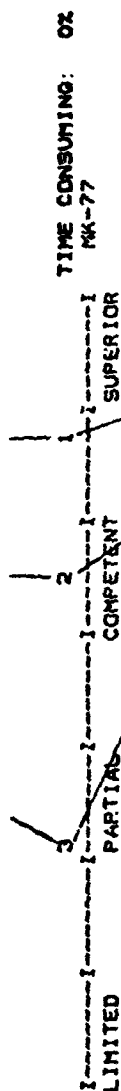


FT(M): RADAR POWER SUPPLY

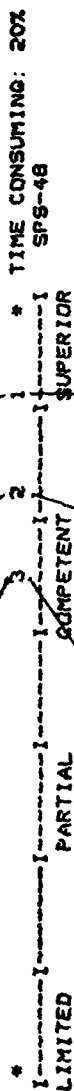
TEST/INSPECT RADAR POWER SUPPLY



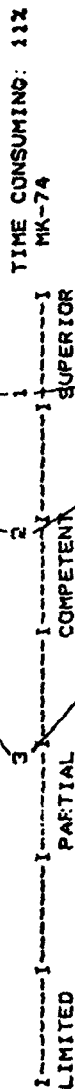
TEST/INSPECT RADAR POWER SUPPLY



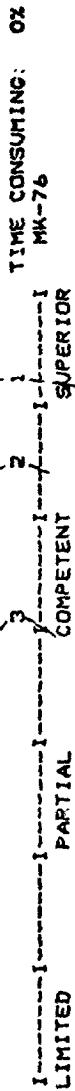
TEST/INSPECT RADAR POWER SUPPLY



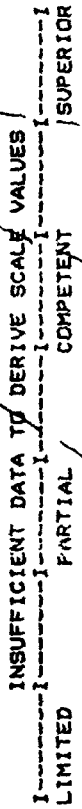
TEST/INSPECT RADAR POWER SUPPLY



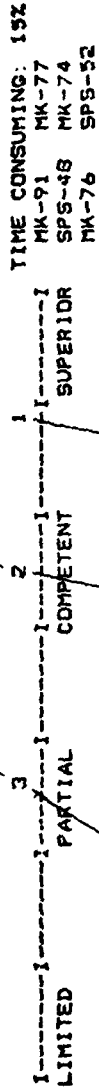
TEST/INSPECT RADAR POWER SUPPLY



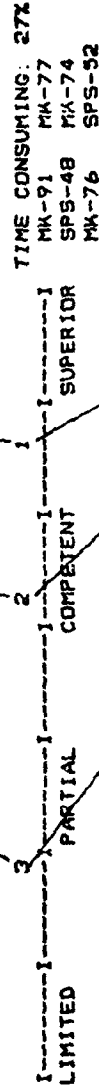
TEST/INSPECT RADAR POWER SUPPLY



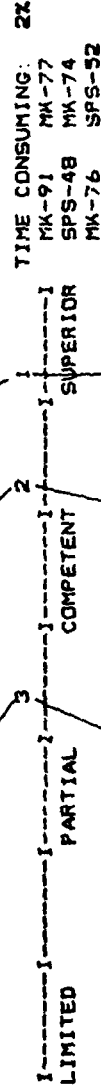
LOCALIZE/ISOLATE RADAR POWER SUPPLY MALFUNCTION TO THE MODULE/CARD LEVEL



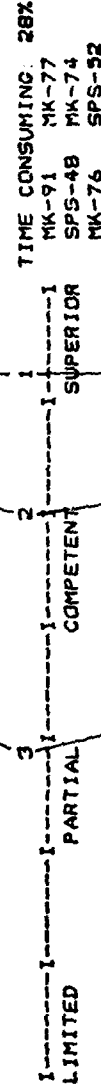
LOCALIZE/ISOLATE RADAR POWER SUPPLY MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



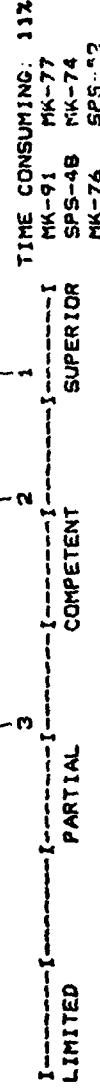
REMOVE/ REPLACE RADAR POWER SUPPLY MODULES/CARDS



REMOVE/REPLACE RADAR POWER SUPPLY COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

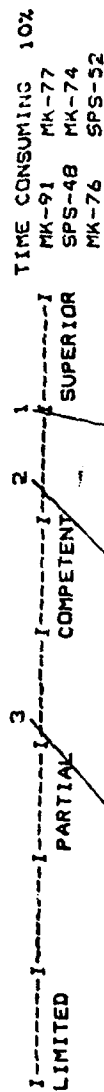


CALIBRATE/ALIGN/ADJUST RADAR POWER SUPPLY

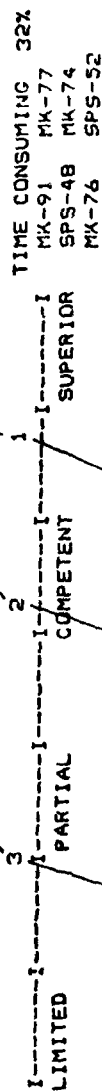


FT(M): RADAR RANGING UNITS

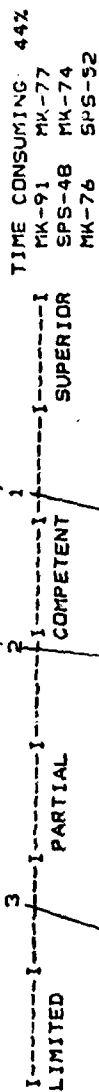
CLEAN/LUBRICATE RADAR RANGING UNITS



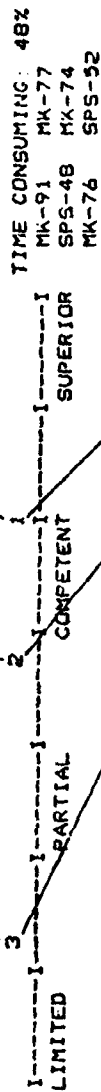
TEST/INSPECT RADAR RANGING UNITS



LOCALIZE/ISOLATE RADAR RANGING UNITS MALFUNCTION TO THE MODULE/CARD LEVEL



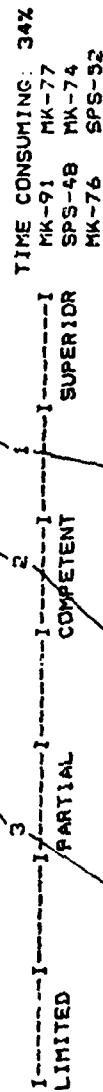
LOCALIZE/ISOLATE RADAR RANGING UNITS MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



REMOVE/REPLACE RADAR RANGING UNITS MODULES/CARDS



REMOVE/REPLACE RADAR RANGING UNITS COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

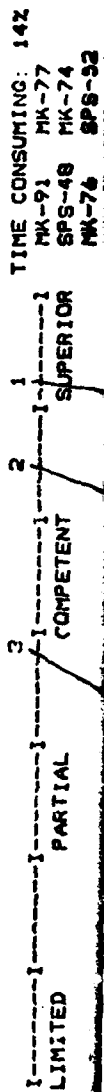


CALIBRATE/ALIGN/ADJUST RADAR RANGING UNITS



FT(M): RADAR RECEIVERS

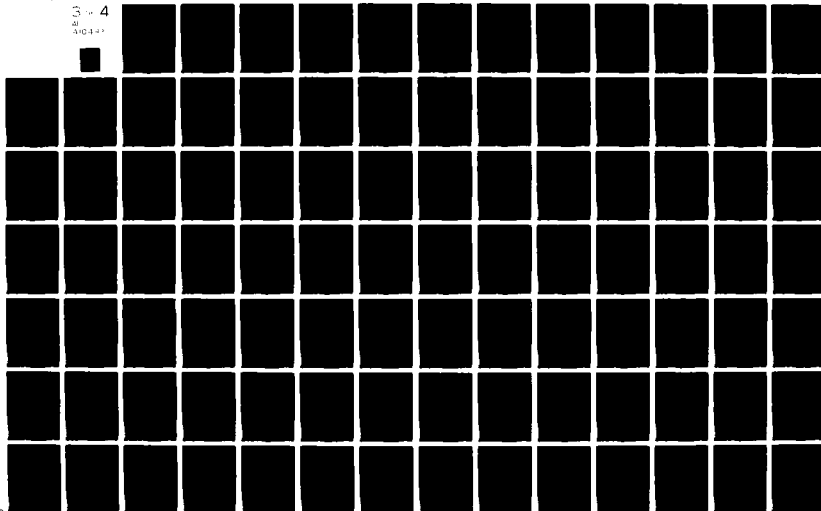
CLEAN RADAR RECEIVERS



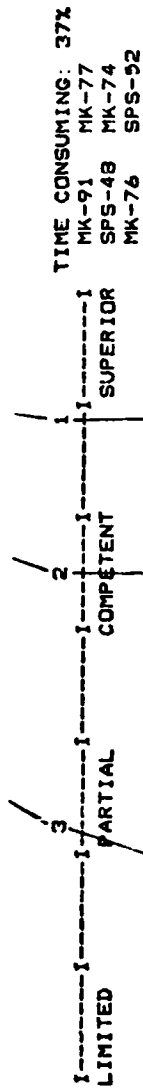
AD-A104 839 NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER SAN D--ETC F/G 5/8
AN ENGINEER'S GUIDE TO THE USE OF HUMAN RESOURCES IN ELECTRONIC--ETC(U)
JUN 79
UNCLASSIFIED NPRODC-TN-79-8 NL

3-4

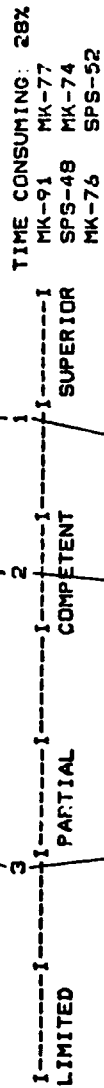
at
3/10/44



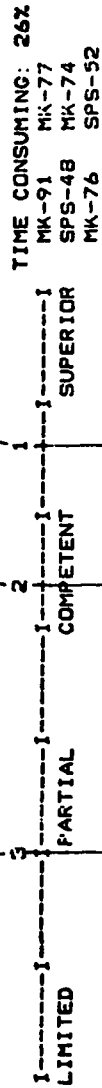
TEST/INSPECT RADAR RECEIVERS



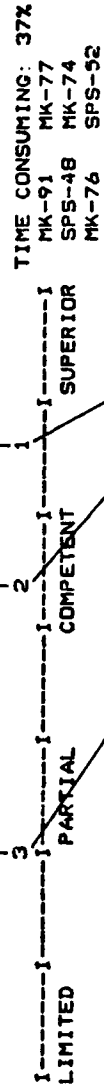
LOCALIZE/ISOLATE RADAR RECEIVERS MALFUNCTION TO A UNIT



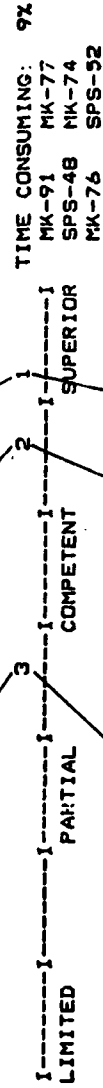
LOCALIZE/ISOLATE RADAR RECEIVERS MALFUNCTION TO THE MODULE/CARD LEVEL



LOCALIZE/ISOLATE RADAR RECEIVERS MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



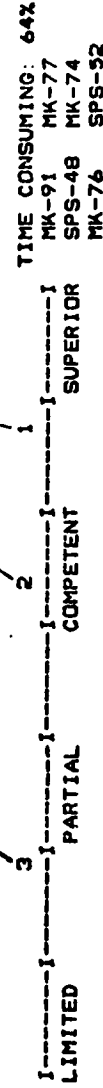
REMOVE/REPLACE RADAR RECEIVERS MODULES/CARDS



REMOVE/REPLACE RADAR RECEIVERS COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

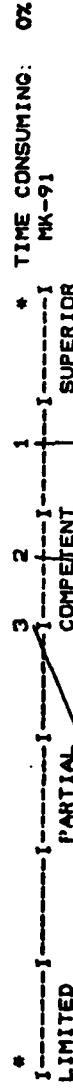


CALIBRATE/ALIGN/ADJUST RADAR RECEIVERS

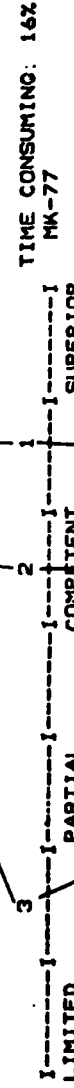


FT(M): RADAR SIGNAL PROCESSING EQUIPMENT

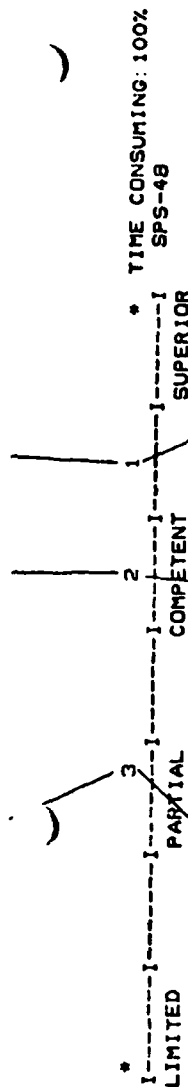
TEST/INSPECT RADAR SIGNAL PROCESSING EQUIPMENT



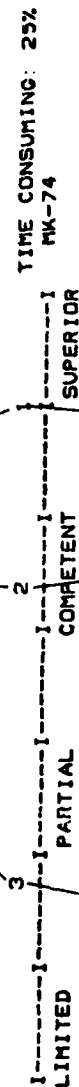
TEST/INSPECT RADAR SIGNAL PROCESSING EQUIPMENT



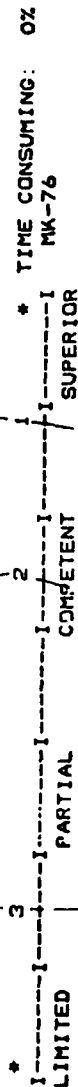
TEST/INSPECT RADAR SIGNAL PROCESSING EQUIPMENT



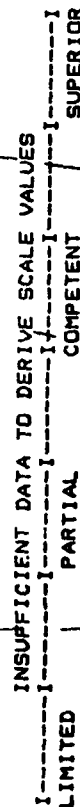
TEST/INSPECT RADAR SIGNAL PROCESSING EQUIPMENT



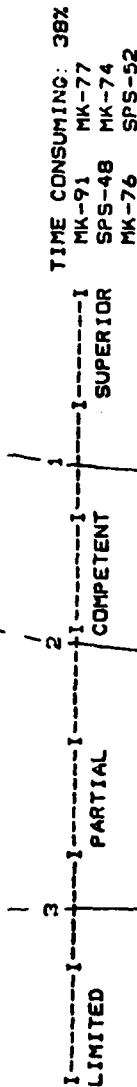
TEST/INSPECT RADAR SIGNAL PROCESSING EQUIPMENT



TEST/INSPECT RADAR SIGNAL PROCESSING EQUIPMENT



LOCALIZE/ISOLATE RADAR SIGNAL PROCESSING EQUIPMENT MALFUNCTION TO THE MODULE/CARD LEVEL



LOCALIZE/ISOLATE RADAR SIGNAL PROCESSING EQUIPMENT MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



REMOVE/REPLACE RADAR SIGNAL PROCESSING EQUIPMENT MODULES/CARDS



REMOVE/REPLACE SIGNAL PROCESSING EQUIPMENT COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



CALIBRATE/ALIGN/ADJUST RADAR SIGNAL PROCESSING EQUIPMENT



FT(M): RADAR TRACKING UNIT

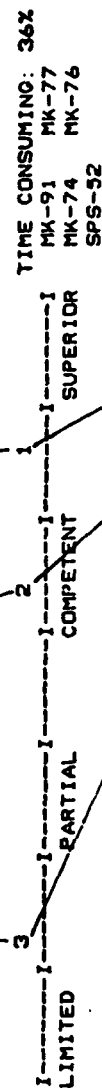
TEST/INSPECT RADAR TRACKING UNIT



LOCALIZE/ISOLATE RADAR TRACKING UNIT MALFUNCTION TO THE MODULE/CARD LEVEL



LOCALIZE/ISOLATE RADAR TRACKING UNIT MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



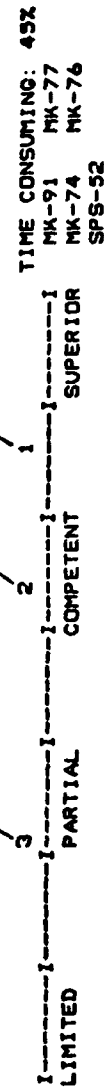
REMOVE/REPLACE RADAR TRACKING UNIT MODULES/CARDS



REMOVE/REPLACE RADAR TRACKING UNIT COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

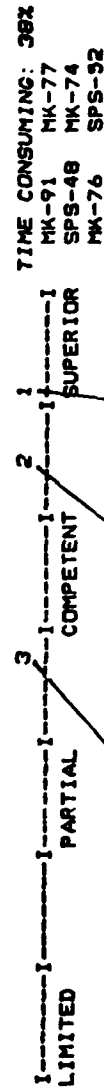


CALIBRATE/ALIGN/ADJUST RADAR TRACKING UNIT

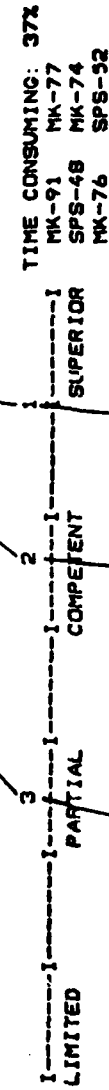


FT(M): RADAR TRANSMITTERS

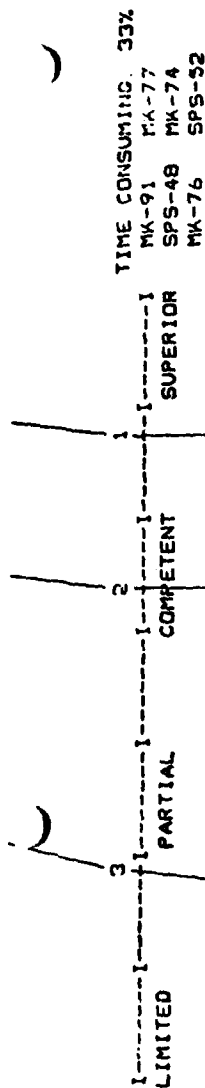
CLEAN RADAR TRANSMITTERS



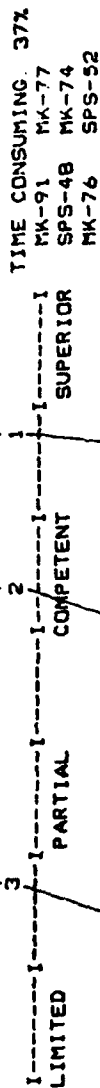
TEST/INSPECT RADAR TRANSMITTERS



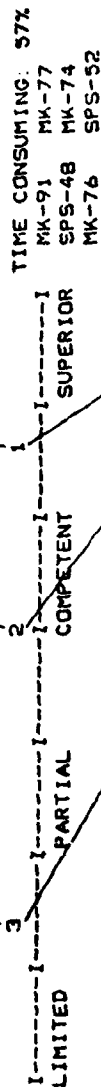
LOCALIZE/ISOLATE RADAR TRANSMITTERS
MALFUNCTION TO A UNIT



LOCALIZE/ISOLATE RADAR TRANSMITTERS
MALFUNCTION TO THE MODULE/CARD
LEVEL



LOCALIZE/ISOLATE RADAR TRANSMITTERS
MALFUNCTION TO THE COMPONENT LEVEL
SUCH AS SWITCHES, RESISTORS, CAPACI-
TORS, TRANSISTORS, ICS, ETC.



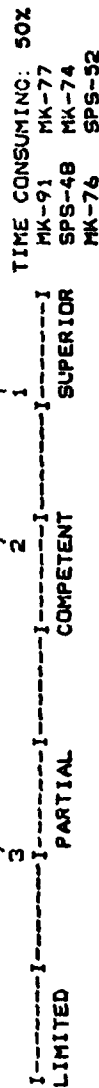
REMOVE/REPLACE RADAR TRANSMITTERS
MODULES/CARDS



REMOVE/REPLACE RADAR TRANSMITTERS
COMPONENTS, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.



CALIBRATE/ALIGN/ADJUST RADAR
TRANSMITTERS



FT(M): RADAR VIDEO INDICATING DISPLAY

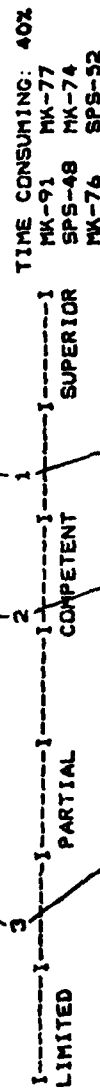
TEST/INSPECT RADAR VIDEO INDICAT-
ING DISPLAY



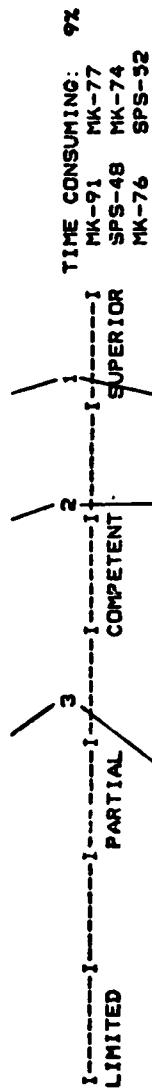
LOCALIZE/ISOLATE RADAR VIDEO
INDICATING DISPLAY MALFUNCTION TO THE
MODULE/CARD LEVEL



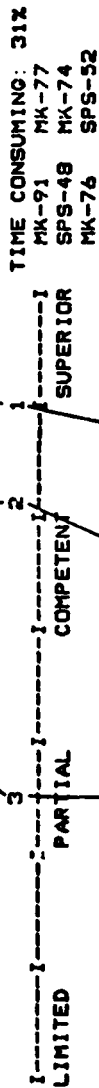
LOCALIZE/ISOLATE RADAR VIDEO INDICATING
DISPLAY MALFUNCTION TO THE
COMPONENT LEVEL, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,



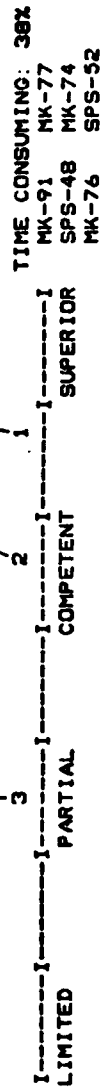
REMOVE/REPLACE RADAR VIDEO INDICATING DISPLAY MODULES/CARDS



REMOVE/REPLACE RADAR VIDEO INDICATING DISPLAY COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



CALIBRATE/ALIGN/ADJUST RADAR VIDEO INDICATING DISPLAY



FT(M): RADAR VIDEO PROCESSING UNIT

TEST/INSPECT RADAR VIDEO PROCESSING UNIT



LOCALIZE/ISOLATE RADAR VIDEO PROCESSING UNIT MALFUNCTION TO THE MODULE/CARD LEVEL



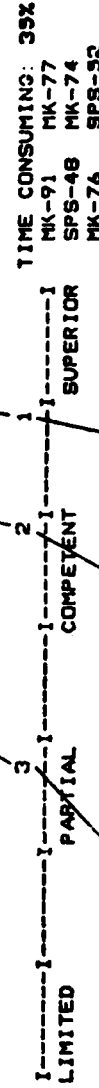
LOCALIZE/ISOLATE RADAR VIDEO PROCESSING UNIT MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



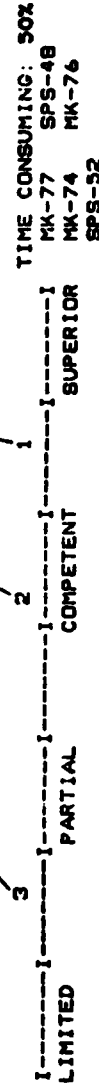
REMOVE/REPLACE RADAR VIDEO PROCESSING UNIT MODULES/CARDS



REMOVE/REPLACE RADAR VIDEO PROCESSING UNIT COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

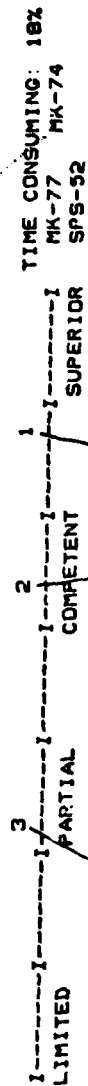


CALIBRATE/ALIGN/ADJUST RADAR VIDEO PROCESSING UNIT

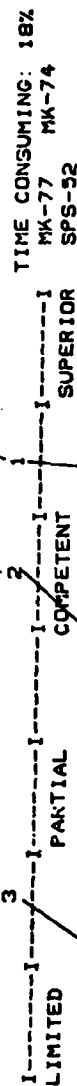


FT(M): STABLE ELEMENTS/STABLE VERTICALS

CLEAN/LUBRICATE STABLE ELEMENTS/
STABLE VERTICALS



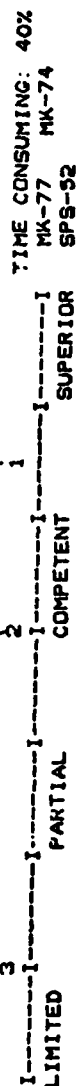
TEST/INSPECT STABLE ELEMENTS/
STABLE VERTICALS



LOCALIZE/ISOLATE STABLE ELEMENTS/
STABLE VERTICALS MALFUNCTION TO
THE COMPONENT LEVEL



REMOVE/REPLACE STABLE ELEMENTS/
STABLE VERTICAL COMPONENTS

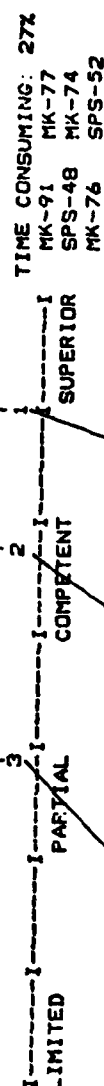


FT(M): SWITCHBOARDS

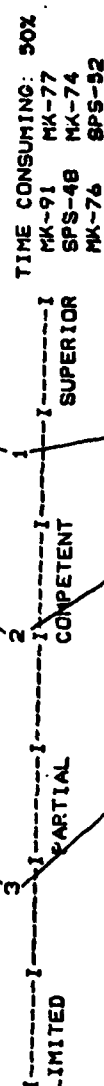
CLEAN/LUBRICATE SWITCHBOARDS



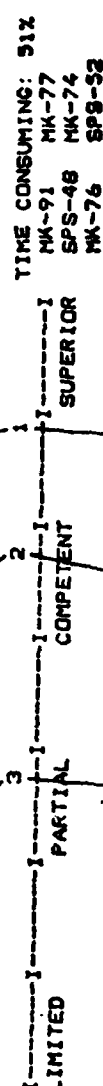
TEST/INSPECT SWITCHBOARDS



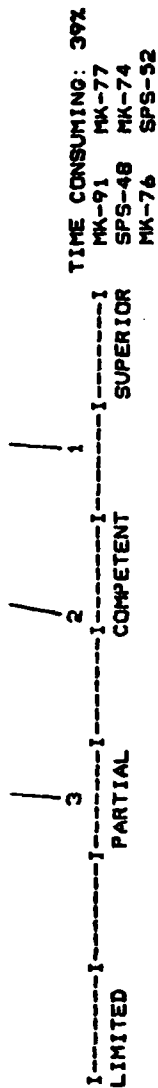
LOCALIZE/ISOLATE SWITCHBOARDS
MALFUNCTION TO THE COMPONENT LEVEL



REMOVE/REPLACE SWITCHBOARDS COMPONENTS



CALIBRATE/ALIGN/ADJUST SWITCHBOARDS

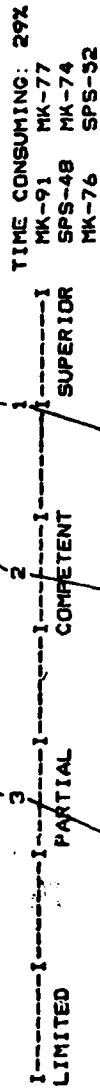


FT(M): SYNCHRO/SERVO SYSTEMS

CLEAN/LUBRICATE SYNCHRO/SERVO SYSTEMS



TEST/INSPECT SYNCHRO/SERVO SYSTEMS



LOCALIZE/ISOLATE SYNCHRO-SERVO SYSTEMS MALFUNCTION TO THE COMPONENT LEVEL



REMOVE/REPLACE SYNCHRO-SERVO SYSTEMS COMPONENTS



CALIBRATE/ALIGN/ADJUST SYNCHRO-SERVO SYSTEMS



FT(M): TARGET DESIGNATION EQUIPMENT

TEST/INSPECT TARGET DESIGNATION EQUIPMENT

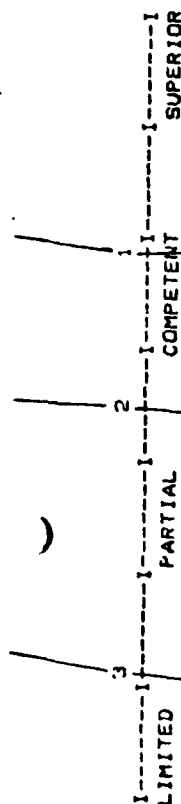


LOCALIZE/ISOLATE TARGET DESIGNATION EQUIPMENT MALFUNCTION TO A UNIT



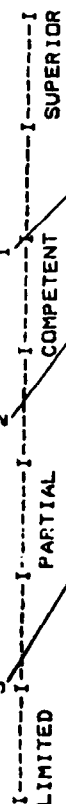
LOCALIZE/ISOLATE TARGET DESIGNATION EQUIPMENT MALFUNCTION TO THE MODULE/CARD LEVEL

TIME CONSUMING: 19%
MK-77 SPS-48
MK-74 MK-76
SPS-52



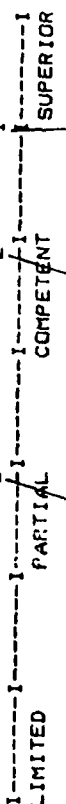
LOCALIZE/ISOLATE TARGET DESIGNATION EQUIPMENT MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

TIME CONSUMING: 28%
MK-77 SPS-48
MK-74 MK-76
SPS-52



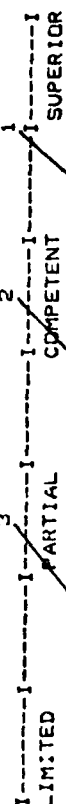
REMOVE/REPLACE TARGET DESIGNATION EQUIPMENT MODULES/CARDS

TIME CONSUMING: 9%
MK-77 SPS-48
MK-74 MK-76
SPS-52



REMOVE/REPLACE TARGET DESIGNATION EQUIPMENT COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

TIME CONSUMING: 19%
MK-77 SPS-48
MK-74 MK-76
SPS-52



CALIBRATE/ALIGN/ADJUST TARGET DESIGNATION EQUIPMENT

TIME CONSUMING: 38%
MK-77 SPS-48
MK-74 MK-76
SPS-52



INDEX OF TASKS PERFORMED BY RMS

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RM: GENERAL MAINTENANCE

RESEARCH TECHNICAL PUBLICATIONS TO FIND APPROPRIATE SCHEMATICS/LOGIC DIAGRAMS/TABLES/TROUBLESHOOTING CHARTS/MAINTENANCE INFORMATION/PART NUMBERS FOR SPECIFIC PIECES OF EQUIPMENT

IDENTIFY STANDARD ELECTRONIC/MECHANICAL SYMBOLS AS USED ON SCHEMATICS, LOGIC DIAGRAMS, FLOW CHARTS, ETC.

CHANGE SYSTEM CONFIGURATION BY PATCHING OR BY SWITCHBOARD CHANGES

ANALYZE EQUIPMENT FRONT PANEL INDICATORS FOR FAULT DETECTION

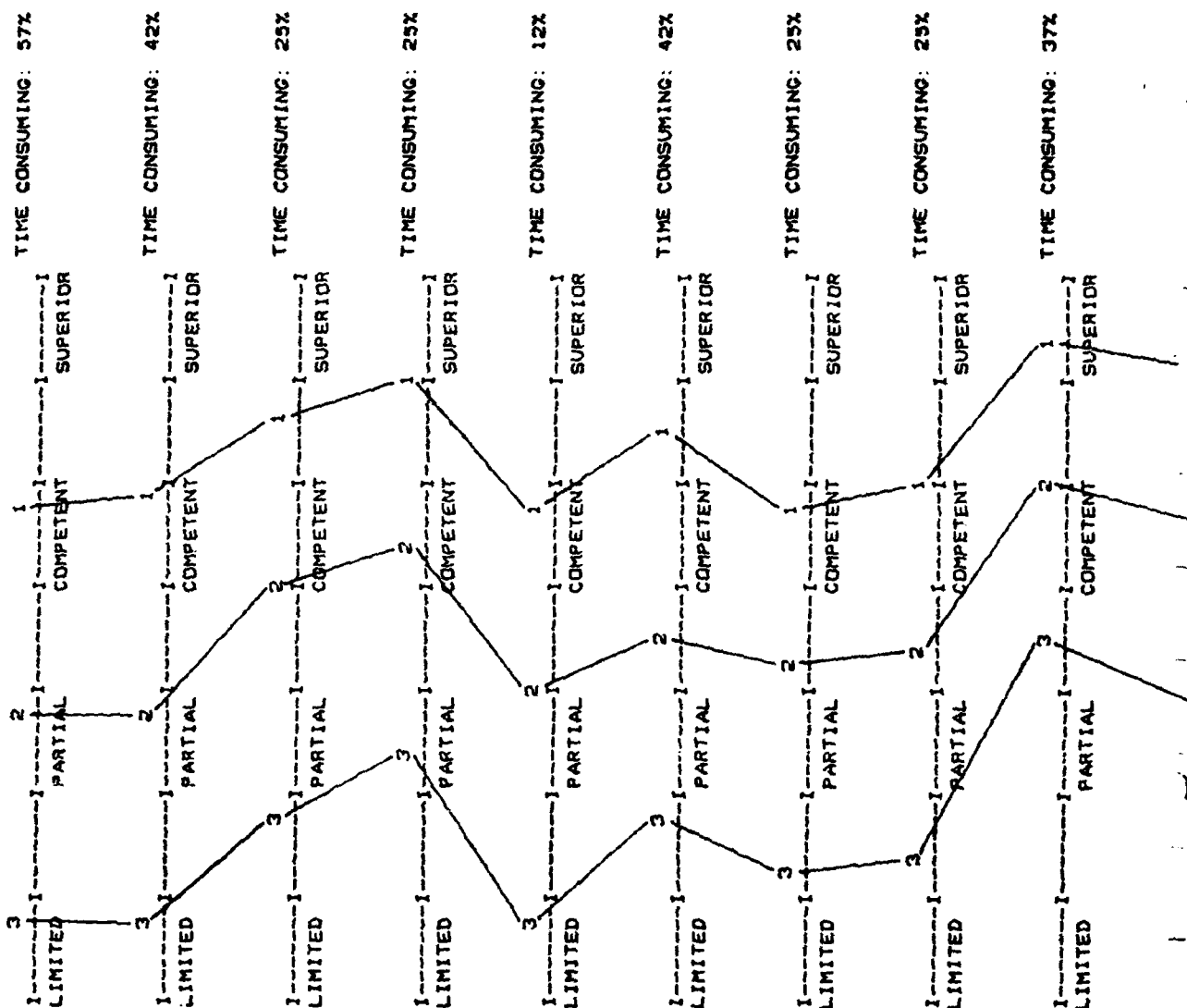
USE TEST EQUIPMENT TO INJECT SIGNALS AND/OR TAKE READINGS

ASSEMBLE/REPAIR CABLES AND TEST LEADS, SUCH AS CONNECTORS, PROBES, ETC.

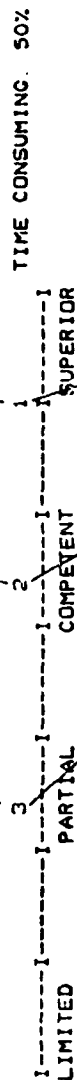
LOCALIZE/ISOLATE EQUIPMENT MALFUNCTION TO A SUBSYSTEM

LOCALIZE/ISOLATE EQUIPMENT MALFUNCTION TO A UNIT

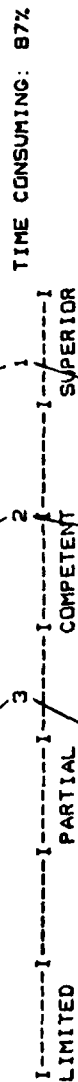
CLEAN MISCELLANEOUS RADIO EQUIPMENT



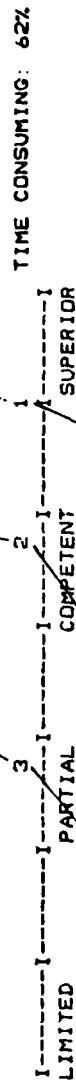
TEST/INSPECT RADIO EQUIPMENT



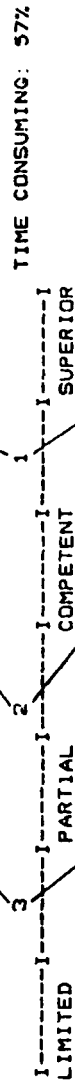
CLEAN/LUBRICATE ANTENNAS



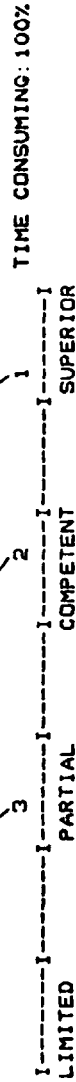
TEST/INSPECT ANTENNAS



LOCALIZE/ISOLATE ANTENNAS MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS INSULATORS, PEDESTALS, BASES, CONDUCTORS, ETC.

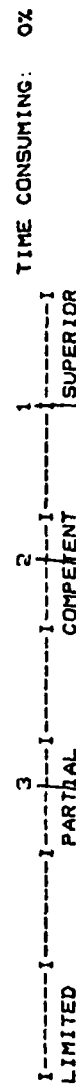


REMOVE/REPLACE ANTENNA COMPONENTS, SUCH AS INSULATORS, PEDESTALS, BASES, CONDUCTORS, ETC.

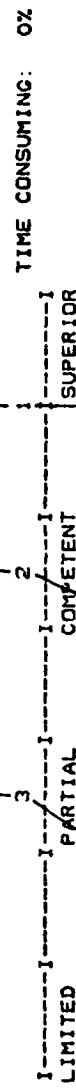


RM: ABNORMAL CONDITIONS

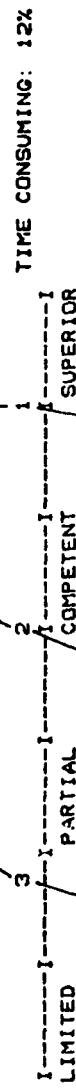
OVERHEATING (RECOGNIZE/UNDERSTAND EFFECTS OF)



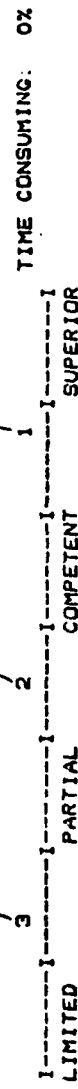
VARIATION IN PRIMARY POWER (RECOGNIZE/UNDERSTAND EFFECTS OF)



UNAUTHORIZED PERSONNEL TAMPERING WITH SYSTEM (RECOGNIZE/UNDERSTAND EFFECTS OF)

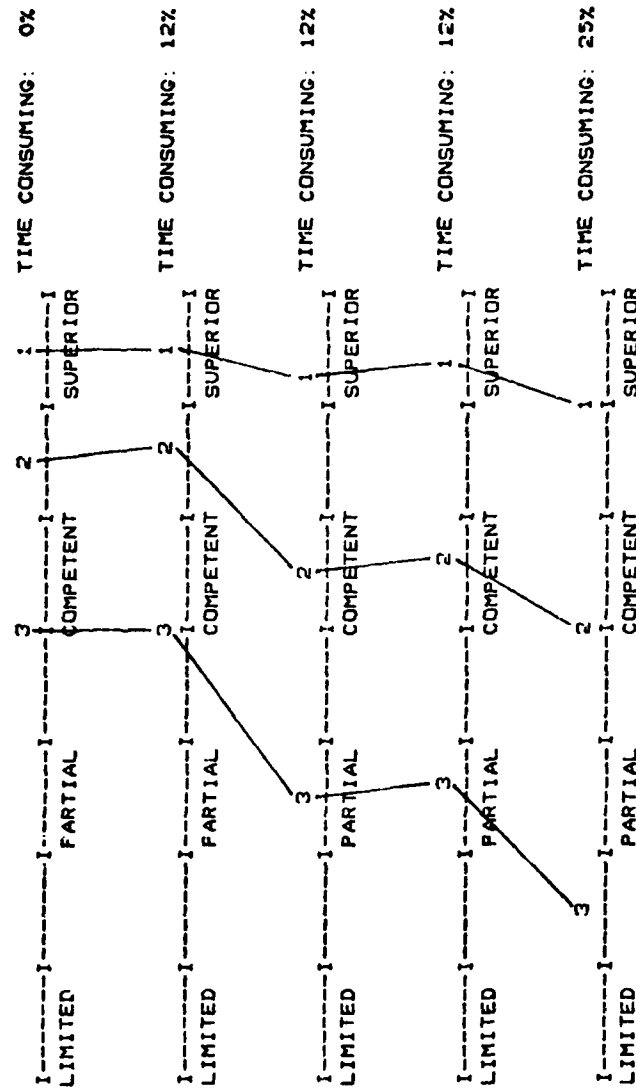


ADVERSE ATMOSPHERIC CONDITIONS (RECOGNIZE/UNDERSTAND EFFECTS OF)



RM: EMERGENCIES AND/OR CASUALTIES

BLOWN FUSES
(RECOGNIZE/UNDERSTAND EFFECTS OF)



LOSS OF PRIMARY POWER
(RECOGNIZE/UNDERSTAND EFFECTS OF)

EQUIPMENT MALFUNCTION
(RECOGNIZE/UNDERSTAND EFFECTS OF)

PERSONNEL ERROR
(RECOGNIZE/UNDERSTAND EFFECTS OF)

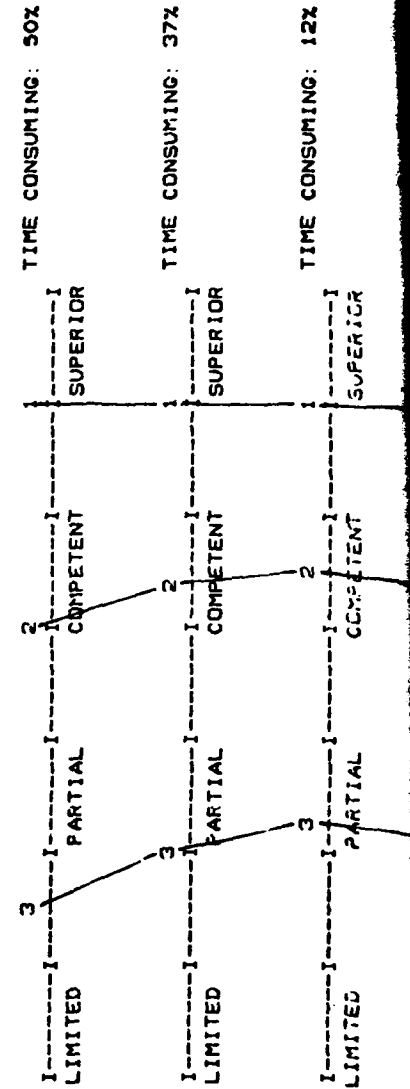
OPEN PATCH CORD
(RECOGNIZE/UNDERSTAND EFFECTS OF)

RM: MISCELLANEOUS SYSTEM OPERATIONS

CHECK FREQUENCIES FOR USABILITY (GAP)

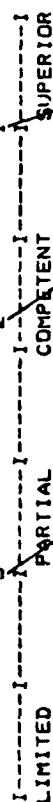
MONITOR RADIO CIRCUITS FOR RELIABILITY

TUNE TRANSCEIVERS



SET UP UCC1-C/D CONVERTER

TIME CONSUMING: 25%



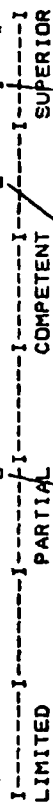
SET UP URA-17 CONVERTER

TIME CONSUMING: 0%



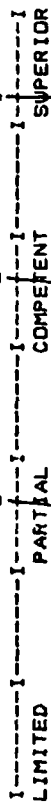
SET UP CV-2460/SCG CONVERTER

TIME CONSUMING: 0%



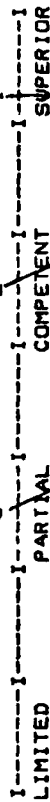
TUNE SRA-49, 50, OR 51 COUPLER

TIME CONSUMING: 16%



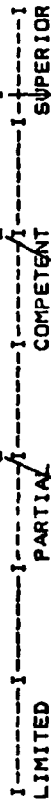
TUNE SRA-33 COUPLER

TIME CONSUMING: 14%



COORDINATE COMMUNICATIONS USING VARIOUS
ORDERWIRE CIRCUITS

TIME CONSUMING: 28%



RECEIVE FLEET BROADCAST USING FREQUENCY
DIVERSITY METHODS

TIME CONSUMING: 12%



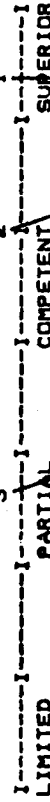
CONDUCT RADIO CHECKS

TIME CONSUMING: 12%



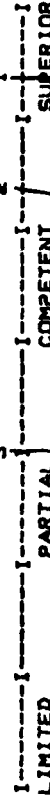
CHANGE (SHIFT) FREQUENCIES (GSY)

TIME CONSUMING: 25%



SET UP SSR-1 SATELLITE RECEIVER

TIME CONSUMING: 0%



SET UP WSC-3 SATELLITE TRANSCEIVER

TIME CONSUMING: 0%



RM: ROUTINE TRAFFIC HANDLING

REVIEW COMMUNICATION SHIFT,
COMMUNICATION GUARD MESSAGES

TIME CONSUMING: 12%



RECORD COMMUNICATION FILING

TIME CONSUMING: 37%



PERFORM REQUIRED SERVICE ACTION ON
MESSAGES AS NEEDED

TIME CONSUMING: 25%



MAKE CORRECTIONS TO MESSAGE
FORMAT LINES

TIME CONSUMING: 12%



ASSIGN DATE-TIME-GROUP TO MESSAGES

TIME CONSUMING: 0%



SORT (SLOT) MESSAGE COPIES FOR DISTRIBUTION

TIME CONSUMING: 37%



SCREEN FLEET BROADCAST FOR UNIT TRAFFIC

TIME CONSUMING: 37%



PREPARE CLOSE-OUT REPORT

TIME CONSUMING: 14%

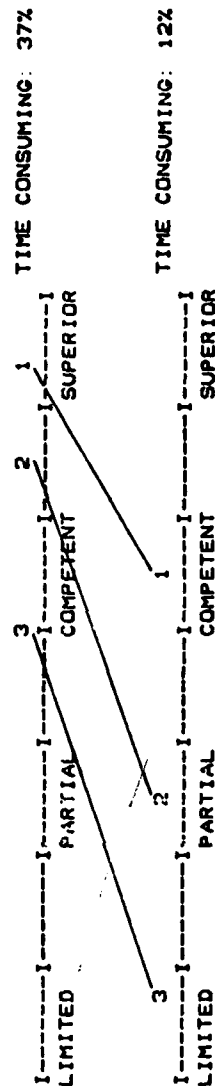


USE TRACER PROCEDURES WHEN REQUIRED



RM: SECURITY

DESTROY CLASSIFIED MATERIAL

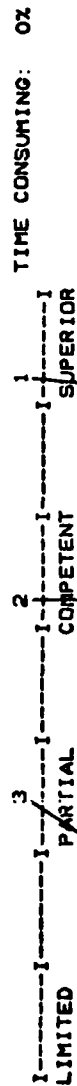


DETECT, IDENTIFY AND REPORT INTRUSION, JAMMING, AND INTERFERENCE (HJ1) ON RADIO RECEIVING EQUIPMENT



RM: TYPE "B" SECURE SIMPLEX TELETYPE (AFTS) SYSTEM

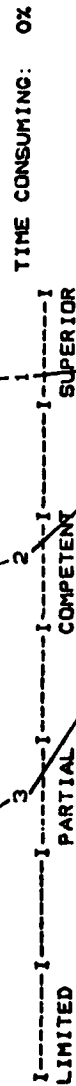
DETERMINE SHIP(S) AND/OR STATION(S) TO BE TERMINATED WITH (TYPE "B" SYSTEM)



DETERMINE THE FREQUENCY TO BE USED (TYPE "B" SYSTEM)



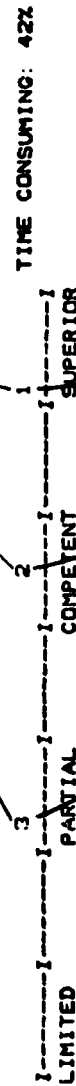
SELECT EQUIPMENTS TO BE USED (TYPE "B" SYSTEM)



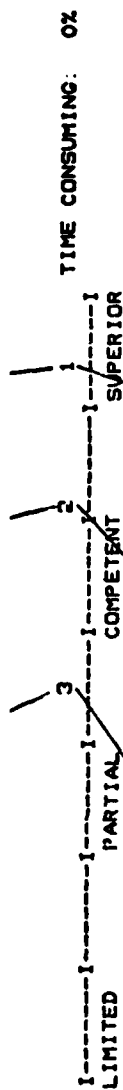
EXERCISE SYSTEM COMPONENTS (TYPE "B" SYSTEM)



INTERFACE THE SYSTEM BY MAKING REQUIRED PATCHES (TYPE "B" SYSTEM)



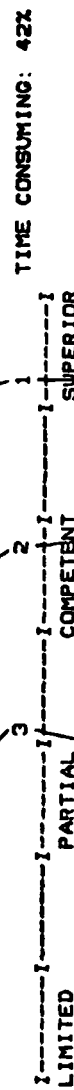
SET UP ASSOCIATED CRYPTO DEVICE
(TYPE "B" SYSTEM)



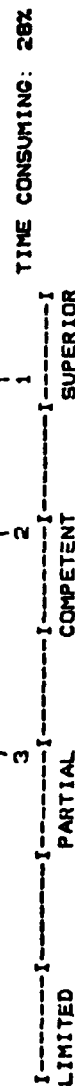
TUNE AND ADJUST SYSTEM COMPONENTS
FOR OPTIMUM PERFORMANCE
(TYPE "B" SYSTEM)



PREPARE OUTGOING MESSAGES IN
CORRECT FORMAT
(TYPE "B" SYSTEM)

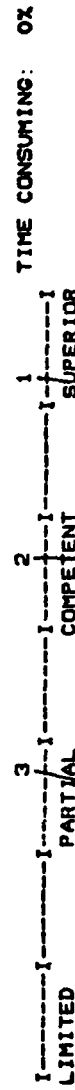


TRANSMIT AND RECEIVE MESSAGES
(TYPE "B" SYSTEM)

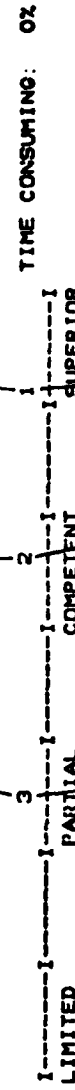


RM: TYPE "C" SECURE DUPLEX TELETYPE (AFTS) SYSTEM

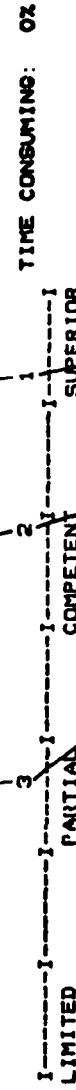
DETERMINE SHIP(S) AND/OR STATION(S) TO
BE TERMINATED WITH
(TYPE "C" SYSTEM)



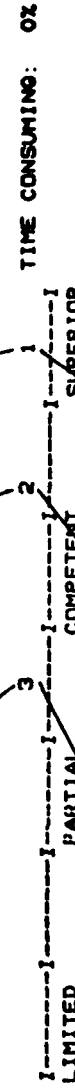
DETERMINE FREQUENCIES TO BE USED
(TYPE "C" SYSTEM)



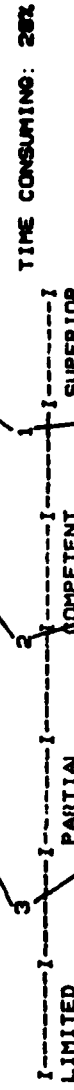
SELECT EQUIPMENTS TO BE USED
(TYPE "C" SYSTEM)



ENERGIZE SYSTEM COMPONENTS
(TYPE "C" SYSTEM)



INTERFACE THE SYSTEM BY MAKING
REQUIRED PATCHES
(TYPE "C" SYSTEM)



TIME CONSUMING. 0%

TIME CONSUMING: 42%

TIME CONSUMING: 42%

TIME CONSUMING. 28%

6-83

TIME CONSUMING: 0%

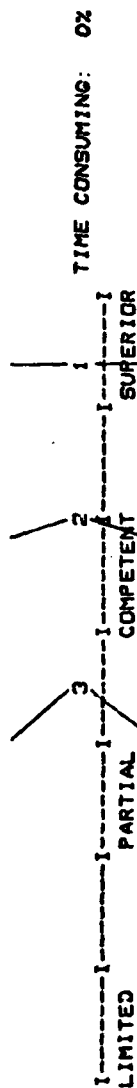
TIME CONSUMING: 12%

TIME CONSUMING: 0%

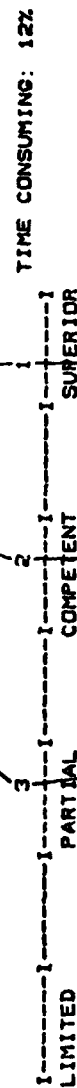
TIME CONSUMING: 0%

TIME CONSUMING: 25%

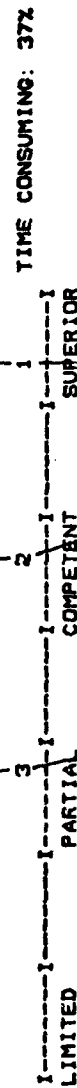
SET UP ASSOCIATED CRYPTO DEVICE
(TYPE "D" SYSTEM)



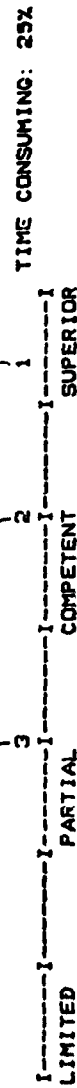
TUNE AND ADJUST SYSTEM COMPONENTS FOR
OPTIMUM PERFORMANCE
(TYPE "D" SYSTEM)



PREPARE OUTGOING MESSAGES IN
CORRECT FORMAT
(TYPE "D" SYSTEM)

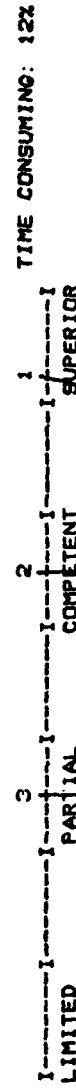


TRANSMIT AND RECEIVE MESSAGES
(TYPE "D" SYSTEM)

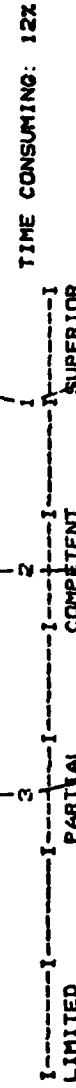


RM: TYPE "Q" SECURE DUPLEX TELETYPE (FSK) SYSTEM

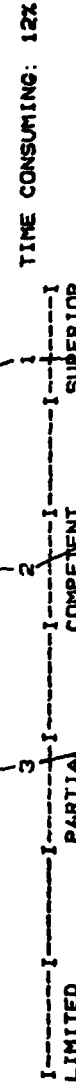
DETERMINE SHIP(S) AND/OR STATION(S) TO
BE TERMINATED WITH
(TYPE "Q" SYSTEM)



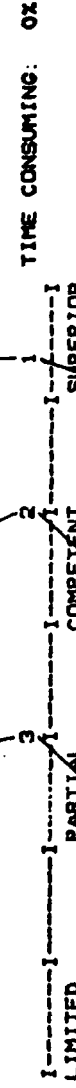
DETERMINE THE FREQUENCIES TO BE USED
(TYPE "Q" SYSTEM)



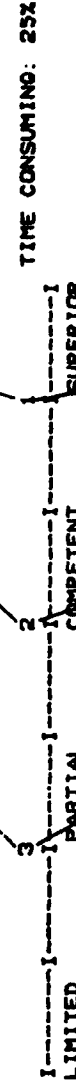
SELECT EQUIPMENTS TO BE USED
(TYPE "Q" SYSTEM)



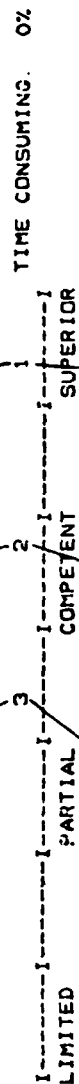
ENERGIZE SYSTEM COMPONENTS
(TYPE "Q" SYSTEM)



INTERFACE THE SYSTEM BY MAKING
REQUIRED PATCHES
(TYPE "Q" SYSTEM)



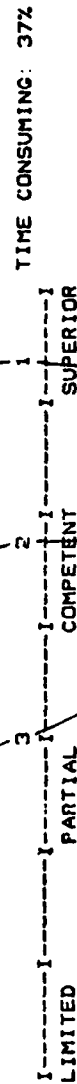
SET UP ASSOCIATED CRYPTO DEVICE
(TYPE "G" SYSTEM)



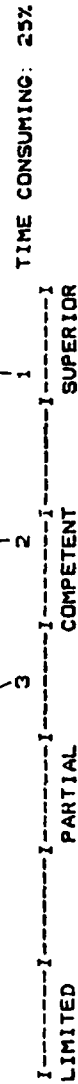
TUNE AND ADJUST SYSTEM COMPONENTS FOR
OPTIMUM PERFORMANCE
(TYPE "G" SYSTEM)



PREPARE OUTGOING MESSAGES IN CORRECT
FORMAT
(TYPE "G" SYSTEM)

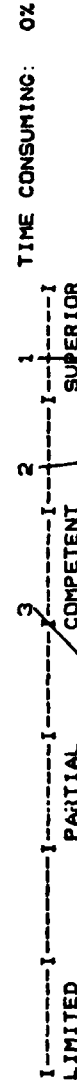


TRANSMIT AND RECEIVE MESSAGES
(TYPE "G" SYSTEM)

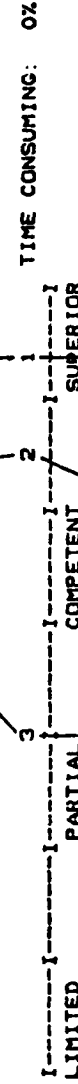


RM: TYPE "N" SECURE MULTICHANNEL FLEET BROADCAST (HF)

DETERMINE AREA BROADCAST TO BE COPIED
(TYPE "N" (HF) SYSTEM)



DETERMINE THE CHANNELS TO BE COPIED
(TYPE "N" (HF) SYSTEM)



DETERMINE THE STATIONS KEYING THE AREA
BROADCAST
(TYPE "N" (HF) SYSTEM)



DETERMINE THE FREQUENCIES KEYED BY
EACH STATION
(TYPE "N" (HF) SYSTEM)



SELECT EQUIPMENTS TO BE USED
(TYPE "N" (HF) SYSTEM)



ENERGIZE SYSTEM COMPONENTS
(TYPE "N" (HF) SYSTEM)



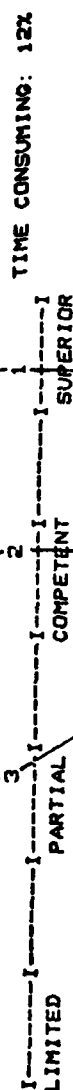
INTERFACE THE SYSTEM BY MAKING
NECESSARY PATCHES
(TYPE "N" (HF) SYSTEM)



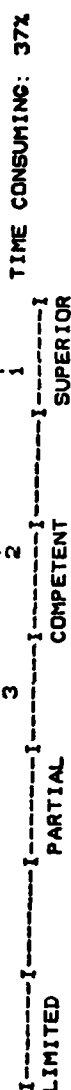
TUNE AND ADJUST SYSTEM COMPONENTS FOR
OPTIMUM PERFORMANCE
(TYPE "N" (HF) SYSTEM)



SET UP ASSOCIATED CRYPTO DEVICES
(TYPE "N" (HF) SYSTEM)

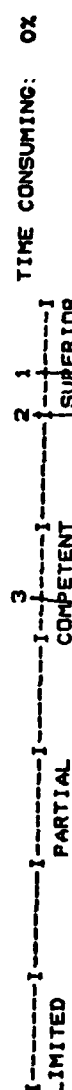


PROCESS INCOMING MESSAGES
(TYPE "N" (HF) SYSTEM)

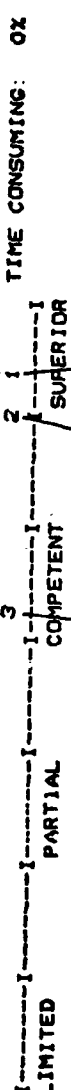


RM: TYPE "N" SECURE MULTICHANNEL FLEET BROADCAST (SATELLITE)

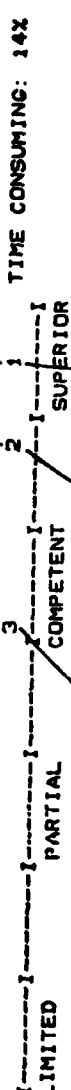
DETERMINE AREA BROADCAST TO BE COPIED
(TYPE "N" (SATELLITE) SYSTEM)



DETERMINE THE CHANNELS TO BE COPIED
(TYPE "N" (SATELLITE) SYSTEM)



DETERMINE THE STATIONS KEYING THE
AREA BROADCAST
(TYPE "N" (SATELLITE) SYSTEM)



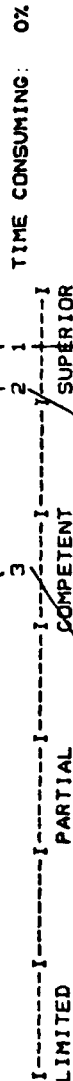
DETERMINE THE FREQUENCIES KEYED BY
EACH STATION
(TYPE "N" (SATELLITE) SYSTEM)



SELECT EQUIPMENTS TO BE USED
(TYPE "N" (SATELLITE) SYSTEM)



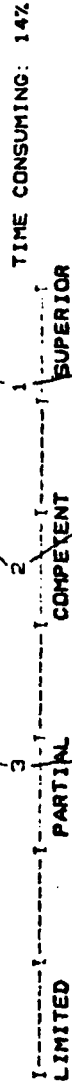
ENERGIZE SYSTEM COMPONENTS
(TYPE "N" (SATELLITE) SYSTEM)



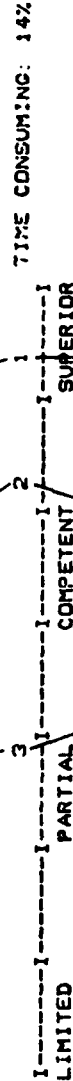
INTERFACE THE SYSTEM BY MAKING
NECESSARY PATCHES
(TYPE "N" (SATELLITE) SYSTEM)



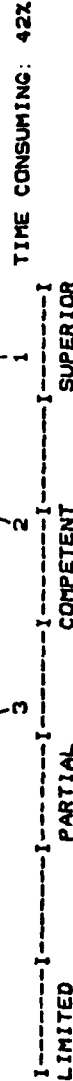
TUNE AND ADJUST SYSTEM COMPONENTS
FOR OPTIMUM PERFORMANCE
(TYPE "N" (SATELLITE) SYSTEM)



SET UP ASSOCIATED CRYPTO DEVICES
(TYPE "N" (SATELLITE) SYSTEM)

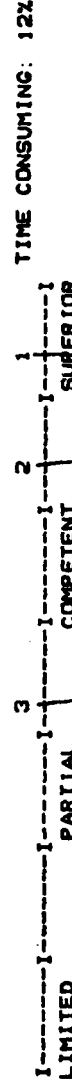


PROCESS INCOMING MESSAGES
(TYPE "N" (SATELLITE) SYSTEM)

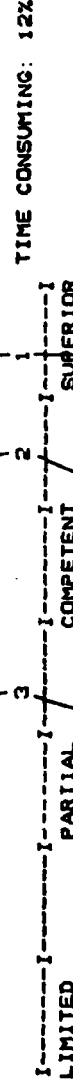


RM: TYPE "R" SECURE WIDEBAND VOICE SYSTEM

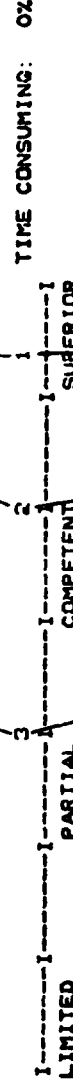
DETERMINE COMMUNICATION NET SUBSCRIBERS
(TYPE "R" SYSTEM)



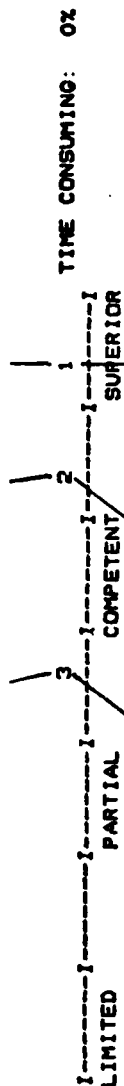
DETERMINE FREQUENCY TO BE USED
(TYPE "R" SYSTEM)



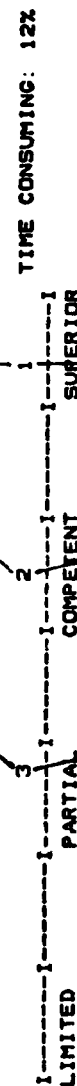
SELECT EQUIPMENTS TO BE USED
(TYPE "R" SYSTEM)



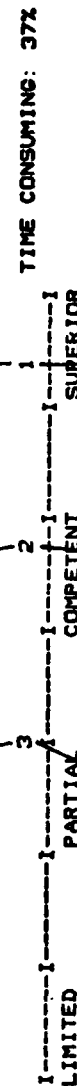
ENERGIZE SYSTEM COMPONENTS
(TYPE "R" SYSTEM)



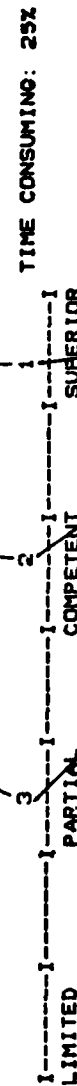
INTERFACE THE SYSTEMS BY MAKING
REQUIRED PATCHES
(TYPE "R" SYSTEM)



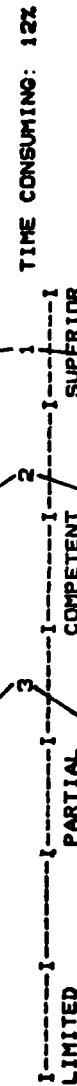
SET UP ASSOCIATED CRYPTO DEVICES
(TYPE "R" SYSTEM)



TUNE AND ADJUST SYSTEM COMPONENTS FOR
OPTIMUM PERFORMANCE
(TYPE "R" SYSTEM)



TRANSMIT AND RECEIVE INTELLIGENCE LOCALLY
(TYPE "R" SYSTEM)

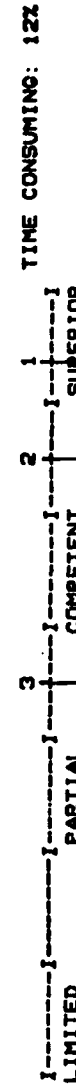


INTERFACE SYSTEM FOR REMOTE OPERATION
(TYPE "R" SYSTEM)

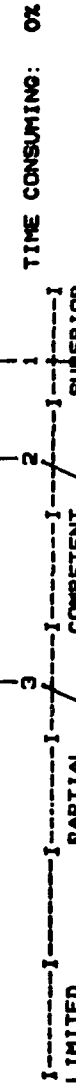


RM: TYPE "U" NONSECURE WIDEBAND VOICE SYSTEM

DETERMINE COMMUNICATIONS NET SUBSCRIBERS
(TYPE "U" SYSTEM)



DETERMINE FREQUENCY TO BE USED
(TYPE "U" SYSTEM)



SELECT EQUIPMENTS TO BE USED
(TYPE "U" SYSTEM)



ENERGIZE SYSTEM COMPONENTS
(TYPE "U" SYSTEM)

TIME CONSUMING: 0%

PATCH RECEIVER AND TRANSMITTER TO
ASSOCIATED ANTENNA
(TYPE "U" SYSTEM)

TIME CONSUMING: 0%

TUNE AND ADJUST SYSTEM COMPONENTS FOR
OPTIMUM PERFORMANCE
(TYPE "U" SYSTEM)

TIME CONSUMING: 12%

TRANSMIT AND RECEIVE INTELLIGENCE LOCALLY
(TYPE "U" SYSTEM)

TIME CONSUMING: 25%

INTERFACE SYSTEM FOR REMOTE OPERATION
(TYPE "U" SYSTEM)

TIME CONSUMING: 0%

RM: TYPE "Y" NONSECURE NARROWBAND VOICE SYSTEM

DETERMINE COMMUNICATION NET SUBSCRIBERS
(TYPE "Y" SYSTEM)

TIME CONSUMING: 14%

DETERMINE FREQUENCY TO BE USED
(TYPE "Y" SYSTEM)

TIME CONSUMING: 0%

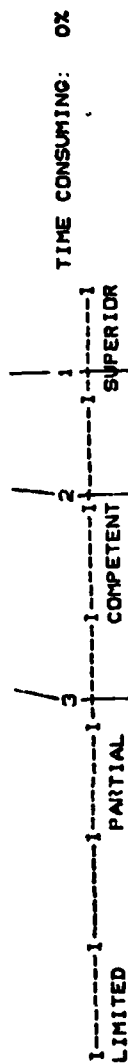
SELECT EQUIPMENTS TO BE USED
(TYPE "Y" SYSTEM)

TIME CONSUMING: 0%

ENERGIZE SYSTEM COMPONENTS
(TYPE "Y" SYSTEM)

TIME CONSUMING: 0%

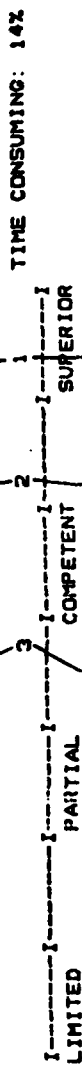
PATCH RECEIVER AND TRANSMITTER TO
ASSOCIATED ANTENNA
(TYPE "Y" SYSTEM)



TUNE AND ADJUST SYSTEM COMPONENTS FOR
OPTIMUM PERFORMANCE
(TYPE "Y" SYSTEM)



TRANSMIT AND RECEIVE INTELLIGENCE LOCALLY
(TYPE "Y" SYSTEM)



INTERFACE SYSTEM FOR REMOTE OPERATION
(TYPE "Y" SYSTEM)



INDEX OF TASKS PERFORMED BY STGS

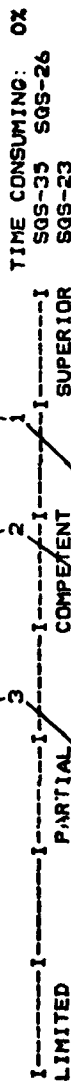
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ST: GENERAL OPERATION

SELECTS OPTIMUM OPERATING MODES IN VIEW OF SVP AND OTHER ENVIRONMENTAL FACTORS



CONDUCTS ACTIVE SEARCH USING ALL CONTROLS OPTIMALLY



DETECTS TRANSISTORY SIGNALS WITH LOW S/N RATIOS



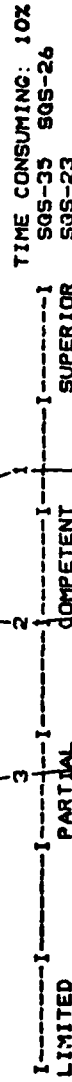
ESTIMATES TARGET DOPPLER USING DOPPLER DISPLAY



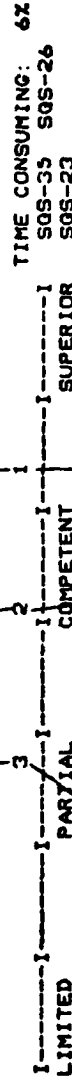
PERFORMS TARGET MOTION ANALYSIS



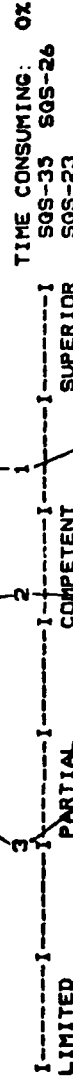
TRACKS MORE THAN 1 TARGET SIMULTANEOUSLY



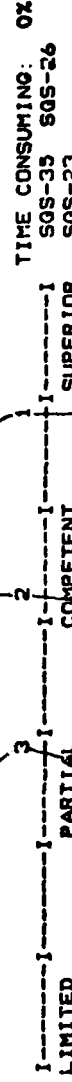
PERCEIVES CHANGES IN TARGET SIGNAL INDICATING CHANGES IN TARGET STATUS



INTERPRETS CHANGES IN SIGNAL PRESENTATION AS A FUNCTION OF TRANSMISSION AND RECEIVER CONTROL SETTINGS



DIFFERENTIATES TARGET SIGNALS FROM REVERBERATION AND NOISE



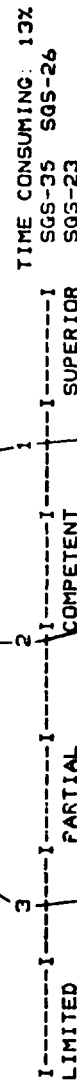
RELATES INFORMATION FROM ALL
AVAILABLE SOURCES IN CLASSIFYING
TARGET



DIFFERENTIATES SUBMARINE FROM
NON-SUBMARINE TARGETS



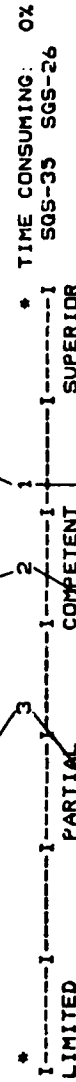
COORDINATES ACTIVITIES OF ALL
SONAR TEAM MEMBERS



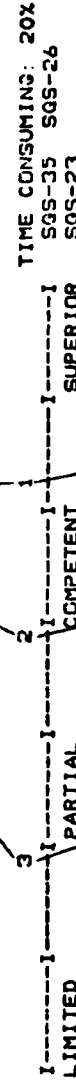
MAKES ALL NECESSARY AND DESIRABLE
REPORTS TO APPROPRIATE HIGHER-
LEVEL PERSONNEL



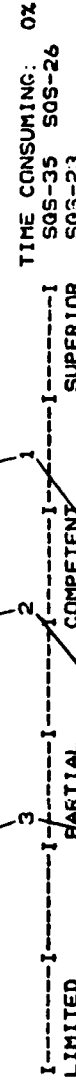
PERFORMS DETECTION OF PASSIVE
SONAR CONTACTS BY BEARING TIME
RECORDER (BTR) TRACES



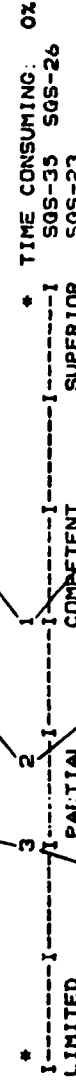
DETECTS AND IDENTIFIES TARGET
MANEUVERS



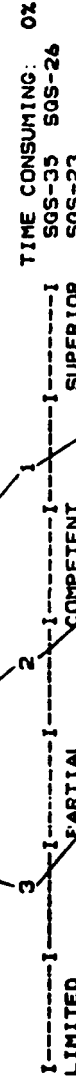
RECOMMENDS SONAR OPERATING MODES
DURING CONTACT PROSECUTION



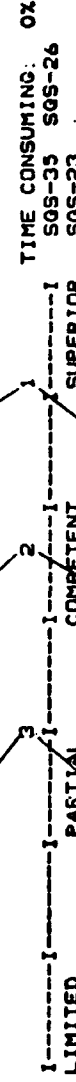
RECOMMENDS TOW DEPTHS FOR TOWED
SENSORS TO AID IN SEARCH FOR
AND PROSECUTION OF SONAR CONTACTS



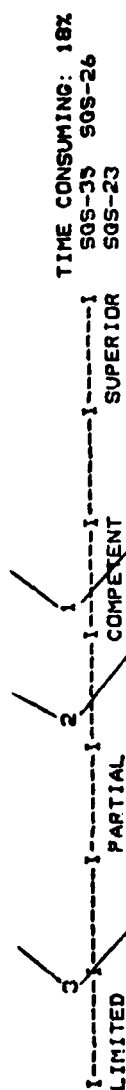
RECOMMENDS CHANGES OF COURSE AND
SPEED OF OWN SHIP DURING PROSE-
CUTION OF A SONAR CONTACT



MAKES RECOMMENDATIONS TO BRIDGE/
CONN/CIC TO CLEAR BAFFLES

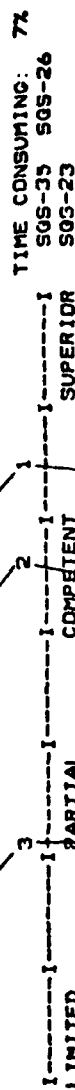


RECOMMENDS USE OF PRAIRIE MASKER
SECURING NOISY EQUIPMENTS, AND
ADJUSTMENTS IN MANEUVERING TO
REDUCE DETECTABILITY



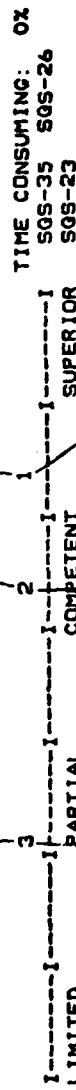
TIME CONSUMING: 18%
SQS-35 SQS-26
SQS-23

USES TARGET PLOT ON UNDERWATER
WEAPONS FIRE CONTROL SYSTEM (UMFCS)
TO DETERMINE TARGET COURSE, SPEED
AND TRACK CONFIDENCE



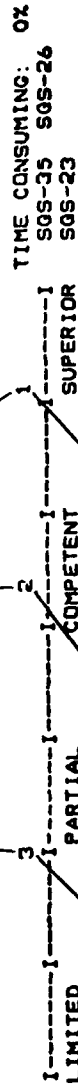
TIME CONSUMING: 7%
SQS-35 SQS-26
SQS-23

RECOMMENDS WEAPON SELECTION AND
SETTING DURING AN ANTISUBMARINE
WARFARE (ASW) ATTACK OR SIMULATED
ATTACK



TIME CONSUMING: 0%
SQS-35 SQS-26
SQS-23

RECOMMENDS SEARCH ARCS BASED ON
UMFCS PLOT WHEN SONAR IS NOT IN
CONTACT



TIME CONSUMING: 0%
SQS-35 SQS-26
SQS-23

CONNS THE SHIP FROM UNDERWATER
BATTERY (UB) PLOT DURING AN
ASW ATTACK OR SIMULATED ASW ATTACK



TIME CONSUMING: 7%
SQS-35 SQS-26
SQS-23

ANALYZES XBT/BSH AND OTHER OCEANO-
GRAPHIC (OCEANO) METEOROLOGICAL
(MET) DATA



TIME CONSUMING: 30%
SQS-35 SQS-26
SQS-23

CALCULATES ACTIVE RANGE FIGURE OF
MERIT (FOM)



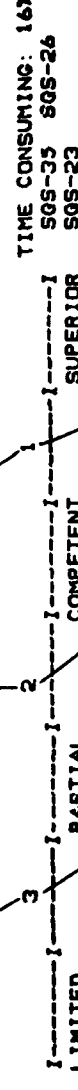
TIME CONSUMING: 28%
SQS-35 SQS-26
SQS-23

CALCULATES PASSIVE FOM



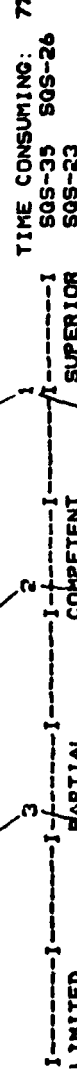
TIME CONSUMING: 9%
SQS-35 SQS-26
SQS-23

USES PUBLICATIONS CONCERNING OCEANO-
GRAPHIC AND METEOROLOGICAL CONDI-
TIONS TO DETERMINE THE BEST PROPA-
GATION PATH TO UTILIZE (SUCH AS DIRECT,
BOTTOM REFLECTED, CONVERGENCE ZONE)



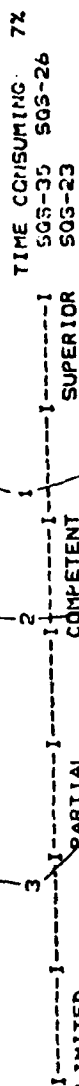
TIME CONSUMING: 16%
SQS-35 SQS-26
SQS-23

CALCULATES BEST DEPTH FOR SUBMARINE
TO AVOID DETECTION

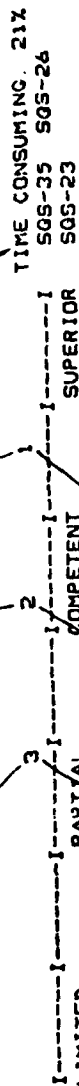


TIME CONSUMING: 7%
SQS-35 SQS-26
SQS-23

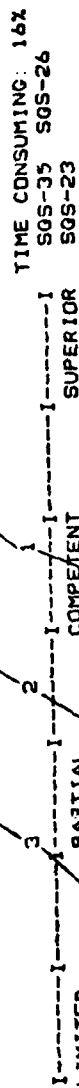
USES NOISE LEVEL METERS INSTALLED
IN EQUIPMENT TO DETERMINE OWN SHIP
NOISE LEVELS



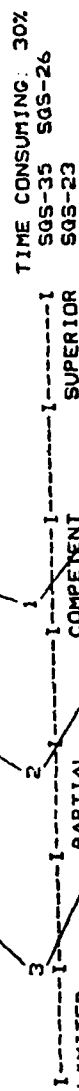
MAKES ACTIVE SONAR DETECTION
RANGE PREDICTIONS USING PERFORMANCE
FIGURE OR FOM



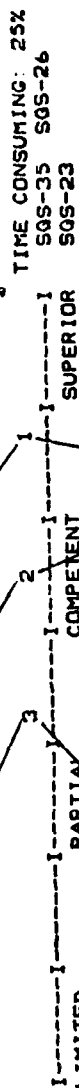
MAKES PASSIVE SONAR DETECTION
RANGE PREDICTIONS USING FOM



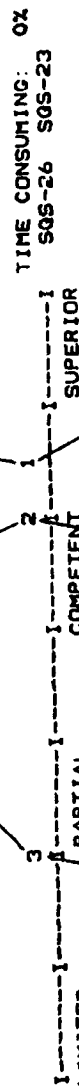
CALCULATES COUNTER-DETECTION
RANGES



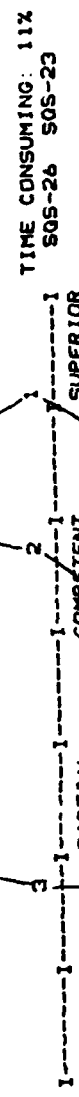
CALCULATES SONAR PERFORMANCE
USING SHARPS



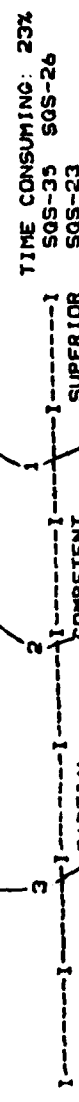
ADJUSTS TRANSMISSION AND RECEPTION
CONTROLS FOR BOTTOM BOUNCE
OPERATION



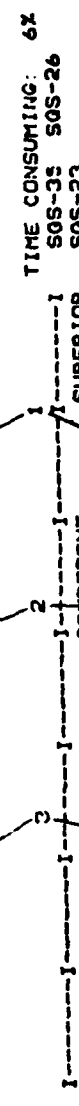
ADJUSTS TRANSMISSION AND RECEPTION
CONTROL FOR CONVERGENCE ZONE
OPERATION



INTERPRETS THE SOUND VELOCITY
PROFILE AND UNDERSTANDS ITS
OPERATIONAL IMPLICATIONS



USES CONTROLS TO MAINTAIN CONTACT
DESPITE O.S. OR TARGET MANEUVERS

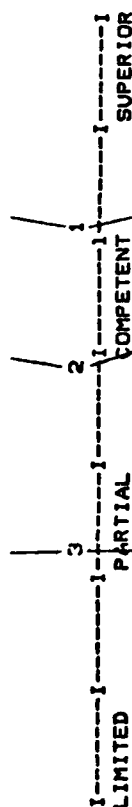


PERCEIVES TRUE AND RELATIVE TARGET
MOTION ON VIDEO DISPLAYS



DETECTS TARGET SIGNALS EVEN
THOUGH THEY MAY BE VERY WEAK OR
MASKED BY NOISE

TIME CONSUMING: 20%
SOS-35 SOS-26
SOS-22



DETERMINES TARGET COURSE AND SPEED
FROM PLOT

TIME CONSUMING: 8%
SOS-35 SOS-26
SOS-23



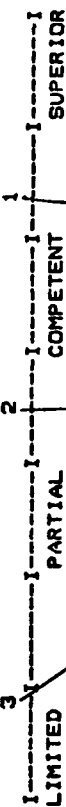
CORRELATES OWN SHIP SONAR DATUM
WITH DATA FROM OUTSIDE SOURCES

TIME CONSUMING: 23%
SOS-35 SOS-26
SOS-23



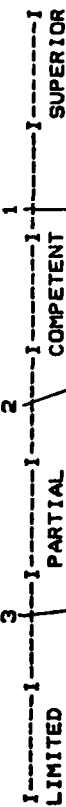
ESTIMATES PROBABLE LOCATIONS OF
LOST CONTACTS USING TIME-LATE
AND FINAL CONTACT DATA

TIME CONSUMING: 9%
SOS-35 SOS-26
SOS-23



DISTINGUISHES BETWEEN MOVING
AND NON-MOVING TARGETS USING
THE SONAR DISPLAYS ONLY

TIME CONSUMING: 13%
SOS-35 SOS-26
SOS-23



DISTINGUISHES MARINE LIFE OR
OTHER NON-SUBMARINE CONTACTS
FROM SUBMARINE CONTACTS

TIME CONSUMING: 13%
SOS-35 SOS-26
SOS-23



UNDERSTANDS MEANING AND RELIABILITY OF
AUDIO CLUES IN CLASSIFYING THE
TARGET

TIME CONSUMING: 13%
SOS-35 SOS-26
SOS-23



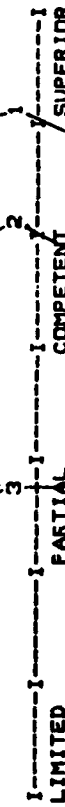
UNDERSTANDS MEANING AND RELIABILITY
OF VIDEO CLUES IN CLASSIFYING
THE TARGET

TIME CONSUMING: 7%
SOS-35 SOS-26
SOS-23



RECOGNIZES EVIDENCE OF TORPEDO
ATTACK

TIME CONSUMING: 0%
SOS-35 SOS-26
SOS-23

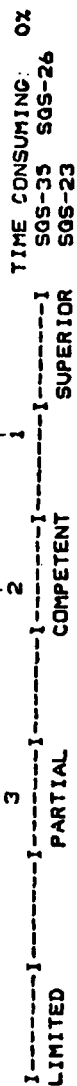


RECOGNIZES HOW TARGET SIGNAL CAN
VARY IN APPEARANCE WITH TARGET
RANGE, TARGET ASPECT, TARGET DEPTH

TIME CONSUMING: 13%
SOS-35 SOS-26
SOS-23

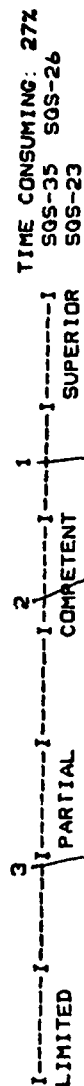


RECOGNIZES HOW TARGET SIGNAL CAN VARY IN APPEARANCE WITH MODE OF TRANSMISSION, POWER LEVEL, PULSE TYPE

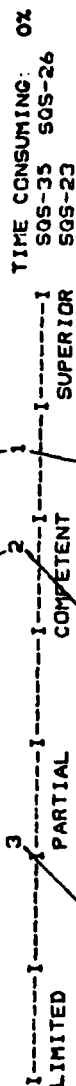


ST: GENERAL MAINTENANCE

RESEARCH TECHNICAL PUBLICATIONS TO FIND APPROPRIATE SCHEMATICS/LOGIC DIAGRAMS/TABLES/TROUBLESHOOTING CHARTS/MAINTENANCE INFORMATION/PART NUMBERS FOR SPECIFIC PIECES OF EQUIPMENT



IDENTIFY STANDARD ELECTRONIC/MECHANICAL SYMBOLS AS USED ON SCHEMATICS, LOGIC DIAGRAMS, FLOW CHARTS, ETC.



MODIFY EQUIPMENT IN ACCORDANCE WITH SH:PALTS, ORDALTS, FIELD CHANGE ORDERS AND ELECTRONIC INFORMATION BULLETINS (EIBS)



CHANGE SYSTEM CONFIGURATION BY PATCHING OR BY SWITCHBOARD CHANGES



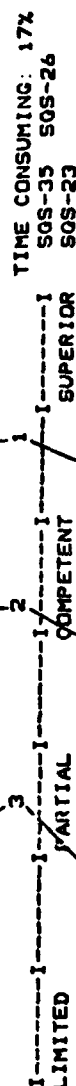
ANALYZE EQUIPMENT FRONT PANEL INDICATORS FOR FAULT DETECTION



USE TEST EQUIPMENT TO INJECT SIGNALS AND/OR TAKE READINGS



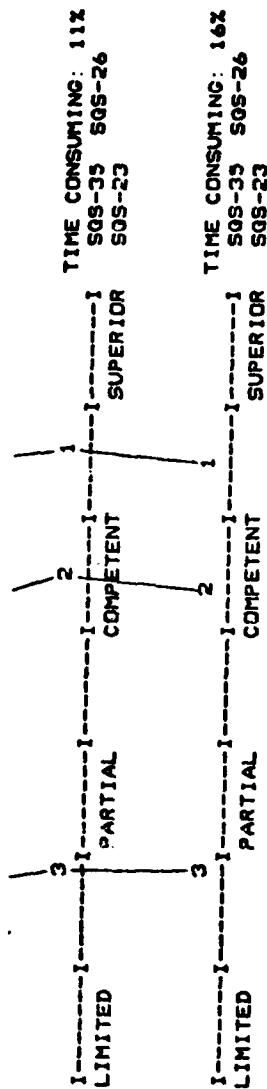
ASSEMBLE/REPAIR CABLES AND TEST LEADS, SUCH AS CONNECTORS, PROBES, ETC.



ALIGN/ADJUST MECHANICAL LINKAGES AND GEAR TRAINS



LOCALIZE/ISOLATE EQUIPMENT MALFUNCTION
TO A SUBSYSTEM



LOCALIZE/ISOLATE EQUIPMENT MALFUNCTION
TO A UNIT



ST: AF AMPLIFIER

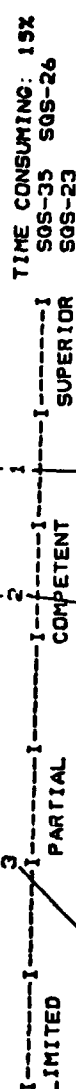
CLEAN AF AMPLIFIER



TEST/INSPECT AF AMPLIFIER



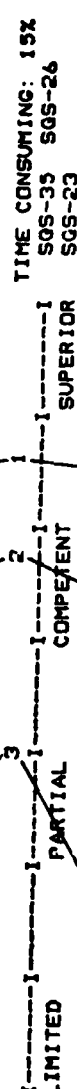
LOCALIZE/ISOLATE AF AMPLIFIER MALFUNCTION
TO THE MODULE/CARD LEVEL



LOCALIZE/ISOLATE AF AMPLIFIER MALFUNCTION
TO THE COMPONENT LEVEL, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.



REMOVE/REPLACE AF AMPLIFIER MODULES/
CARDS



REMOVE/REPLACE AF AMPLIFIER COMPONENTS,
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



CALIBRATE/ADJUST AF AMPLIFIER

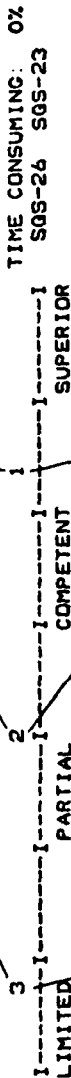


ST: AMPLIFIER-MODULATOR

CLEAN SONAR AMPLIFIER-MODULATOR



TEST/INSPECT SONAR AMPLIFIER-MODULATOR



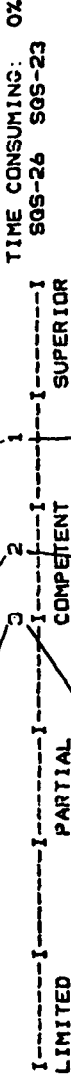
LOCALIZE/ISOLATE SONAR AMPLIFIER-MODULATOR
MALFUNCTION TO THE MODULE/CARD LEVEL



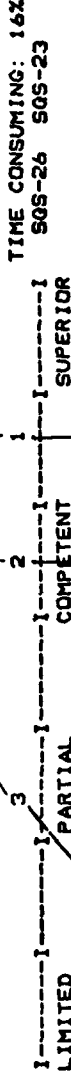
LOCALIZE/ISOLATE SONAR AMPLIFIER-MODULATOR
MALFUNCTION TO THE COMPONENT LEVEL, SUCH
AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



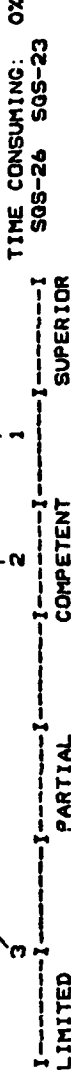
REMOVE/REPLACE SONAR AMPLIFIER-MODULATOR
MODULES/CARDS



REMOVE/REPLACE SONAR AMPLIFIER-MODULATOR
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

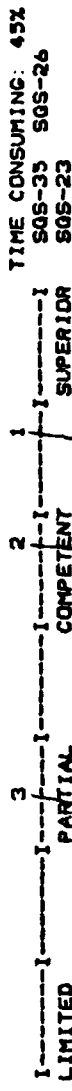


CALIBRATE/ALIGN/ADJUST SONAR
AMPLIFIER-MODULATOR

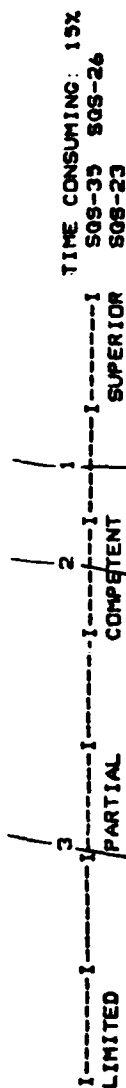


ST: AMPLIFIER-SCANNER

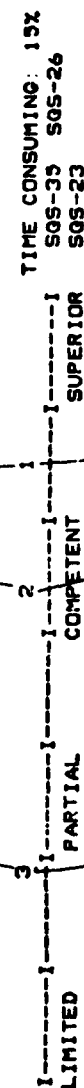
CLEAN SONAR AMPLIFIER-SCANNER



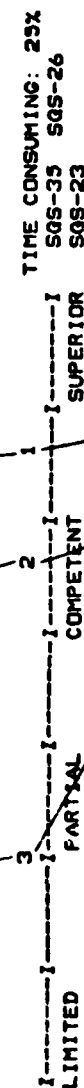
TEST/INSPECT SONAR AMPLIFIER-SCANNER



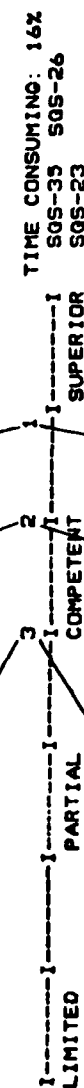
LOCALIZE/ISOLATE SONAR AMPLIFIER-SCANNER MALFUNCTION TO THE MODULE/CARD LEVEL



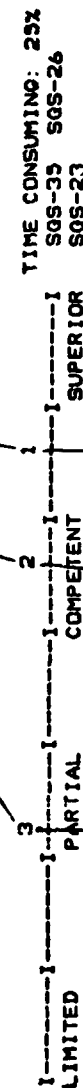
LOCALIZE/ISOLATE SONAR AMPLIFIER-SCANNER MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



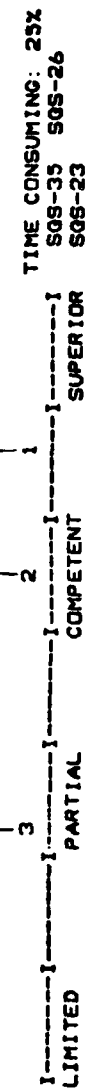
REMOVE/REPLACE SONAR AMPLIFIER-SCANNER MODULES/CARDS



REMOVE/REPLACE SONAR AMPLIFIER-SCANNER COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

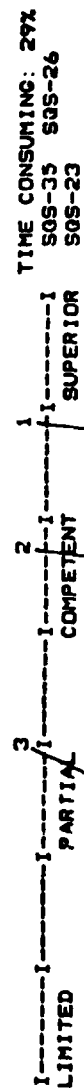


CALIBRATE/ALIGN/ADJUST SONAR AMPLIFIER-SCANNER

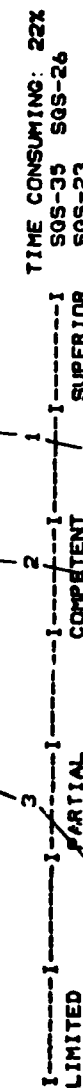


ST: CONSOLE 1/CONTROL INDICATOR

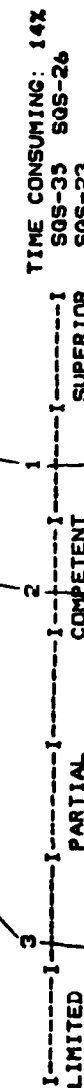
CLEAN/LUBRICATE CONSOLE 1/CONTROL INDICATOR



TEST/INSPECT CONSOLE 1/CONTROL INDICATOR



LOCALIZE/ISOLATE CONSOLE 1/CONTROL INDICATOR MALFUNCTION TO THE MODULE/CARD LEVEL



TIME CONSUMING: 29%
SQS-35 SQS-26
SQS-23

TIME CONSUMING: 20%
SQS-35 SQS-26
SQS-23

TIME CONSUMING: 27%
SQS-35 SQS-26
SQS-23

TIME CONSUMING: 38%
SQS-35 SQS-26
SQS-23

LIMITED PARTIAL COMPETENT SUPERIOR

LIMITED PARTIAL COMPETENT SUPERIOR

LIMITED PARTIAL COMPETENT SUPERIOR

LIMITED PARTIAL COMPETENT SUPERIOR

TIME CONSUMING: 20%
S05-35 S05-26
S05-23

1
2
3

PARTIAL
COMPETENT
SUPERIOR

LIMITED

TIME CONSUMING: 27%
SOS-35 SOS-26
SOS-23
3 2 1
LIMITED PARTIAL COMPETENT SUPERIOR

TIME CONSUMING: 382
SQS-35 SQS-26
SQS-23

1
2
3

PARTIAL
COMPETENT
SUPERIOR

-LIMITED

TIME CONSUMING: 22%
SQS-35 SQS-26
SQS-23

1
2
3

PARTIAL
COMPETENT
SUPERIOR

LIMITED

[illegible]

TIME CONSUMING: OX
SOS-35 SOS-26
SOS-23
SUPERIOR
COMPETENT
PARTIAL
LIMITED

TIME CONSUMING: 10X
SOS-25 SOS-26
SOS-23

1
2
3

LIMITED PARTIAL COMPETENT SUPERIOR

TIME CONSUMING: 02
SOS-35 SOS-26
SOS-23

1
2
3

LIMITED
PARTIAL
COMPETENT
SUPERIOR

REMOVE/REPLACE CONSOLE 2 COMPONENTS
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



CALIBRATE/ALIGN/ADJUST CONSOLE 2



ST: CONSOLE 3/CONTROL INDICATOR

CLEAN CONSOLE 3



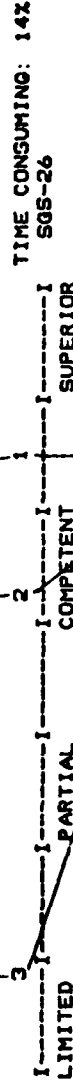
TEST/INSPECT CONSOLE 3



LOCALIZE/ISOLATE CONSOLE 3 MALFUNCTION
TO THE MODULE/CARD LEVEL



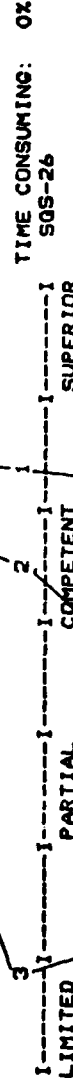
LOCALIZE/ISOLATE CONSOLE 3 MALFUNCTION
TO THE COMPONENT LEVEL SUCH AS
SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



REMOVE/REPLACE CONSOLE 3 MODULES/CARDS



REMOVE/REPLACE CONSOLE 3 COMPONENTS, SUCH
AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



CALIBRATE/ALIGN/ADJUST CONSOLE 3

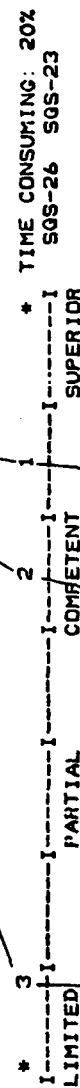


ST. CONTROL CONVERTER

CLEAN CONTROL CONVERTER



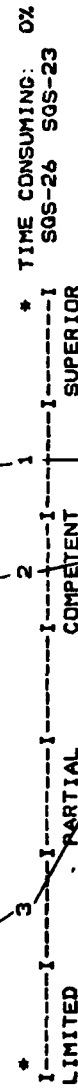
TEST/INSPECT CONTROL CONVERTER



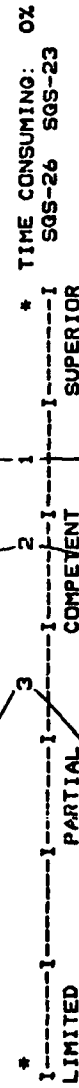
LOCALIZE/ISOLATE CONTROL CONVERTER
MALFUNCTION TO THE MODULE/CARD LEVEL



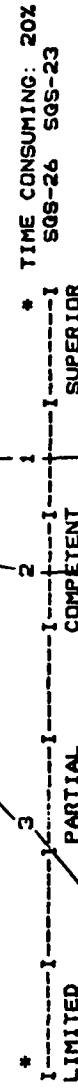
LOCALIZE/ISOLATE CONTROL CONVERTER
MALFUNCTION TO THE COMPONENT LEVEL, SUCH
AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



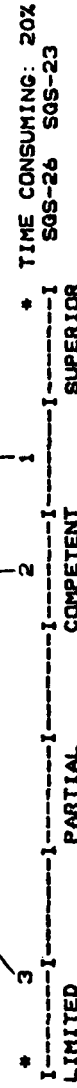
REMOVE/REPLACE CONTROL CONVERTER
MODULES/CARDS



REMOVE/REPLACE CONTROL CONVERTER
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.



CALIBRATE/ALIGN/ADJUST CONTROL
CONVERTER



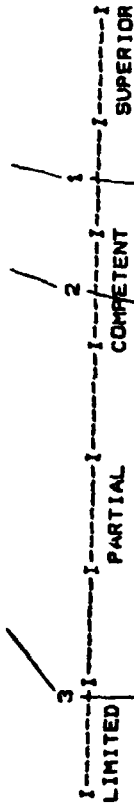
ST: CONVERTER A-SCAN

CLEAN CONVERTER A-SCAN



TEST/INSPECT CONVERTER A-SCAN

TIME CONSUMING: 28%
SQS-26



LOCALIZE/ISOLATE CONVERTER A-SCAN MALFUNCTION TO THE MODULE/CARD LEVEL

TIME CONSUMING: 14%
SQS-26



LOCALIZE/ISOLATE CONVERTER A-SCAN MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

TIME CONSUMING: 0%
SQS-26



REMOVE/REPLACE CONVERTER A-SCAN MODULES/CARDS

TIME CONSUMING: 0%
SQS-26



REMOVE/REPLACE CONVERTER A-SCAN COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

TIME CONSUMING: 0%
SQS-26



CALIBRATE/ALIGN/ADJUST CONVERTER A-SCAN

TIME CONSUMING: 42%
SQS-26



ST: CONVERTER B-SCAN

CLEAN CONVERTER B-SCAN

TIME CONSUMING: 0%
SQS-26



TEST/INSPECT CONVERTER B-SCAN

TIME CONSUMING: 16%
SQS-26



LOCALIZE/ISOLATE CONVERTER B-SCAN MALFUNCTION TO THE MODULE/CARD LEVEL

TIME CONSUMING: 0%
SQS-26



LOCALIZE/ISOLATE CONVERTER B-SCAN
MALFUNCTION TO THE COMPONENT LEVEL, SUCH
AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

REMOVE/REPLACE CONVERTER B-SCAN
MODULES/CARDS

REMOVE/REPLACE CONVERTER B-SCAN
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

CALIBRATE/ALIGN/ADJUST CONVERTER B-SCAN

ST: MODULATOR-SCANNER

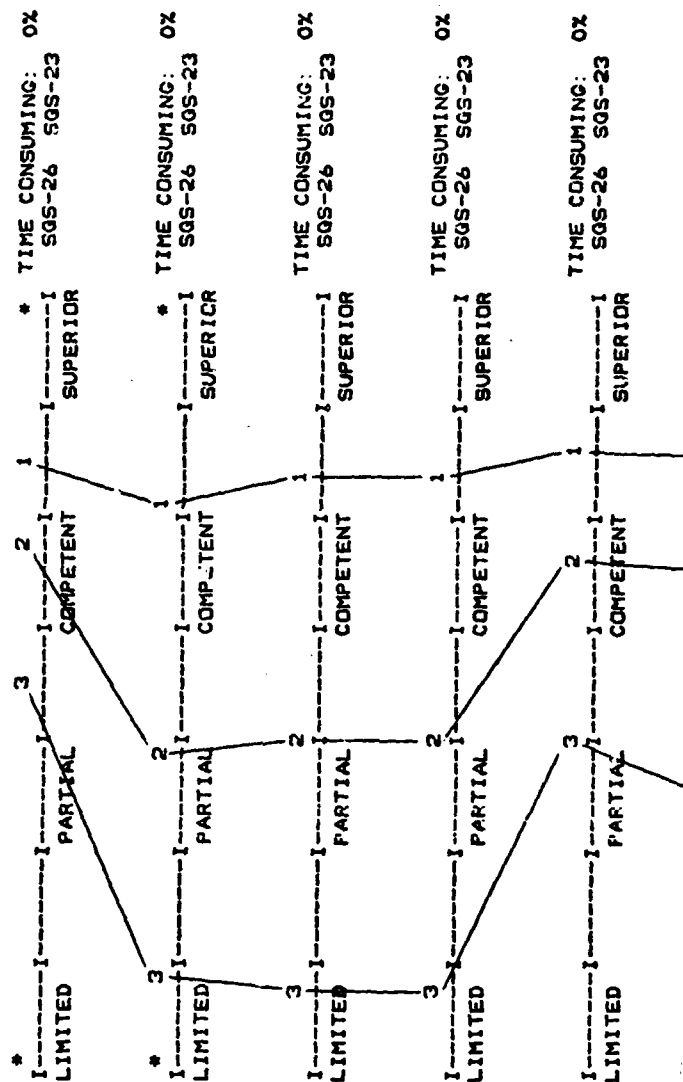
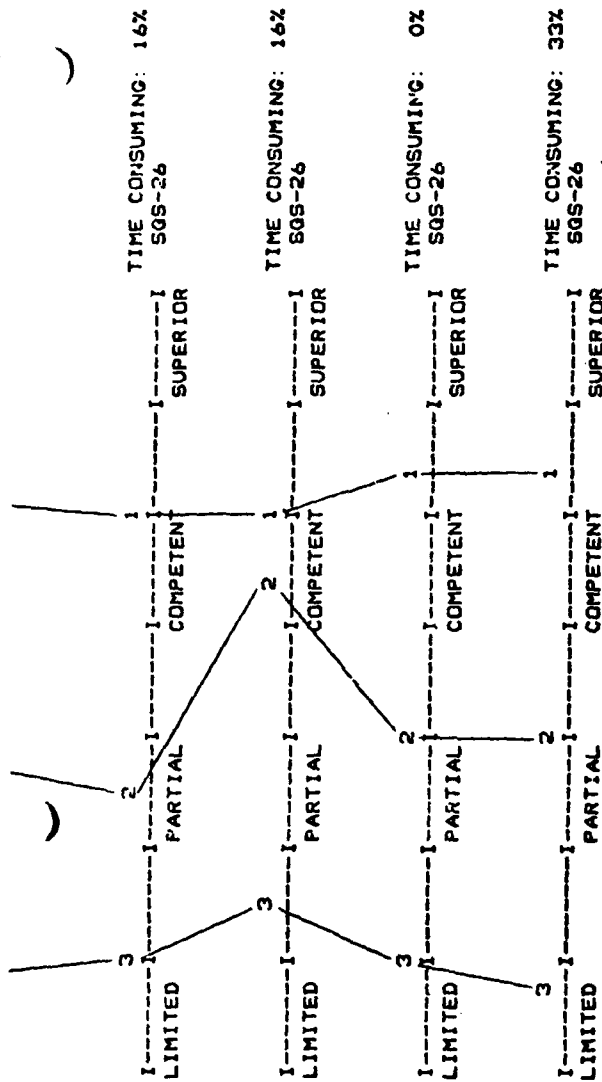
CLEAN SONAR MODULATOR-SCANNER

TEST/INSPECT SONAR MODULATOR-SCANNER

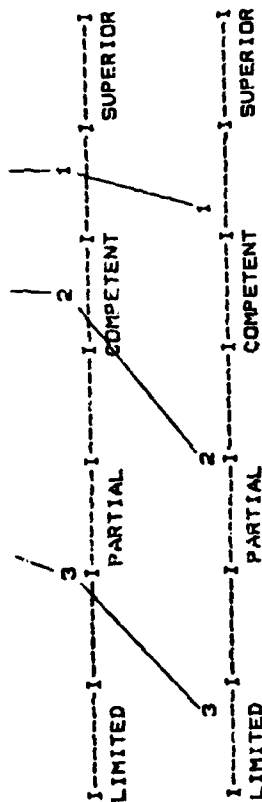
LOCALIZE/ISOLATE SONAR MODULATOR-SCANNER
MALFUNCTION TO THE MODULE/CARD LEVEL

LOCALIZE/ISOLATE SONAR MODULATOR-SCANNER
MALFUNCTION TO THE COMPONENT LEVEL, SUCH
AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

REMOVE/REPLACE SONAR MODULATOR-SCANNER
MODULES/CARDS

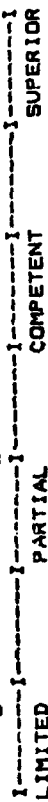


TIME CONSUMING: 16%
SGS-26 SGS-23



REMOVE/REPLACE SONAR MODULATOR-SCANNER
COMPONENTS. SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

TIME CONSUMING: 16%
SGS-26 SGS-23



CALIBRATE/ALIGN/ADJUST SONAR MODULATOR-
SCANNER

ST: MOTOR GENERATOR/ALTERNATOR

TIME CONSUMING: 40%
SGS-35 SGS-26
SGS-23



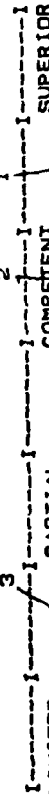
CLEAN/LUBRICATE MOTOR GENERATOR/
ALTERNATOR

TIME CONSUMING: 13%
SGS-35 SGS-26
SGS-23



TEST/INSPECT MOTC- GENERATOR/
ALTERNATOR

TIME CONSUMING: 13%
SGS-35 SGS-26
SGS-23



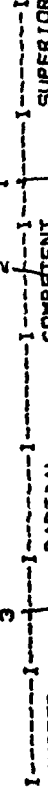
LOCALIZE/ISOLATE MOTOR GENERATOR/
ALTERNATOR MALFUNCTION TO A UNIT

TIME CONSUMING: 38%
SGS-35 SGS-26
SGS-23



LOCALIZE/ISOLATE MOTOR GENERATOR/
ALTERNATOR MALFUNCTION TO THE
COMPONENT LEVEL

TIME CONSUMING: 40%
SGS-35 SGS-26
SGS-23



REMOVE/REPLACE MOTOR GENERATOR/
ALTERNATOR COMPONENTS

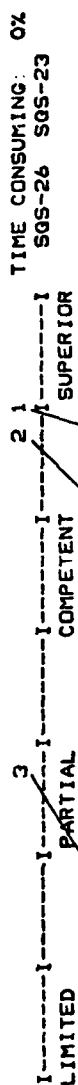
TIME CONSUMING: 33%
SGS-35 SGS-26
SGS-23



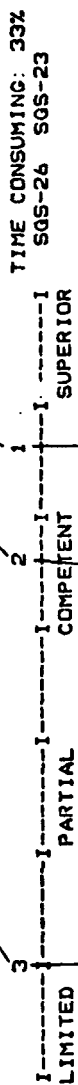
CALIBRATE/ALIGN/ADJUST MOTOR
GENERATOR/ALTERNATOR

ST: PHASE CHANGING NETWORK

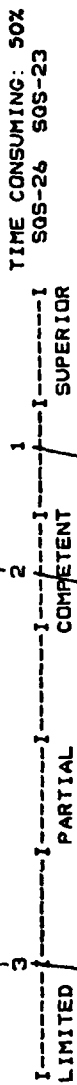
CLEAN PHASE CHANGING NETWORK



TEST/INSPECT PHASE CHANGING NETWORK



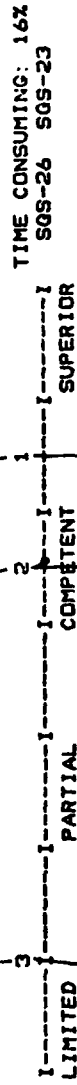
TEST/INSPECT PHASE CHANGING NETWORK



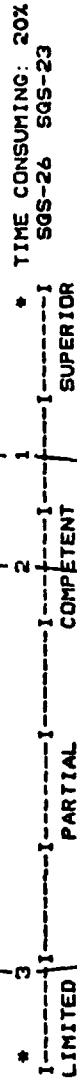
LOCALIZE/ISOLATE PHASE CHANGING NETWORK MALFUNCTION TO THE MODULE/CARD LEVEL



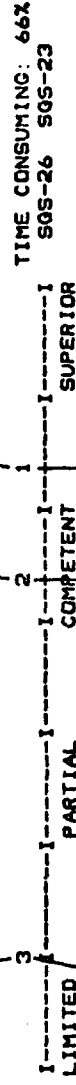
LOCALIZE/ISOLATE PHASE CHANGING NETWORK MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



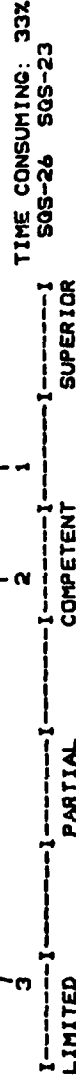
REMOVE/REPLACE PHASE CHANGING NETWORK MODULES/CARDS



REMOVE/REPLACE PHASE CHANGING NETWORK COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



CALIBRATE/ALIGN/ADJUST PHASE CHANGING NETWORK



ST: POWER SUPPLY ASSEMBLY

CLEAN/LUBRICATE POWER SUPPLY ASSEMBLY

TEST/INSPECT POWER SUPPLY ASSEMBLY

LOCALIZE/ISOLATE POWER SUPPLY ASSEMBLY

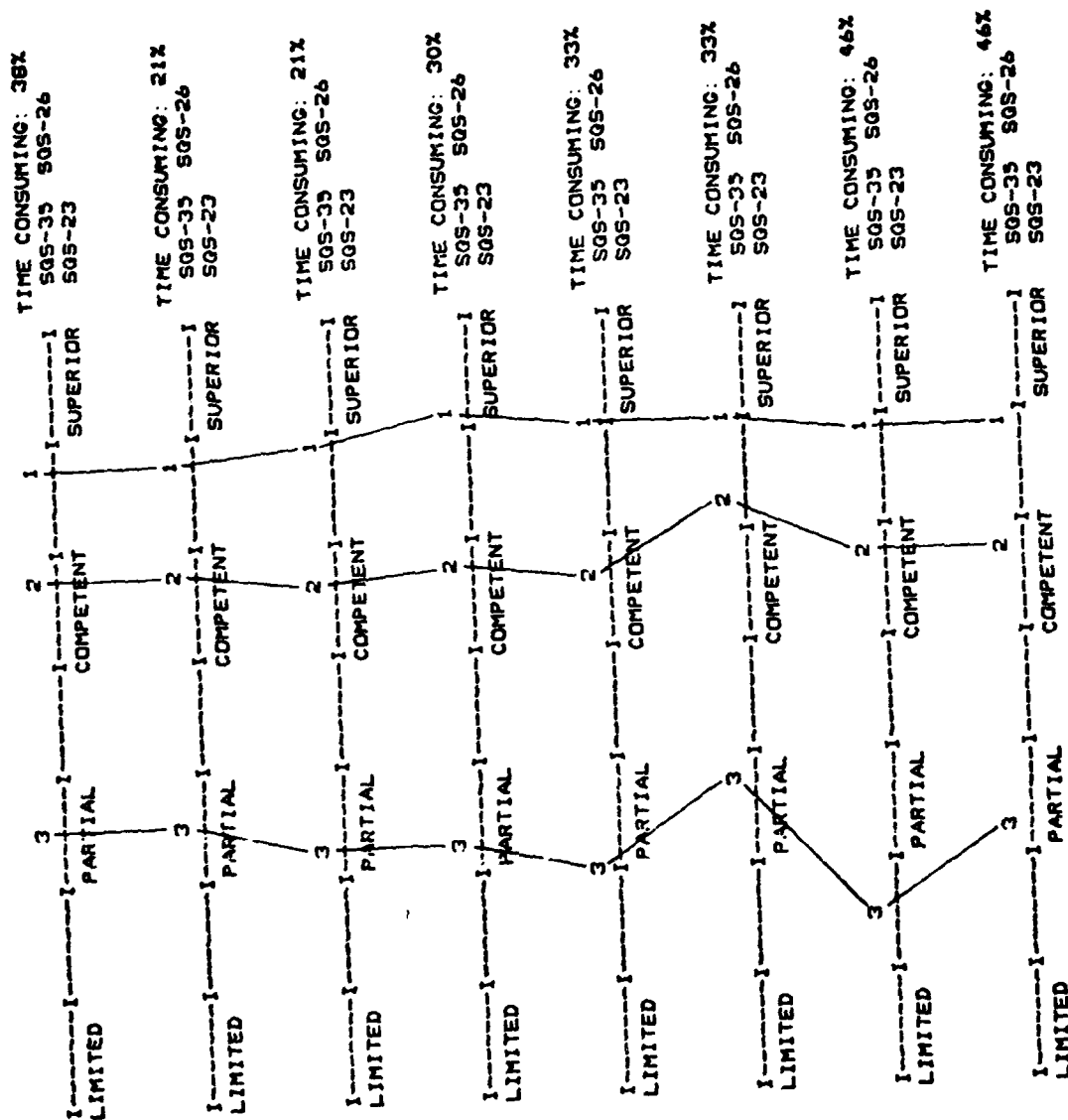
LOCALIZE/ISOLATE POWER SUPPLY ASSEMBLY
MALFUNCTION TO THE MODULE/CARD LEVEL

LOCALIZE/ISOLATE POWER SUPPLY ASSEMBLY
MALFUNCTION TO THE COMPONENT LEVEL,
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

REMOVE/REPLACE POWER SUPPLY ASSEMBLY
MODULES/CARDS

REMOVE/REPLACE POWER SUPPLY ASSEMBLY
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

CALIBRATE/ALIGN/ADJUST POWER
SUPPLY ASSEMBLY



ST: PRE-AMP AND BEAMFORMER

CLEAN PREAMP AND BEAMFORMER
 TIME CONSUMING: 23%
 1- LIMITED 3- PARTIAL 2- COMPETENT 1- SUPERIOR
 1- SOS-35 SOS-26
 1- SOS-23

TEST/INSPECT PREAMP AND BEAMFORMER
 TIME CONSUMING: 25%
 1- LIMITED 3- PARTIAL 2- COMPETENT 1- SUPERIOR
 1- SOS-35 SOS-26
 1- SOS-23

LOCALIZE/ISOLATE PREAMP AND BEAMFORMER
 MALFUNCTION TO THE MODULE/CARD LEVEL
 TIME CONSUMING: 23%
 1- LIMITED 3- PARTIAL 2- COMPETENT 1- SUPERIOR
 1- SOS-35 SOS-26
 1- SOS-23

LOCALIZE/ISOLATE PREAMP AND BEAMFORMER
 MALFUNCTION TO THE COMPONENT LEVEL,
 SUCH AS SWITCHES, RESISTORS, CAPACITORS,
 TRANSISTORS, ICS, ETC.
 TIME CONSUMING: 23%
 1- LIMITED 3- PARTIAL 2- COMPETENT 1- SUPERIOR
 1- SOS-35 SOS-26
 1- SOS-23

REMOVE/REPLACE PREAMP AND BEAMFORMER
 MODULES/CARDS
 TIME CONSUMING: 15%
 1- LIMITED 3- PARTIAL 2- COMPETENT 1- SUPERIOR
 1- SOS-35 SOS-26
 1- SOS-23

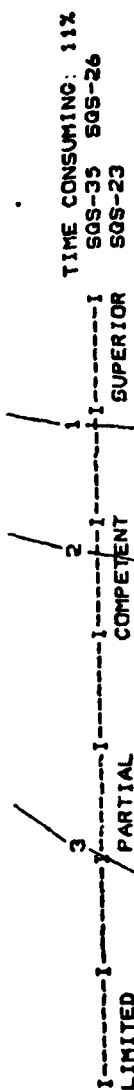
REMOVE/REPLACE PREAMP AND BEAMFORMER
 COMPONENTS, SUCH AS SWITCHES, RESISTORS,
 CAPACITORS, TRANSISTORS, ICS, ETC.
 TIME CONSUMING: 29%
 1- LIMITED 3- PARTIAL 2- COMPETENT 1- SUPERIOR
 1- SOS-35 SOS-26
 1- SOS-23

CALIBRATE/ALIGN/ADJUST PREAMP AND
 BEAMFORMER
 TIME CONSUMING: 29%
 1- LIMITED 3- PARTIAL 2- COMPETENT 1- SUPERIOR
 1- SOS-35 SOS-26
 1- SOS-23

ST: PULSE SWEEP GENERATOR

CLEAN PULSE SWEEP GENERATOR
 TIME CONSUMING: 12%
 1- LIMITED 3- PARTIAL 2- COMPETENT 1- SUPERIOR
 1- SOS-35 SOS-26
 1- SOS-23

TEST/INSPECT PULSE SWEEP GENERATOR



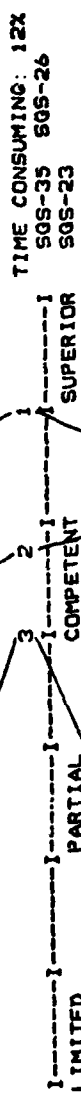
LOCALIZE/ISOLATE PULSE SWEEP GENERATOR
MALFUNCTION TO THE MODULE/CARD LEVEL



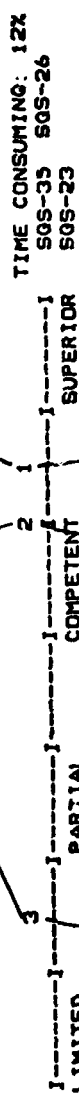
LOCALIZE/ISOLATE PULSE SWEEP GENERATOR
MALFUNCTION TO THE COMPONENT LEVEL,
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



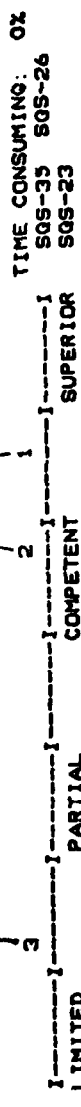
REMOVE/REPLACE PULSE SWEEP GENERATOR
MODULES/CARDS



REMOVE/REPLACE PULSE SWEEP GENERATOR
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

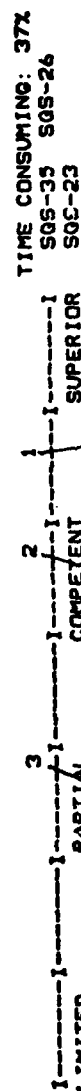


CALIBRATE/ALIGN/ADJUST PULSE SWEEP
GENERATOR

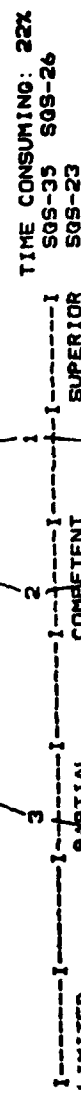


ST: RECEIVER-SCANNER

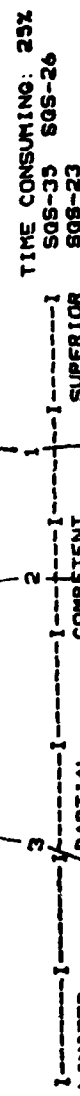
CLEAN SONAR RECEIVER-SCANNER



TEST/INSPECT SONAR RECEIVER-SCANNER

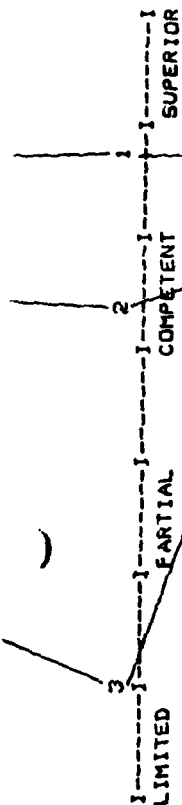


LOCALIZE/ISOLATE SONAR RECEIVER-SCANNER
MALFUNCTION TO THE MODULE/CARD LEVEL



LOCALIZE/ISOLATE SONAR RECEIVER-SCANNER
MALFUNCTION TO THE COMPONENT LEVEL, SUCH
AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

TIME CONSUMING: 23%
SGS-35 SGS-26
SGS-23



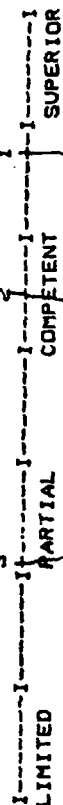
REMOVE/REPLACE SONAR RECEIVER/SCANNER
MODULES/CARDS

TIME CONSUMING: 15%
SGS-35 SGS-26
SGS-23



REMOVE/REPLACE SONAR RECEIVER-SCANNER
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

TIME CONSUMING: 29%
SGS-35 SGS-26
SGS-23



CALIBRATE/ALIGN/ADJUST SONAR RECEIVER-
SCANNER

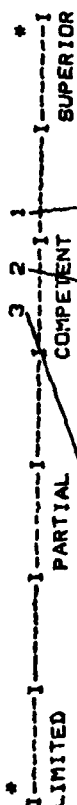
TIME CONSUMING: 44%
SGS-35 SGS-26
SGS-23



ST: SCAN SWITCH CONVERTER

CLEAN SCAN SWITCH CONVERTER

TIME CONSUMING: 20%
SGS-26 SGS-23



TEST/INSPECT SCAN SWITCH CONVERTER

TIME CONSUMING: 0%
SGS-26 SGS-23



LOCALIZE/ISOLATE SCAN SWITCH CONVERTER
MALFUNCTION TO THE MODULE/CARD LEVEL

TIME CONSUMING: 0%
SGS-26 SGS-23



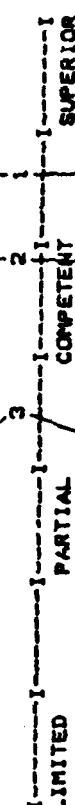
LOCALIZE/ISOLATE SCAN SWITCH CONVERTER
MALFUNCTION TO THE COMPONENT LEVEL, SUCH
AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

TIME CONSUMING: 0%
SGS-26 SGS-23



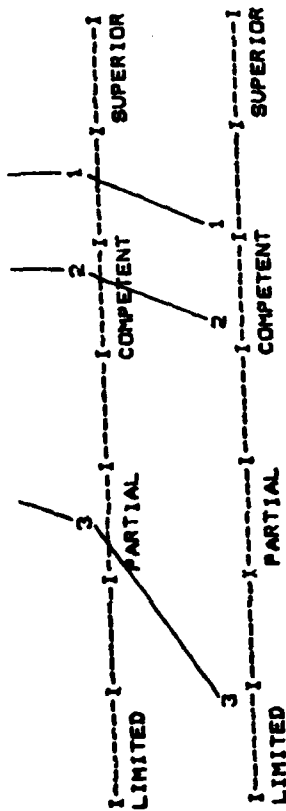
REMOVE/REPLACE SCAN SWITCH CONVERTER
MODULES/CARDS

TIME CONSUMING: 0%
SGS-26 SGS-23



REMOVE/REPLACE SCAN SWITCH CONVERTER
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

TIME CONSUMING: 14%
SQS-26 SQS-23



TIME CONSUMING: 28%
SQS-26 SQS-23



CALIBRATE/ALIGN/ADJUST SCAN SWITCH
CONVERTER

ST: SIGNAL DATA CONVERTER

CLEAN SIGNAL DATA CONVERTER

TIME CONSUMING: 12%
SQS-33 SQS-26
SQS-23



TEST/INSPECT SIGNAL DATA CONVERTER

TIME CONSUMING: 17%
SQS-35 SQS-26
SQS-23



LOCALIZE/ISOLATE SIGNAL DATA CONVERTER
MALFUNCTION TO THE MODULE/CARD LEVEL

TIME CONSUMING: 16%
SQS-35 SQS-26
SQS-23



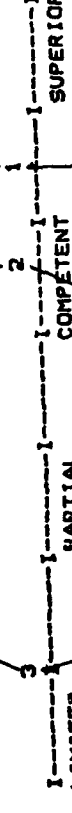
LOCALIZE/ISOLATE SIGNAL DATA CONVERTER
MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS
SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

TIME CONSUMING: 23%
SQS-35 SQS-26
SQS-23



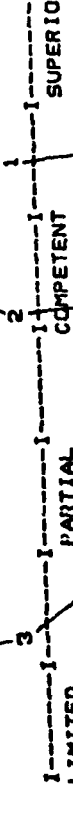
REMOVE/REPLACE SIGNAL DATA CONVERTER
MODULES/CARDS

TIME CONSUMING: 41%
SQS-26 SQS-23



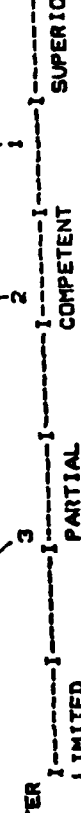
REMOVE/REPLACE SIGNAL DATA CONVERTER
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

TIME CONSUMING: 31%
SQS-35 SQS-26
SQS-23



CALIBRATE/ALIGN/ADJUST SIGNAL DATA CONVERTER

TIME CONSUMING: 29%
SQS-35 SQS-26
SQS-23



ST: SIGNAL PROCESSOR

CLEAN SONAR SIGNAL PROCESSOR



TEST/INSPECT SONAR SIGNAL PROCESSOR



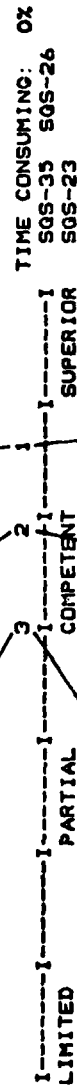
LOCALIZE/ISOLATE SONAR SIGNAL PROCESSOR
MALFUNCTION TO THE MODULE/CARD LEVEL



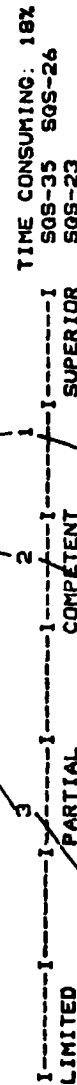
LOCALIZE/ISOLATE SONAR SIGNAL PROCESSOR
MALFUNCTION TO THE COMPONENT LEVEL, SUCH
AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



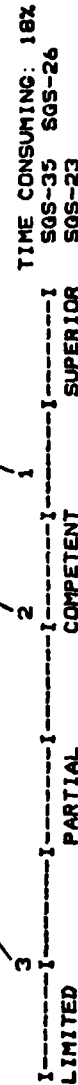
REMOVE/REPLACE SONAR SIGNAL
PROCESSOR MODULES/CARDS



REMOVE/REPLACE SONAR SIGNAL PROCESSOR
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

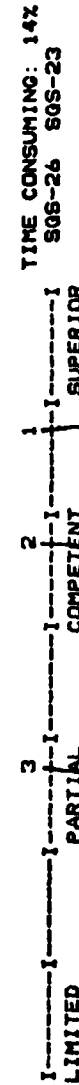


CALIBRATE/ALIGN/ADJUST SONAR SIGNAL
PROCESSOR



ST: TIMER SEQUENTIAL

CLEAN TIMER SEQUENTIAL



TEST/INSPECT TIMER SEQUENTIAL

TIME CONSUMING: 12X
SOS-26 SOS-23



LOCALIZE/ISOLATE TIMER SEQUENTIAL MALFUNCTION TO THE MODULE/CARD LEVEL

TIME CONSUMING: 12X
SOS-26 SOS-23



LOCALIZE/ISOLATE TIMER SEQUENTIAL MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

TIME CONSUMING: 12X
SOS-26 SOS-23



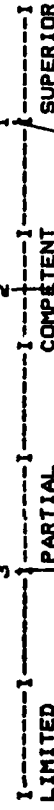
REMOVE/REPLACE TIMER SEQUENTIAL MODULES/CARDS

TIME CONSUMING: 12X
SOS-26 SOS-23



REMOVE/REPLACE TIMER SEQUENTIAL COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

TIME CONSUMING: 25X
SOS-26 SOS-23



CALIBRATE/ALIGN/ADJUST TIMER SEQUENTIAL

TIME CONSUMING: 37X
SOS-26 SOS-23



ST: TRANSMITTER

CLEAN SONAR TRANSMITTER

TIME CONSUMING: 17X
SOS-35 SOS-26
SOS-23



TEST/INSPECT SONAR TRANSMITTER

TIME CONSUMING: 11X
SOS-35 SOS-26
SOS-23

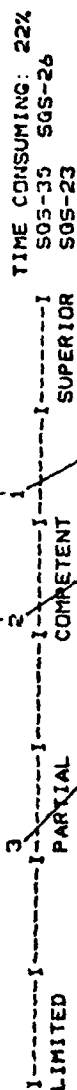


LOCALIZE/ISOLATE SONAR TRANSMITTER MALFUNCTION TO THE MODULE/CARD LEVEL

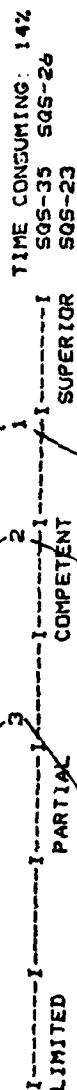
TIME CONSUMING: 20X
SOS-35 SOS-26
SOS-23



LOCALIZE/ISOLATE SONAR TRANSMITTER
MALFUNCTION TO THE COMPONENT LEVEL,
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



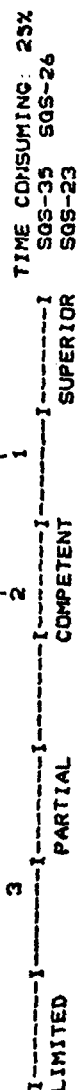
REMOVE/REPLACE SONAR TRANSMITTER
MODULES/CARDS



REMOVE/REPLACE SONAR TRANSMITTER
COMPONENTS, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.

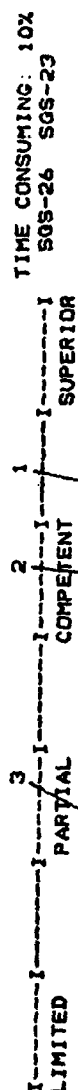


CALIBRATE/ALIGN/ADJUST SONAR TRANSMITTER

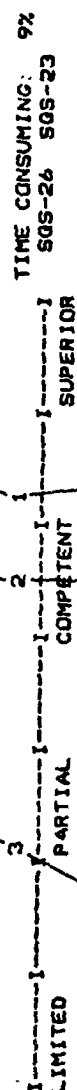


ST: TRANSMITTER CONTROL

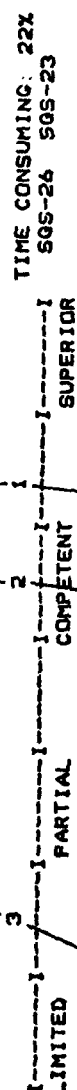
CLEAN TRANSMITTER CONTROL



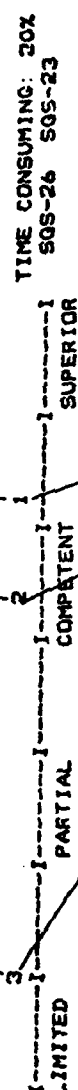
TEST/INSPECT TRANSMITTER CONTROL



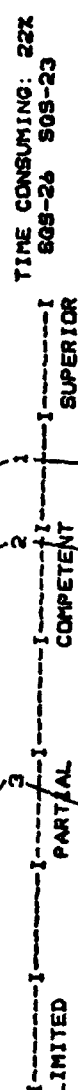
LOCALIZE/ISOLATE TRANSMITTER CONTROL
MALFUNCTION TO THE MODULE/CARD LEVEL



LOCALIZE/ISOLATE TRANSMITTER CONTROL
MALFUNCTION TO THE COMPONENT LEVEL,
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

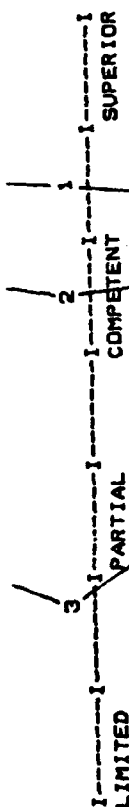


REMOVE/REPLACE TRANSMITTER CONTROL MODULES/
CARDS



REMOVE/REPLACE TRANSMITTER CONTROL
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

TIME CONSUMING: 27%
SOS-26 SOS-23



CALIBRATE/ALIGN/ADJUST TRANSMITTER CONTROL

TIME CONSUMING: 18%
SOS-26 SOS-23



ST: TRANSMITTER DRIVE CONTROL

CLEAN TRANSMITTER DRIVE CONTROL

TIME CONSUMING: 30%
SOS-26 SOS-23



TEST/INSPECT TRANSMITTER DRIVE CONTROL

TIME CONSUMING: 13%
SOS-26 SOS-23



LOCALIZE/ISOLATE TRANSMITTER DRIVE
CONTROL MALFUNCTION TO THE MODULE/
CARD LEVEL

TIME CONSUMING: 16%
SOS-26 SOS-23



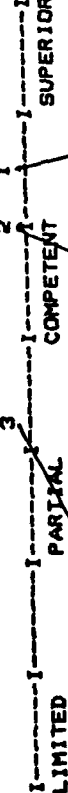
LOCALIZE/ISOLATE TRANSMITTER DRIVE CONTROL
MALFUNCTION TO THE COMPONENT LEVEL, SUCH
AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

TIME CONSUMING: 16%
SOS-26 SOS-23



REMOVE/REPLACE TRANSMITTER DRIVE
CONTROL MODULES/CARDS

TIME CONSUMING: 0%
SOS-26 SOS-23



REMOVE/REPLACE TRANSMITTER DRIVE CONTROL
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

TIME CONSUMING: 30%
SOS-26 SOS-23



CALIBRATE/ALIGN/ADJUST TRANSMITTER DRIVE
CONTROL

TIME CONSUMING: 30%
SOS-26 SOS-23



ST: TRANSMITTER-RECEIVER SWITCH

CLEAN TRANSMITTER-RECEIVER SWITCH



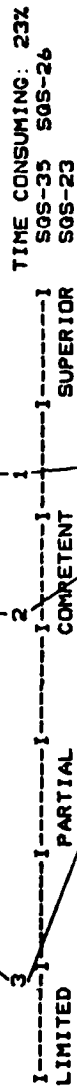
TEST/INSPECT TRANSMITTER-RECEIVER SWITCH



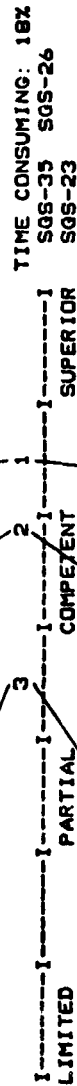
LOCALIZE/ISOLATE TRANSMITTER-RECEIVER SWITCH MALFUNCTION TO THE MODULE/CARD LEVEL



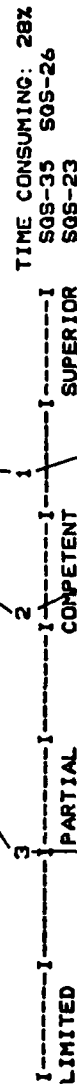
LOCALIZE/ISOLATE TRANSMITTER-RECEIVER SWITCH MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



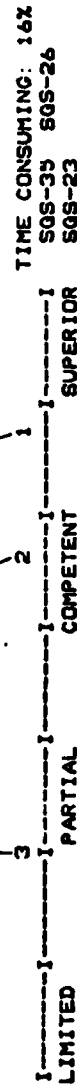
REMOVE/REPLACE TRANSMITTER-RECEIVER SWITCH MODULES/CARDS



REMOVE/REPLACE TRANSMITTER-RECEIVER SWITCH COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



CALIBRATE/ALIGN/ADJUST TRANSMITTER-RECEIVER SWITCH



SECTION 7
DIFFICULT AND TIME-CONSUMING TASKS

ADDRESSING QUESTION 7

What skill levels and number of operator and maintenance personnel are required to perform these tasks?

As shown in Figure 16, both Sections 6 and 7 of this guide need to be used in making estimates of the number and skill levels of required

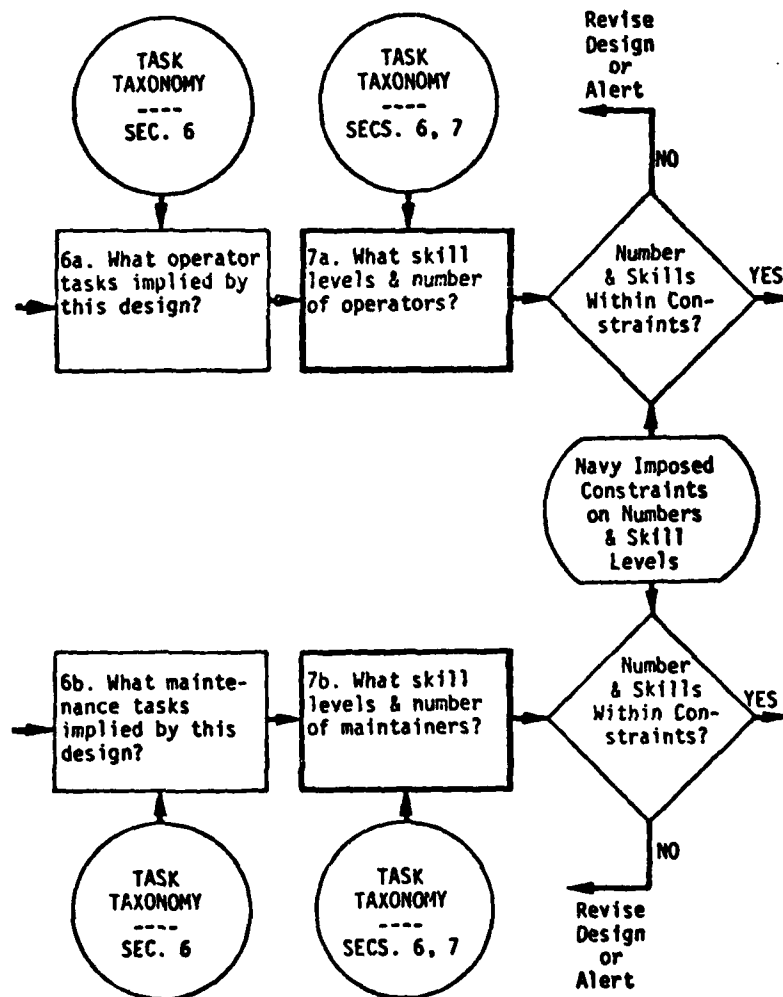


Figure 16. Addressing Question 7.

operator and maintainer personnel. However, the data in this guide can only partially answer Question 7. In addition to the task difficulty information provided here, information on the number of operator workstations to be manned for various watch conditions, operator task composition at each watch station, frequency and duration of maintenance tasks, and the difficulty level of new tasks (i.e., those not listed in Sections 6 and 7) must be employed. Most of this additional information will be specific to each new design, and can be estimated only by the system developer. The system developer can be aided in doing this, and in answering Question 7, by comparing the new design in detail to existing operational systems and their manning requirements. Unfortunately, total support of these steps is beyond the present scope of this guide.

However, regardless of the absolute numbers and skill levels required, it is clear that reducing the number of skill and manpower-intensive tasks should be a primary design objective. Even where the total effect of such reductions is not sufficient to decrease the required number or level of personnel, the effect will be to decrease task loading per man, thus benefiting operators and/or maintenance. The matter of difficult and time-consuming tasks can be addressed using data in this section. It provides selected data from the taxonomies presented in Section 6, on tasks that historically have proved most difficult and time consuming for Navy technical personnel to perform.

THE FOCUS IS ON DIFFICULT TASKS

The most difficult tasks performed by each rating are skill-intensive and should be considered primary candidates for redesign or elimination.

To the extent that the designer can eliminate or simplify the more difficult operator and maintainer tasks, he should obviously do so in the interest of greater utilization of less skilled personnel and reduced training costs. To make it convenient to identify these tasks, a listing

of the 36 tasks considered most difficult for each rating to perform is presented on the following pages.

In many cases it will be seen that even second enlistment personnel (2nd class petty officers) are less than fully proficient at these tasks. For example, for DS personnel (see page 7-9) maintenance tasks associated with malfunctions in the chilled water system are likely to be competently performed only by 1st class (or higher) petty officer personnel. Therefore, anything the designer can do to simplify or eliminate these types of tasks in the new system would have a beneficial impact on required skill level and training.

TIME-CONSUMING TASKS ARE ALSO OF CONCERN

The most time-consuming tasks are manpower-intensive and should also be considered primary candidates for redesign or elimination.

Following the difficult-task listing, a second group of tasks is listed that are considered to be particularly time consuming. There were substantial differences among the ratings in the number of tasks considered time consuming, and those differences are reflected in the different lengths of this second list.

A time-consuming task need not be particularly difficult to perform although it may be. For example, the task of calibrating and aligning display consoles is one of the most time-consuming tasks for DS personnel (page 7-13) but even 3rd class petty officers are considered "partially" proficient at this task.

In any case, whatever the designer can do to eliminate or simplify the most time-consuming tasks will be of obvious benefit in terms of manpower requirements.

USING THE DIFFICULT- AND TIME-CONSUMING-TASK DATA

How are the data on difficult and time-consuming tasks to be used in the design process?

There are two potential uses of these two listings of tasks. One is to focus the designer's attention on tasks that are particularly demanding of high skill levels and man-hours as primary candidates for simplification or elimination. The second is to provide a means for comparative analysis of two or more designs under consideration with respect to the number of difficult and time-consuming tasks generated by each.

COMPARATIVE ANALYSIS

How can a comparative analysis be done?

One simple approach to a comparative analysis is to complete a table of the type presented on page 7-5 (Table 3). This table is designed for any analysis of difficult tasks. Using the data in this section, the analyst first lists all tasks pertaining to any of his design options that appear in the list of difficult tasks. He then reviews each design alternative to determine if each of these tasks:

- Exists essentially unchanged from previous systems of this type.
- Exists, but has been made easier to perform.
- Has been eliminated (i.e., no longer requires human action).

Each task falling in the first category is assigned a weight of -1 and this value is entered into the table in the appropriate cell; similarly, each task in the second category is assigned +1; and each in the third category is assigned +3. (These values are admittedly arbitrary; other weighting schemes may be devised if desired.)

TABLE 3
DIFFICULT TASK ANALYSIS

TASK DESCRIPTION	SYSTEM A			SYSTEM B		
	UNCH* -1	EZ* +1	ELIM* +3	UNCH* -1	EZ* +1	ELIM* +3
1. _____						
2. _____						
3. _____						
4. _____						
5. _____						
6. _____						
7. _____						
8. _____						
9. _____						
10. _____						
11. _____						
12. _____						
13. _____						
14. _____						
15. _____						
16. _____						
17. _____						
18. _____						
19. _____						
20. _____						
21. _____						
22. _____						
23. _____						
24. _____						
25. _____						
26. _____						
27. _____						
28. _____						
29. _____						
30. _____						
31. _____						
32. _____						
33. _____						
34. _____						
35. _____						
36. _____						
Σ	a	b	c	a	b	c

Difficult Task Index $[\Sigma(a+b+c)] =$

*UNCH - Task essentially unchanged from taxonomy or other baseline equipment.

EZ - Task made easier to perform; simplified.

ELIM - Task no longer requires human involvement.

COMPUTING A DIFFICULT TASK INDEX

The result of this analysis is a "Difficult Task" index which serves as a basis for comparing all designs under consideration.

The algebraic sum of each column of Table 3 is next computed and entered into the boxes labeled a, b, and c. These sums are in turn summed into a "Difficult Task" index for each system. That system with the most positive score is preferred.

If the scores are substantially different, the design with the highest score is clearly less dependent on scarce, highly experienced personnel. Even if senior personnel remain essential for certain tasks, designs receiving a comparatively high score will make possible more complete use of lower level personnel for performing many operator and maintainer functions.

COMPUTING A TIME-CONSUMING INDEX

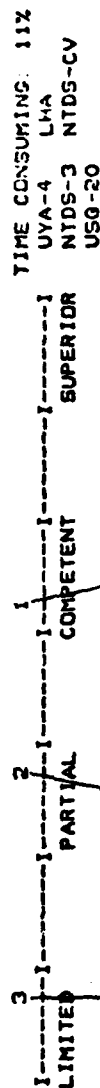
A "Time-Consuming" index can be developed using a similar procedure.

The model provided in Table 3 can also be used to perform a comparative analysis of two or more system designs with respect to the list of time-consuming tasks. Essentially, the procedure is the same as that described for the difficult-task list. If the analyst has actual data available on the time required for performing these tasks, he might find it desirable to weight each task by a factor based on those times prior to summing the scores for each design alternative.

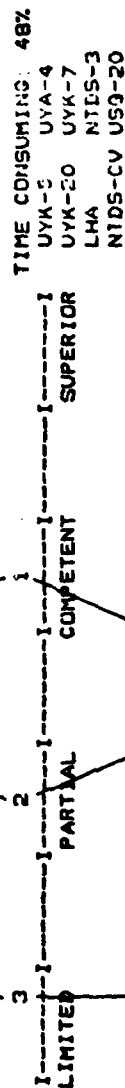
DIFFICULT AND TIME-CONSUMING TASKS
DS

DIFFICULT DS TASKS

LOCALIZE/ISOLATE COOLING CHILLED WATER
SYSTEM MALFUNCTION TO THE PART LEVEL



DEBUG PROGRAMS (MAINTENANCE,
OPERATIONAL)



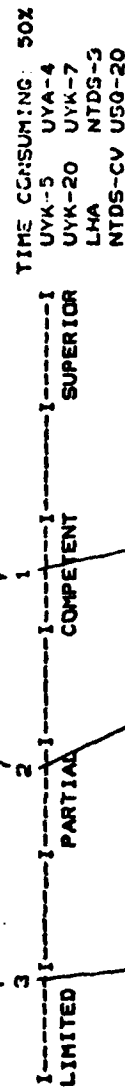
REMOVE/REPLACE COOLING CHILLED WATER
SYSTEM PARTS



CALIBRATE/ALIGN/ADJUST COOLING CHILLED WATER
SYSTEM



WRITE/REWRITE PROGRAMS (MAINTENANCE,
OPERATIONAL)



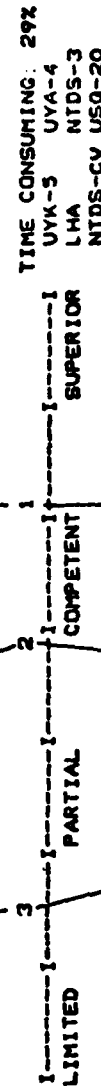
LOCALIZE/ISOLATE COOLING CHILLED WATER
SYSTEM MALFUNCTION TO A UNIT



TEST NEW PROGRAMS (MAINTENANCE,
OPERATIONAL)



CALIBRATE/ALIGN/ADJUST TELETYPE



LOCALIZE/ISOLATE DISK FILE MALFUNCTION TO
THE COMPONENT LEVEL, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.

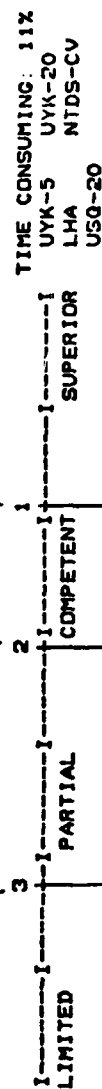


DIFFICULT DS TASKS

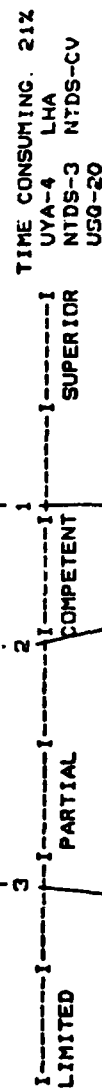
CALIBRATE/ALIGN/ADJUST A TO D AND D TO A CONVERTERS



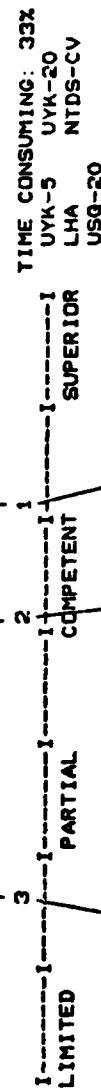
LOCALIZE/ISOLATE DISK FILE MALFUNCTION TO THE MODULE/CARD LEVEL



TEST/INSPECT COOLING CHILLED WATER SYSTEM



CALIBRATE/ALIGN/ADJUST DISK FILE



CALIBRATE/ALIGN/ADJUST CARD PUNCH



LOCALIZE/ISOLATE A TO D AND D TO A CONVERTERS MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



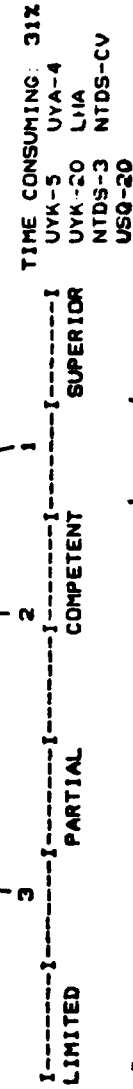
CLEAN COOLING CHILLED WATER SYSTEM



MAKE AUTHORIZED CHANGES TO PROGRAMS



ALIGN/ADJUST MECHANICAL LINKAGES AND GEAR TRAINS



REMOVE/REPLACE DISK FILE COMPONENTS,
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

REMOVE/REPLACE PAPER TAPE PUNCH COMPONENTS,
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

REMOVE/REPLACE A TO D AND D TO A CONVERTERS
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.

LOCALIZE/ISOLATE CARD READER MALFUNCTION
TO THE COMPONENT LEVEL, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.

CLEAN/LUBRICATE DISK FILE

INITIATE COMMUNICATIONS LINKS SUCH
AS LINK 11, LINK 4A, LINK 14

TEST/INSPECT DISK FILE

CALIBRATE/ALIGN/ADJUST PULSE
AMPLIFIER-SYMBOL GENERATOR

LOCALIZE/ISOLATE DATA TERMINAL SET
MALFUNCTION TO THE COMPONENT LEVEL,
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

TIME CONSUMING	11Z	UYK-5	UYK-20	LHA	NTDS-CV	USQ-20
TIME CONSUMING	19Z	UYA-4	UYA-7	LHA	NTDS-3	NTDS-CV
TIME CONSUMING	15Z	UYA-4	UYA-20	UYA-7	LHA	NTDS-3
TIME CONSUMING	23Z	UYA-5	UYK-20	LHA	NTDS-CV	USQ-20
TIME CONSUMING	11Z	UYK-5	UYK-20	LHA	NTDS-CV	USQ-20
TIME CONSUMING	0Z	UYA-4	UYK-7	LHA	NTDS-3	NTDS-CV
TIME CONSUMING	11Z	UYK-5	UYK-20	LHA	NTDS-CV	USQ-20
TIME CONSUMING	41Z	UYA-4	LHA	NTDS-3	NTDS-CV	
TIME CONSUMING	0Z	UYA-4	UYK-7	LHA	NTDS-3	NTDS-CV

DIFFICULT DB TASKS

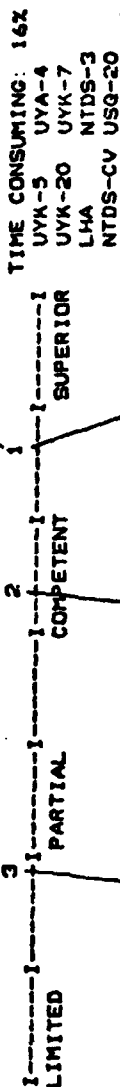
CALIBRATE/ALIGN/ADJUST DATA TERMINAL SET



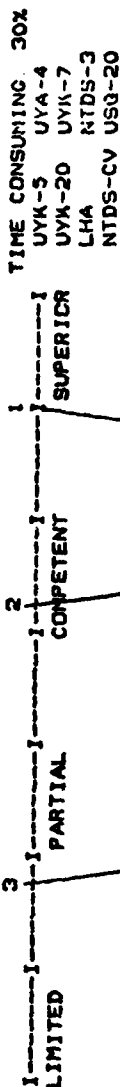
REMOVE/REPLACE VIDEO SIMULATOR COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



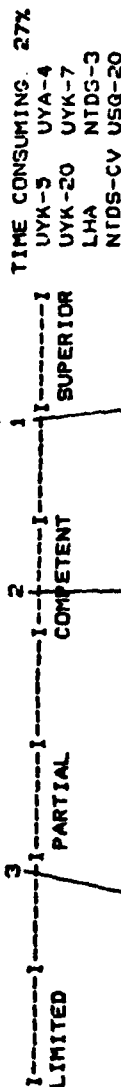
CALIBRATE/ALIGN/ADJUST PAPER TAPE READER



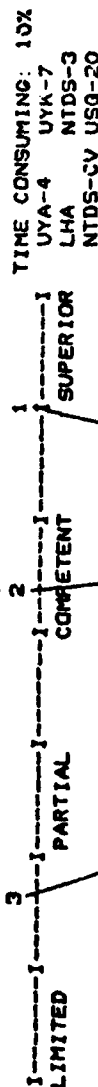
CALIBRATE/ALIGN/ADJUST PAPER TAPE PUNCH



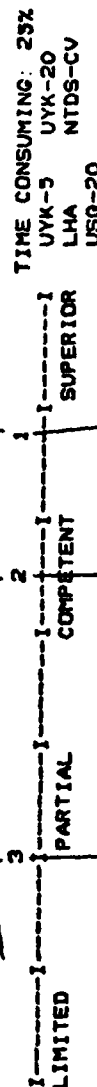
LOCALIZE/ISOLATE DIGITAL COMPUTER ELECTRONICS MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



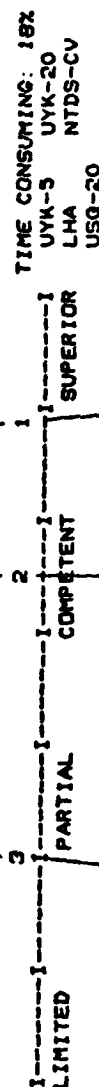
LOCALIZE/ISOLATE A TO D AND D TO A CONVERTERS MALFUNCTION TO THE MODULE/CARD LEVEL



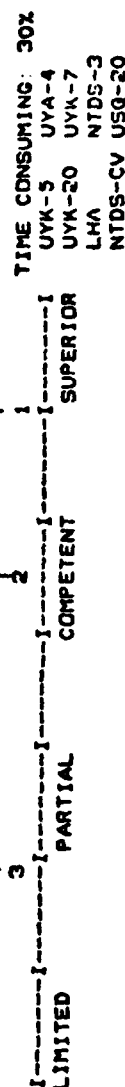
LOCALIZE/ISOLATE CARD PUNCH MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



LOCALIZE/ISOLATE CARD READER MALFUNCTION TO THE MODULE/CARD LEVEL



LOCALIZE/ISOLATE MAGNETIC TAPE CONTROLLER MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



TIME CONSUMING DE TASKS

CALIBRATE/ALIGN/ADJUST DISPLAY CONSOLE

WRITE/REWRITE PROGRAMS (MAINTENANCE, OPERATIONAL)

DEBUG PROGRAMS (MAINTENANCE, OPERATIONAL)

CALIBRATE/ALIGN/ADJUST CARD READER

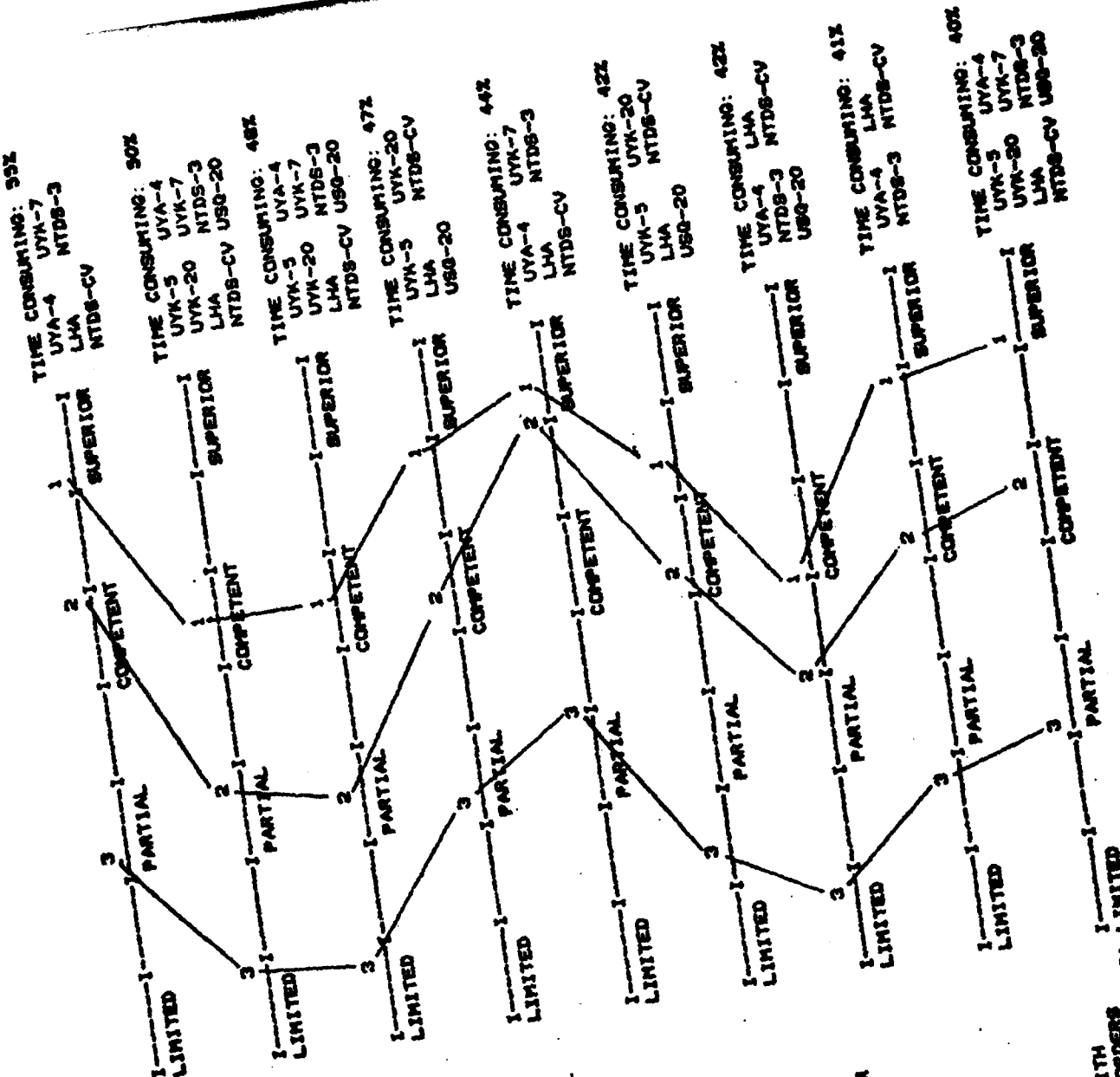
CLEAN DISPLAY CONSOLE

CALIBRATE/ALIGN/ADJUST CARD PUNCH

REMOVE/REPLACE COOLING CHILLED WATER SYSTEM PARTS

CALIBRATE/ALIGN/ADJUST PULSE AMPLIFIER-SYMBOL GENERATOR

MODIFY EQUIPMENT IN ACCORDANCE WITH SHIPALTS, ORDALTS, FIELD CHANGE ORDERS AND ELECTRONIC INFORMATION BULLETINS (EIBS) LIMITED

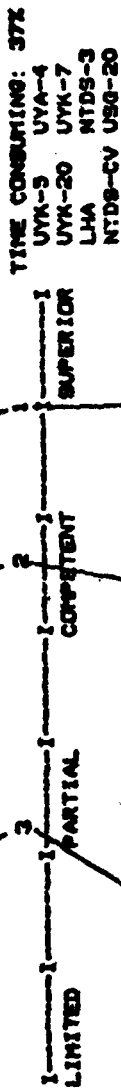


TIME CONSUMING DO TASKS

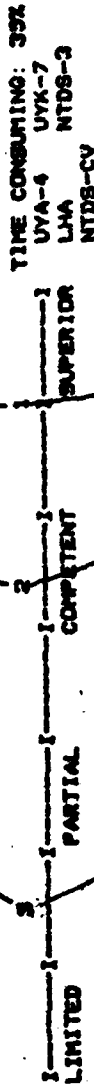
CLEAN COOLING CHILLED WATER SYSTEM



ASSEMBLE/REPAIR CABLES AND TEST LEADS,
SUCH AS CONNECTORS, PROBES, ETC.



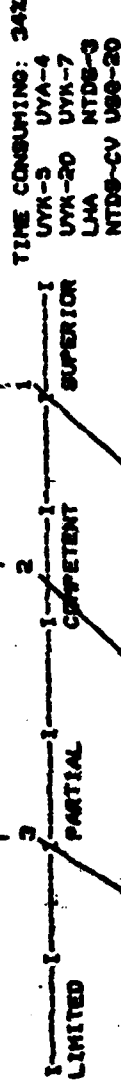
CALIBRATE/ALIGN/ADJUST DATA TERMINAL SET



REMOVE/REPLACE DIGITAL COMPUTER
ELECTRONICS COMPONENTS, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICs, ETC.



CALIBRATE/ALIGN/ADJUST MAGNETIC TAPE
TRANSPORT



TEST NEW PROGRAMS (MAINTENANCE,
OPERATIONAL)



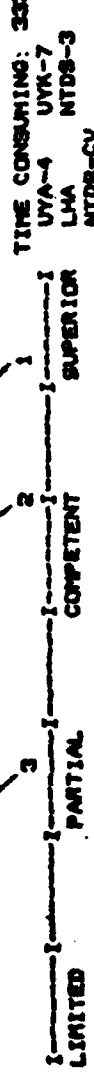
CALIBRATE/ALIGN/ADJUST DIGITAL
COMPUTER ELECTRONICS



CALIBRATE/ALIGN/ADJUST DISK FILE



TEST/INSPECT DISPLAY CONSOLE



DIFFICULT AND TIME-CONSUMING TASKS
ET(N) & ET(R)

DIFFICULT ET TASKS

LOCALIZE/ISOLATE IF MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

CALIBRATE/ALIGN/ADJUST SYNCHRO/SERVO AMPLIFIERS

CALIBRATE/ALIGN/ADJUST IF

LOCALIZE/ISOLATE MIXERS (FREQ TRANSLATION) MALFUNCTION TO A UNIT

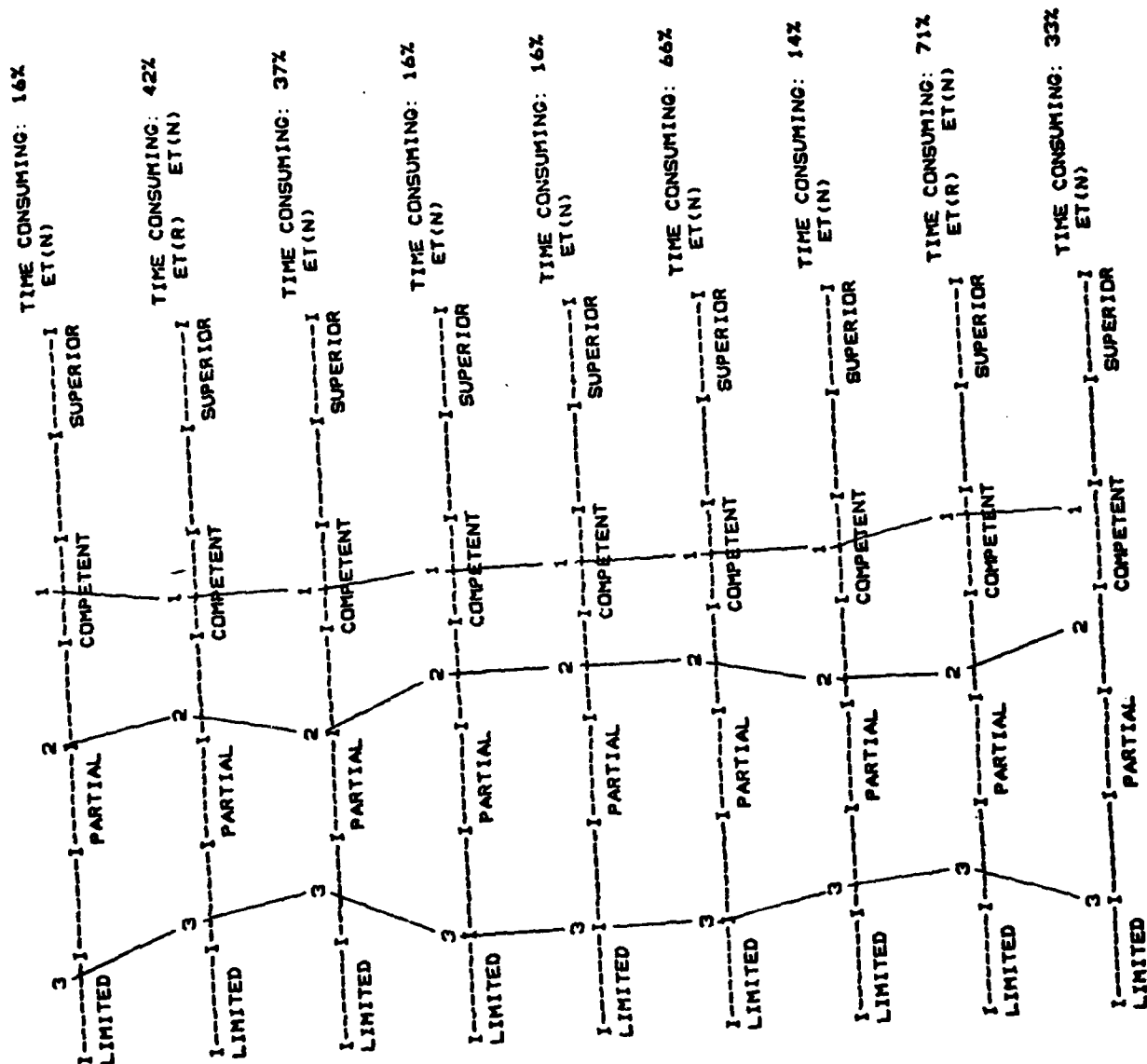
LOCALIZE/ISOLATE MIXERS (FREQ TRANSLATION) MALFUNCTION TO THE MODULE/CARD LEVEL

CALIBRATE/ALIGN/ADJUST MIXERS (FREQ TRANSLATION)

LOCALIZE/ISOLATE IF MALFUNCTION TO THE MODULE/CARD LEVEL

ALIGN/ADJUST MECHANICAL LINKAGES AND GEAR TRAINS

REMOVE/REPLACE IF COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



DIFFICULT ET TASKS

LOCALIZE/ISOLATE TEST EQUIPMENT
MALFUNCTION TO THE COMPONENT LEVEL,
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

LOCALIZE/ISOLATE COMMUNICATION
ANTENNA SYSTEMS MALFUNCTION TO
THE COMPONENT LEVEL

LOCALIZE/ISOLATE TEST EQUIPMENT
MALFUNCTION TO THE MODULE/CARD
LEVEL

LOCALIZE/ISOLATE MOTOR/GENERATORS

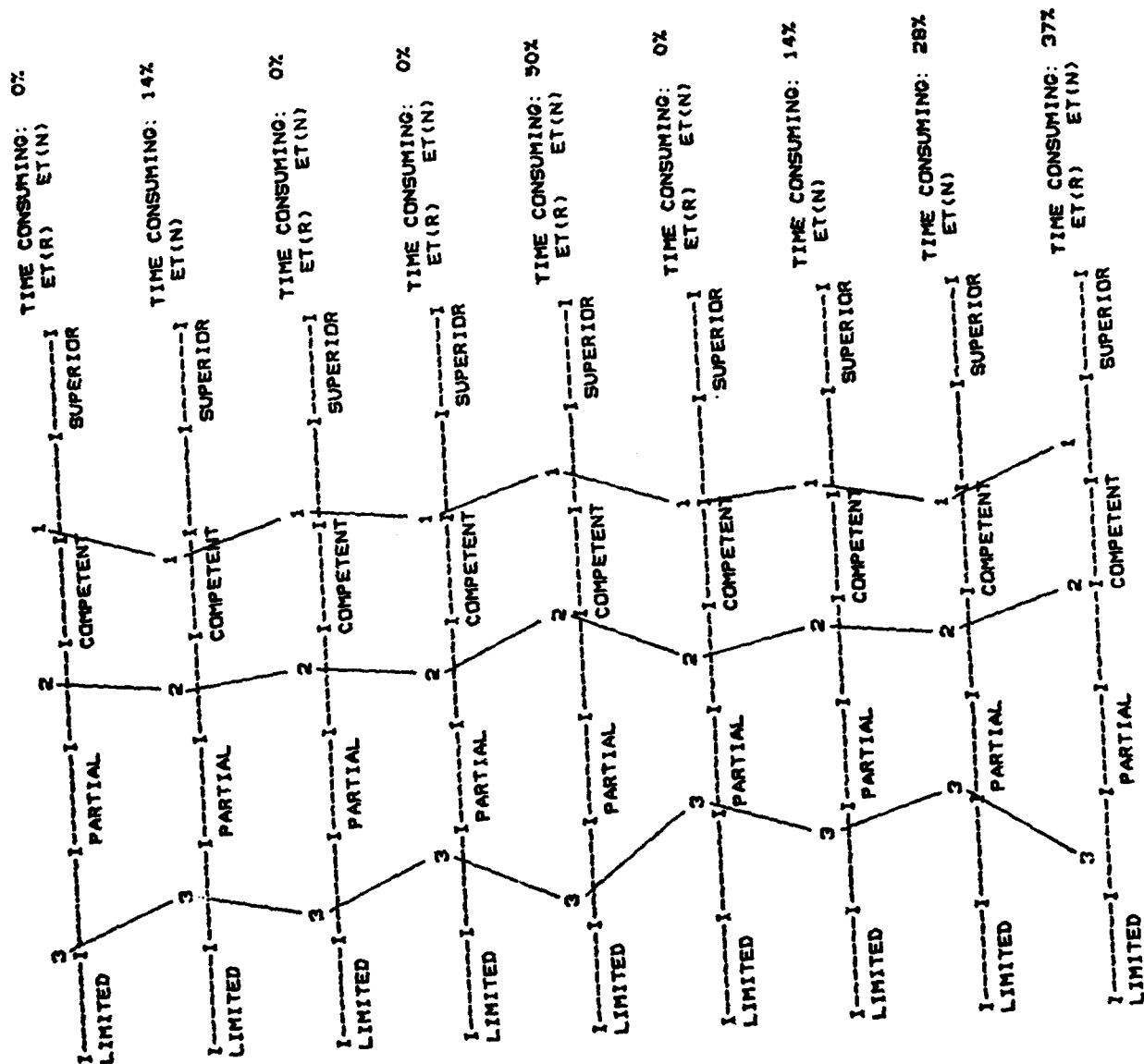
CALIBRATE/ALIGN/ADJUST TEST
EQUIPMENT

TEST/INSPECT MOTOR/GENERATORS

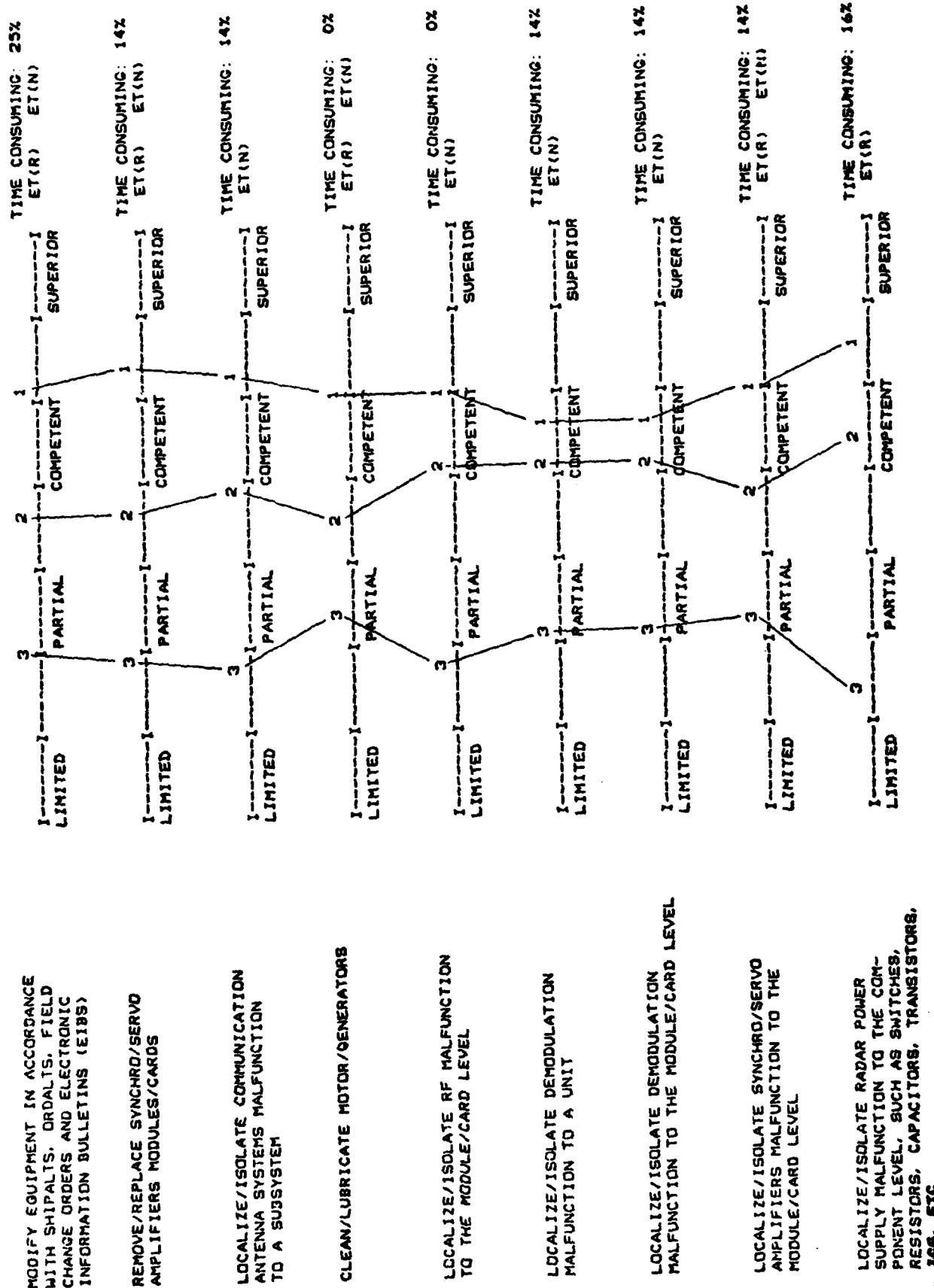
LOCALIZE/ISOLATE COMMUNICATION
ANTENNA SYSTEMS MALFUNCTION TO
A UNIT

CALIBRATE/ALIGN/ADJUST RF

LOCALIZE/ISOLATE ELECTRONIC
EQUIPMENT COOLING SYSTEM MAL-
FUNCTION TO THE FAILED PART

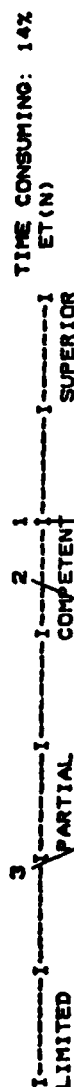


DIFFICULT ET TASKS

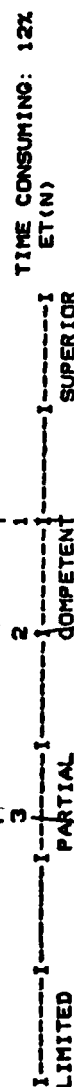


DIFFICULT ET TASKS

CALIBRATE/ALIGN/ADJUST MODULATION



LOCALIZE/ISOLATE IF MALFUNCTION TO A UNIT



LOCALIZE/ISOLATE RF MALFUNCTION TO A UNIT



LOCALIZE/ISOLATE EQUIPMENT MALFUNCTION TO A UNIT



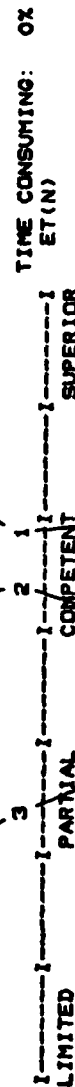
CALIBRATE/ALIGN/ADJUST DEMODULATION



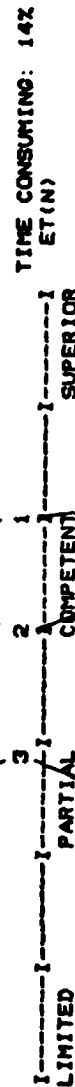
TEST/INSPECT ELECTRONIC EQUIPMENT COOLING SYSTEM



LOCALIZE/ISOLATE MODULATION MALFUNCTION TO THE MODULE/CARD LEVEL



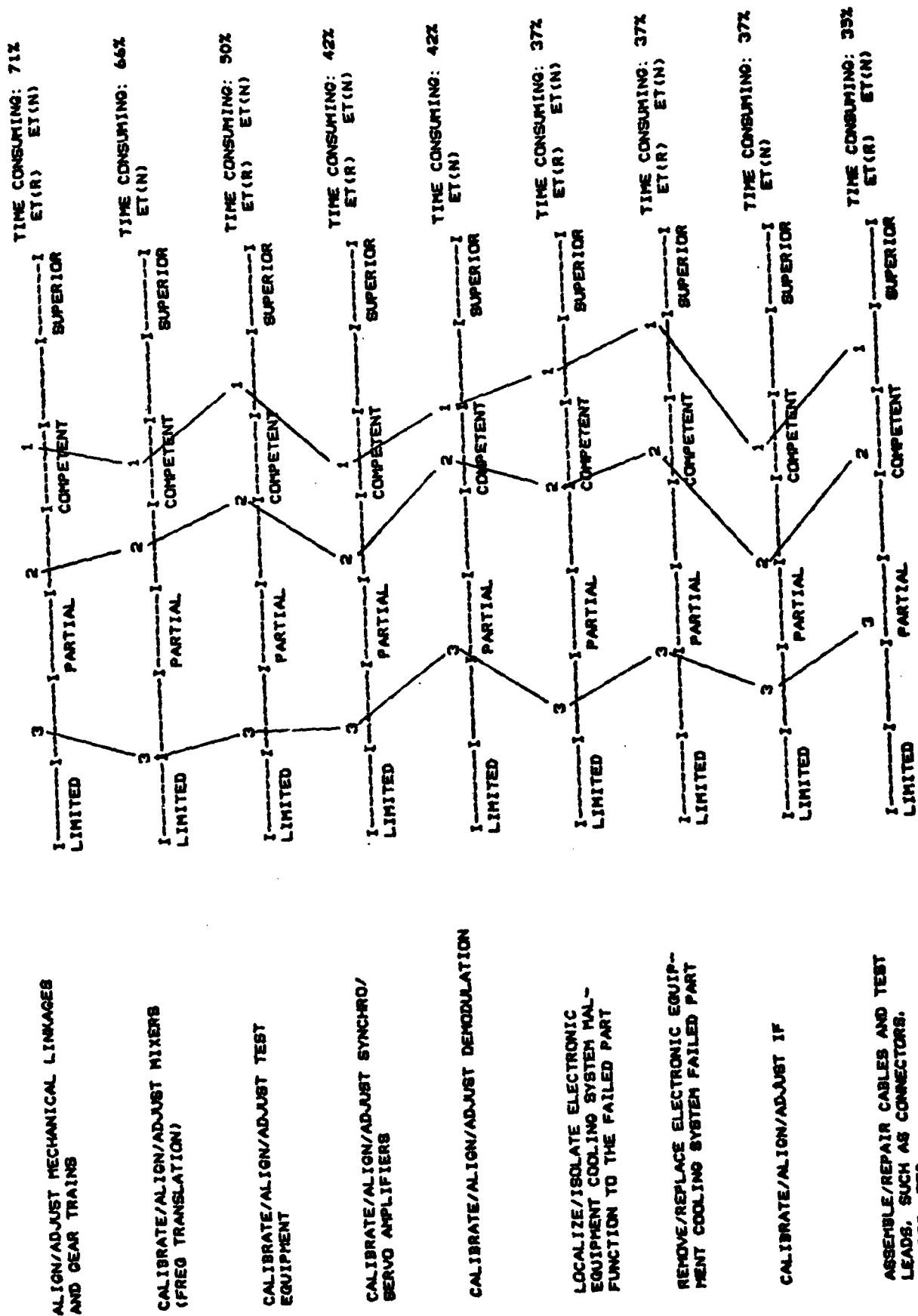
CLEAN/LUBRICATE COMMUNICATION ANTENNA SYSTEMS



LOCALIZE/ISOLATE AUDIO MALFUNCTION TO THE MODULE/CARD LEVEL



TIME CONSUMING ET TASKS



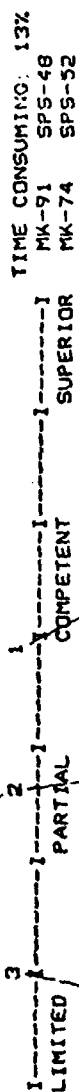
DIFFICULT AND TIME-CONSUMING TASKS
FT(M)

DIFFICULT FT TASKS

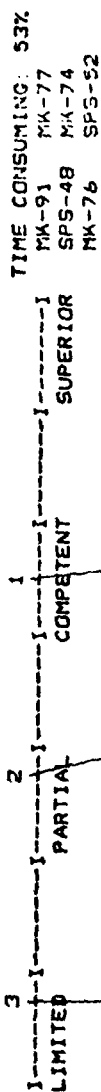
MAKE ALIGNMENT CORRECTIONS TO OWN
MOUNTS/MISSILE LAUNCHERS



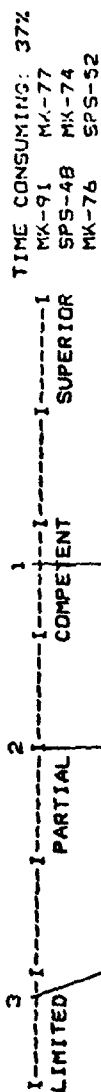
INITIATE ELECTRONIC COUNTER
COUNTERMEASURES (ECCH) ACTION
FROM AURAL ANALYSIS



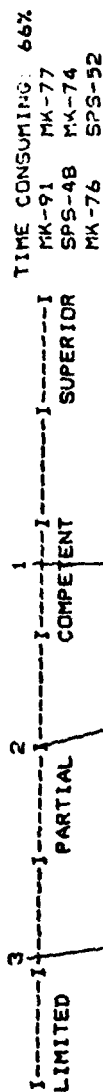
DETERMINE BATTERY ALIGNMENT ERROR



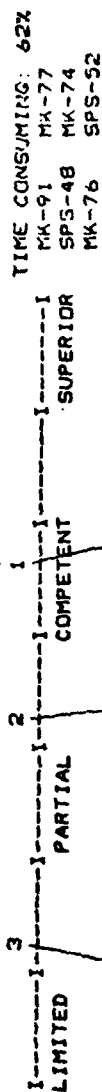
ANALYZE/ANNOTATE SYSTEMS
TEST DATA



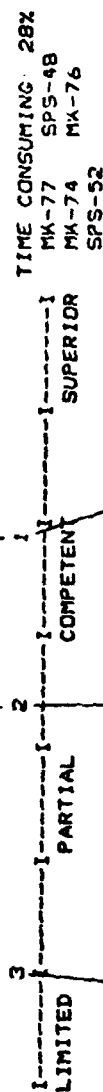
CHECK BATTERY ALIGNMENT (BORESIGHT)



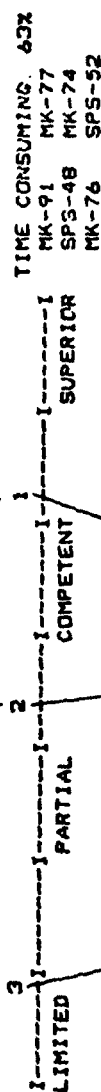
ALIGN/ADJUST MECHANICAL LINKAGES
AND GEAR TRAINS



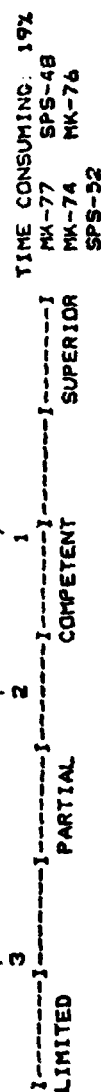
LOCALIZE/ISOLATE TARGET DESIGNA-
TION EQUIPMENT MALFUNCTION TO THE
COMPONENT LEVEL, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.



COORDINATE WEAPON SYSTEMS TESTS



LOCALIZE/ISOLATE TARGET DESIGNA-
TION EQUIPMENT MALFUNCTION TO
THE MODULE/CARD LEVEL

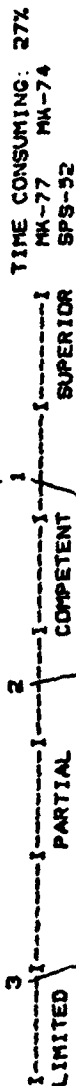


DIFFICULT FT TASKS

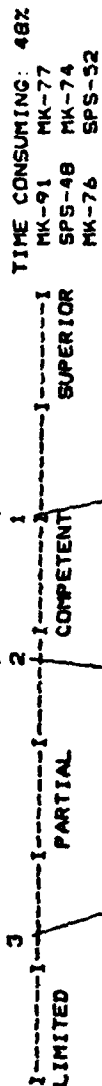
CALIBRATE/ALIGN/ADJUST TARGET DESIGNATION EQUIPMENT



LOCALIZE/ISOLATE STABLE ELEMENTS/ STABLE VERTICALS MALFUNCTION TO THE COMPONENT LEVEL



LOCALIZE/ISOLATE RADAR RANGING UNITS MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



LOCALIZE/ISOLATE TARGET DESIGNATION EQUIPMENT MALFUNCTION TO A UNIT



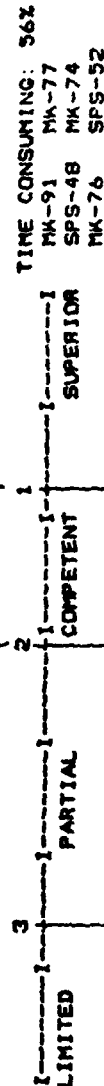
REMOVE/REPLACE STABLE ELEMENTS/ STABLE VERTICAL COMPONENTS



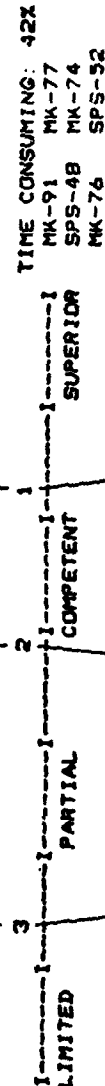
CALIBRATE/ALIGN/ADJUST RADAR RANGING UNITS



REMOVE/REPLACE RADAR ANTENNAS/ DRIVE SYSTEMS COMPONENTS



LOCALIZE/ISOLATE RADAR VIDEO PROCESSING UNIT MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

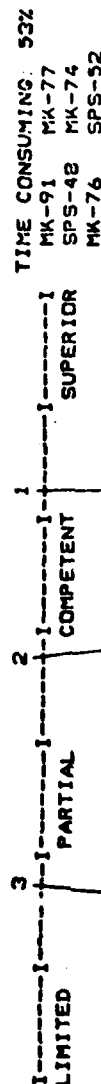


LOCALIZE/ISOLATE RADAR SIGNAL PROCESSING EQUIPMENT MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

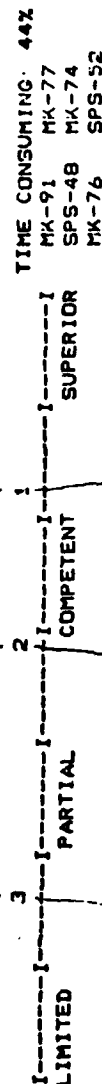


DIFFICULT FT TASKS

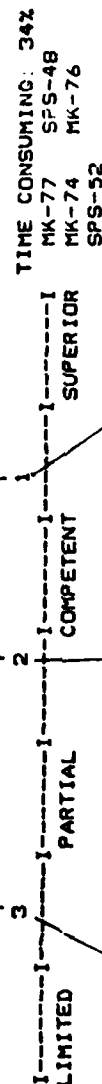
LOCALIZE/ISOLATE FIRE CONTROL DIRECTORS MALFUNCTION TO THE COMPONENT



LOCALIZE/ISOLATE RADAR RANGING UNITS MALFUNCTION TO THE MODULE/CARD LEVEL



CHANGE SYSTEM CONFIGURATION BY PATCHING OR BY SWITCHBOARD CHANGES



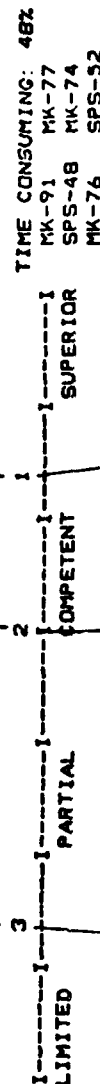
CONDUCT HORIZON CHECKS



LOCALIZE/ISOLATE RADAR VIDEO INDICATING DISPLAY MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



MODIFY EQUIPMENT IN ACCORDANCE WITH SHIPALTS, ORDALTS, FIELD CHANGE ORDERS AND ELECTRONIC INFORMATION BULLETINS (EIBS)



LOCALIZE/ISOLATE RADAR TRACKING UNIT MALFUNCTION TO THE MODULE/CARD LEVEL



LOCALIZE/ISOLATE RADAR SIGNAL PROCESSING EQUIPMENT MALFUNCTION TO THE MODULE/CARD LEVEL



CONDUCT COMBAT SYSTEMS LEVEL DBOT



DIFFICULT FT TASKS

LOCALIZE/ISOLATE RADAR TRANSMITTERS
MALFUNCTION TO THE COMPONENT LEVEL
SUCH AS SWITCHES, RESISTORS, CAPACI-
TORS, TRANSISTORS, ICS, ETC.



LOCALIZE/ISOLATE RADAR VIDEO PRO-
CESSING UNIT MALFUNCTION TO THE
MODULE/CARD LEVEL



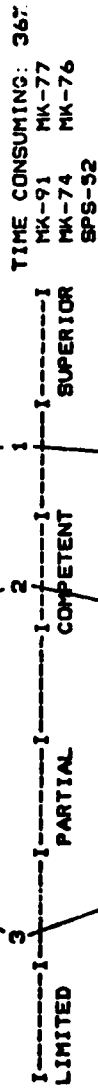
CALIBRATE/ALIGN/ADJUST FIRE
CONTROL DIRECTORS



CALIBRATE/ALIGN/ADJUST SYNCHRO-
SERVO SYSTEMS



LOCALIZE/ISOLATE RADAR TRACKING
UNIT MALFUNCTION TO THE COMPONENT
LEVEL, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.



LOCALIZE/ISOLATE FIRE CONTROL
COMPUTERS MALFUNCTION TO THE
COMPONENT LEVEL, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.



LOCALIZE/ISOLATE FIRE CONTROL
COMPUTERS MALFUNCTION TO THE
MODULE/CARD LEVEL



LOCALIZE/ISOLATE SWITCHBOARDS
MALFUNCTION TO THE COMPONENT LEVEL



ANALYZE TARGETS BY AURAL MEANS



TIME CONSUMING PT TASKS

MAKE ALIGNMENT CORRECTIONS TO GUN MOUNTS/MISSILE LAUNCHERS



CONDUCT COMBAT SYSTEMS LEVEL DSOT



CHECK BATTERY ALIGNMENT (BORESIGHT)



CALIBRATE/ALIGN/ADJUST RADAR RECEIVERS



COORDINATE WEAPON SYSTEMS TESTS



ALIGN/ADJUST MECHANICAL LINKAGES AND GEAR TRAINS



CALIBRATE/ALIGN/ADJUST RADAR ANTENNAS/DRIVE SYSTEMS



CLEAN/LUBRICATE SWITCHBOARDS



LOCALIZE/ISOLATE RADAR TRANSMITTERS MALFUNCTION TO THE COMPONENT LEVEL SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



TIME CONSUMING FT TASKS

CLEAN DESSICATED AIR/COOLANT SYSTEMS



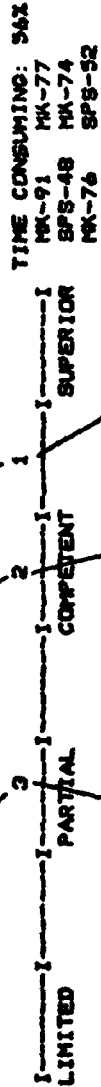
REMOVE/REPLACE DESSICATED AIR/COOLANT SYSTEMS COMPONENTS



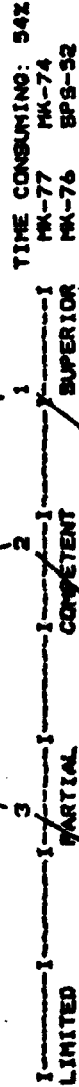
REMOVE/REPLACE RADAR ANTENNAS/DRIVE SYSTEMS COMPONENTS



REMOVE/REPLACE FIRE CONTROL DIRECTORS COMPONENTS



REMOVE/REPLACE CONTINUOUS WAVE ILLUMINATION (CWI) COMPONENTS



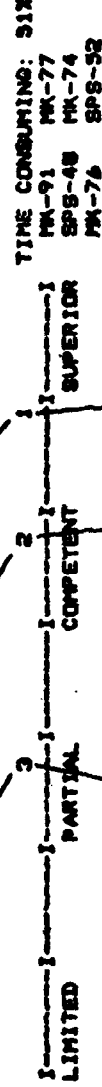
LOCALIZE/ISOLATE FIRE CONTROL DIRECTORS MALFUNCTION TO THE COMPONENT



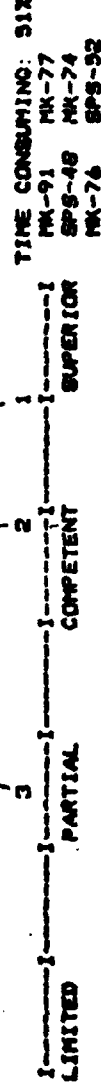
DETERMINE BATTERY ALIGNMENT ERROR



REMOVE/REPLACE SWITCHBOARDS COMPONENTS



ASSEMBLE/REPAIR CABLES AND TEST LEADS, SUCH AS CONNECTORS, PHONES, ETC.

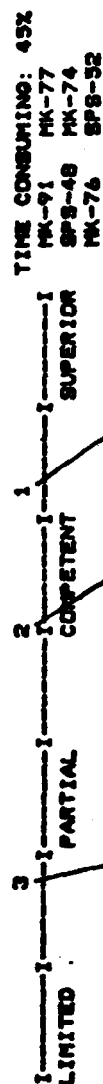


The diagram illustrates the electrical connections between several radar-related units and their internal components. Each unit is represented by a vertical column of boxes labeled with their functional level: LIMITED, PARTIAL, COMPETENT, and SUPERIOR. Lines connect these levels across different units, indicating signal or power paths. To the right of each unit's columns, there are specifications including 'TIME CONSUMING' values (e.g., 50Z, 48Z) and lists of associated parts (e.g., MK-91, SPS-48, MK-74, SPS-52).

- CALIBRATE/ALIGN/ADJUST RADAR TRANSMITTERS:** Shows connections from LIMITED to PARTIAL (3), PARTIAL to COMPETENT (2), and COMPETENT to SUPERIOR (1). Time consuming: 50Z. Parts: MK-91, MK-77, SPS-48, MK-74, MK-76, SPS-52.
- CALIBRATE/ALIGN/ADJUST RADAR VIDEO PROCESSING UNIT:** Similar connection pattern to the transmitter. Time consuming: 50Z. Parts: MK-77, SPS-48, MK-74, MK-76, SPS-52.
- LOCALIZE/ISOLATE SWITCHBOARDS HALF-FUNCTION TO THE COMPONENT LEVEL:** Connections include LIMITED to PARTIAL (3), PARTIAL to COMPETENT (2), and COMPETENT to SUPERIOR (1). Time consuming: 50Z. Parts: MK-91, MK-77, SPS-48, MK-74, MK-76, SPS-52.
- MODIFY EQUIPMENT IN ACCORDANCE WITH SHIPALTS, ORDALTS, FIELD CHANGE ORDERS AND ELECTRONIC INFORMATION BULLETINS (EIBS):** Connections include LIMITED to PARTIAL (3), PARTIAL to COMPETENT (2), and COMPETENT to SUPERIOR (1). Time consuming: 48Z. Parts: MK-91, MK-77, SPS-48, MK-74, MK-76, SPS-52.
- LOCALIZE/ISOLATE RADAR RANGING UNITS HALF-FUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.:** Connections include LIMITED to PARTIAL (3), PARTIAL to COMPETENT (2), and COMPETENT to SUPERIOR (1). Time consuming: 47Z. Parts: MK-91, MK-77, SPS-48, MK-74, MK-76, SPS-52.
- CLEAN/LUBRICATE FIRE CONTROL DIRECTORS:** Connections include LIMITED to PARTIAL (3), PARTIAL to COMPETENT (2), and COMPETENT to SUPERIOR (1). Time consuming: 44Z. Parts: MK-91, MK-77, SPS-48, MK-74, MK-76, SPS-52.
- CALIBRATE/ALIGN/ADJUST RADAR RANGING UNITS:** Connections include LIMITED to PARTIAL (3), PARTIAL to COMPETENT (2), and COMPETENT to SUPERIOR (1). Time consuming: 46Z. Parts: MK-91, MK-77, SPS-48, MK-74, MK-76, SPS-52.
- CALIBRATE/ALIGN/ADJUST RADAR TRACKING UNIT:** Connections include LIMITED to PARTIAL (3), PARTIAL to COMPETENT (2), and COMPETENT to SUPERIOR (1). Time consuming: 45Z. Parts: MK-91, MK-77, SPS-48, MK-74, MK-76, SPS-52.

TIME CONSUMING FT TASKS

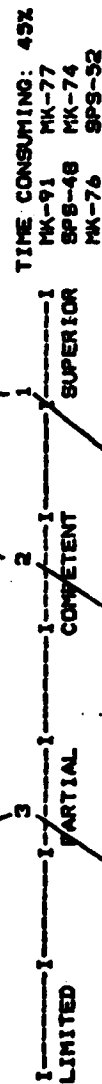
CALIBRATE/ALIGN/ADJUST FIRE
CONTROL DIRECTORS



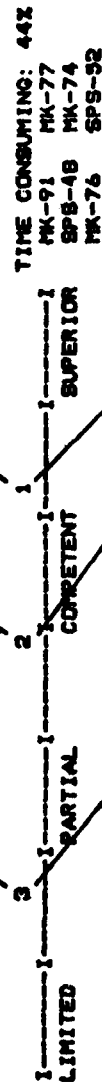
CALIBRATE/ALIGN/ADJUST RADAR
CONSOLES



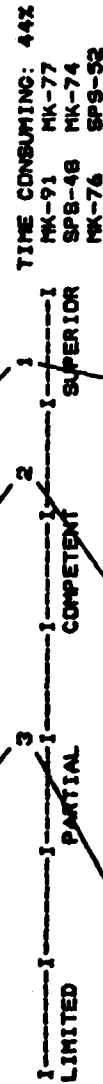
CONDUCT SUBSYSTEMS LEVEL DSOT



LOCALIZE/ISOLATE RADAR RANGING
UNITS HALF FUNCTION TO THE MODULE/
CARD LEVEL



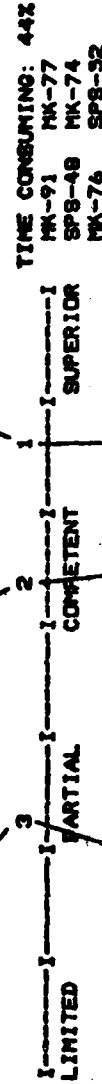
SYSTEMS OPERATION TESTS (DSOT)



CONDUCT HORIZON CHECKS



LOCALIZE/ISOLATE RADAR CONSOLES
HALF FUNCTION TO THE MODULE/CARD
LEVEL



LOCALIZE/ISOLATE RADAR ANTENNAS/
DRIVE SYSTEMS HALF FUNCTION TO THE
COMPONENT LEVEL



LOCALIZE/ISOLATE RADAR VIDEO PRO-
CESSING UNIT HALF FUNCTION TO THE
MODULE/CARD LEVEL



TIME CONSUMING FT TASKS

LOCALIZE/ISOLATE RADAR VIDEO PROCESSING UNIT MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

CALIBRATE/ALIGN/ADJUST BEARING-RANGE INDICATORS

LOCALIZE/ISOLATE RADAR VIDEO INDICATING DISPLAY MALFUNCTION TO THE MODULE/CARD LEVEL

CALIBRATE/ALIGN/ADJUST SYNCHRO-SERVO SYSTEMS

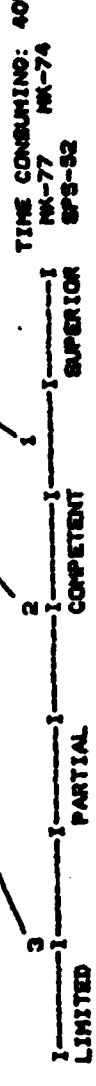
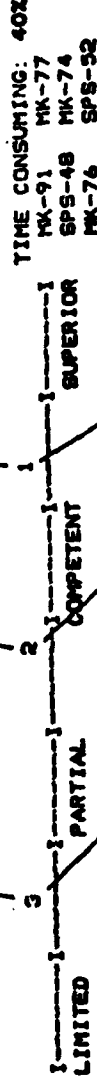
LOCALIZE/ISOLATE RADAR SIGNAL PROCESSING EQUIPMENT MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

REMOVE/REPLACE SIGNAL PROCESSING EQUIPMENT COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

LOCALIZE/ISOLATE RADAR VIDEO INDICATING DISPLAY MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.

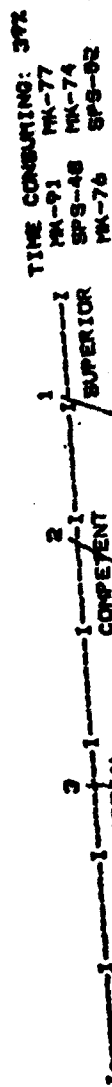
CLEAN/LUBRICATE RADAR ANTENNAS/DRIVE SYSTEMS

REMOVE/REPLACE STABLE ELEMENTS/STABLE VERTICAL COMPONENTS

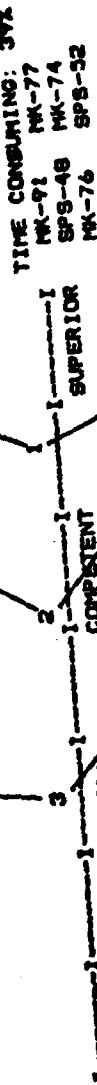


TIME CONSUMING FT TASKS

CALIBRATE/ALIGN/ADJUST DESIGNATED
AIR COOLANT SYSTEMS



CALIBRATE/ALIGN/ADJUST SWITCHBOARDS



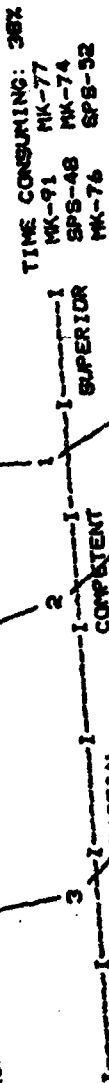
CLEAN RADAR TRANSMITTERS



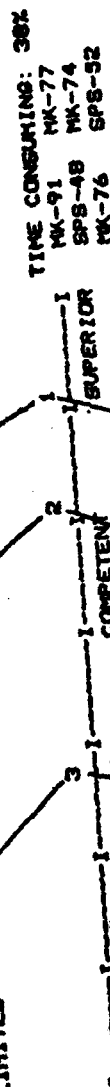
LOCALIZE/ISOLATE RADAR SIGNAL
PROCESSING EQUIPMENT HALF-FUNCTION
TO THE MODULE/CARD LEVEL



CALIBRATE/ALIGN/ADJUST RADAR SIGNAL
PROCESSING EQUIPMENT



REMOVE/REPLACE RADAR CONSOLES
COMPONENTS, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICB, ETC.



CALIBRATE/ALIGN/ADJUST RADAR VIDEO
INDICATING DISPLAY



CALIBRATE/ALIGN/ADJUST TARGET
DESIGNATION EQUIPMENT



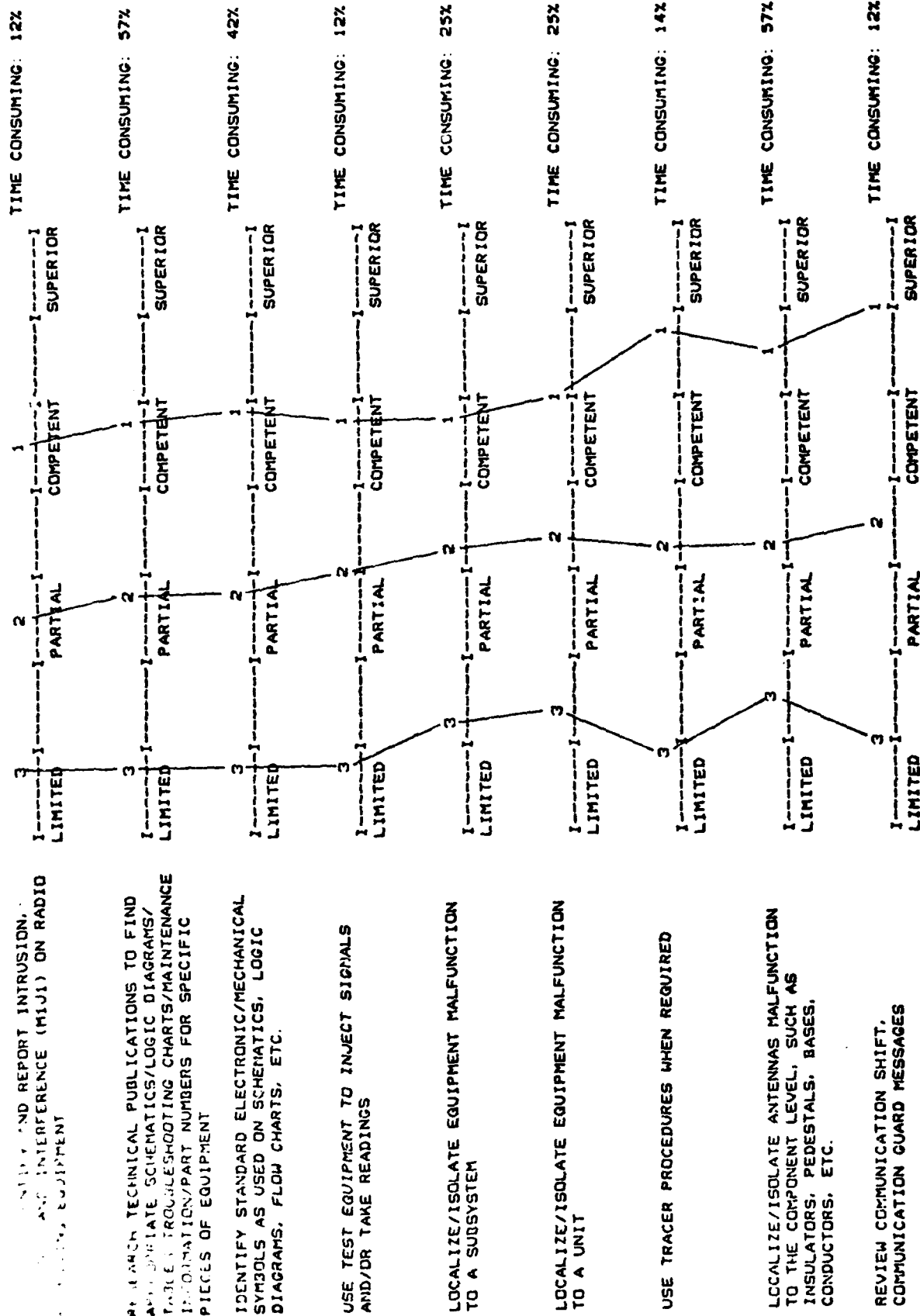
LOCALIZE/ISOLATE FIRE CONTROL
COMPONENTS HALF-FUNCTION TO THE
COMPONENT LEVEL, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICB, ETC.



DIFFICULT AND TIME-CONSUMING TASKS

RM

DIFFICULT RM TASKS



DIFFICULT RM TASKS

PERFORM REQUIRED SERVICE ACTION ON
MESSAGES AS NEEDED



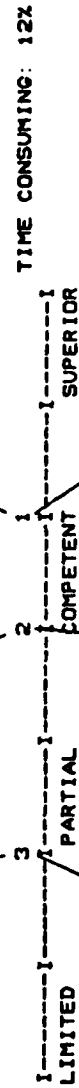
ADVERSE ATMOSPHERIC CONDITIONS
(RECOGNIZE/UNDERSTAND EFFECTS OF)



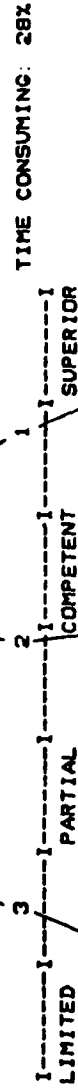
ASSEMBLE/REPAIR CABLES AND TEST LEADS,
SUCH AS CONNECTORS, PROBES, ETC.



DETERMINE THE FREQUENCY TO BE USED
(TYPE "D" SYSTEM)



INTERFACE THE SYSTEM BY MAKING
REQUIRED PATCHES
(TYPE "C" SYSTEM)



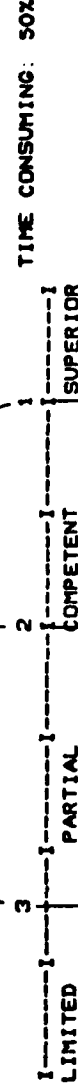
INTERFACE THE SYSTEM BY MAKING
REQUIRED PATCHES
(TYPE "D" SYSTEM)



CHANGE SYSTEM CONFIGURATION BY PATCHING
OR BY SWITCHBOARD CHANGES



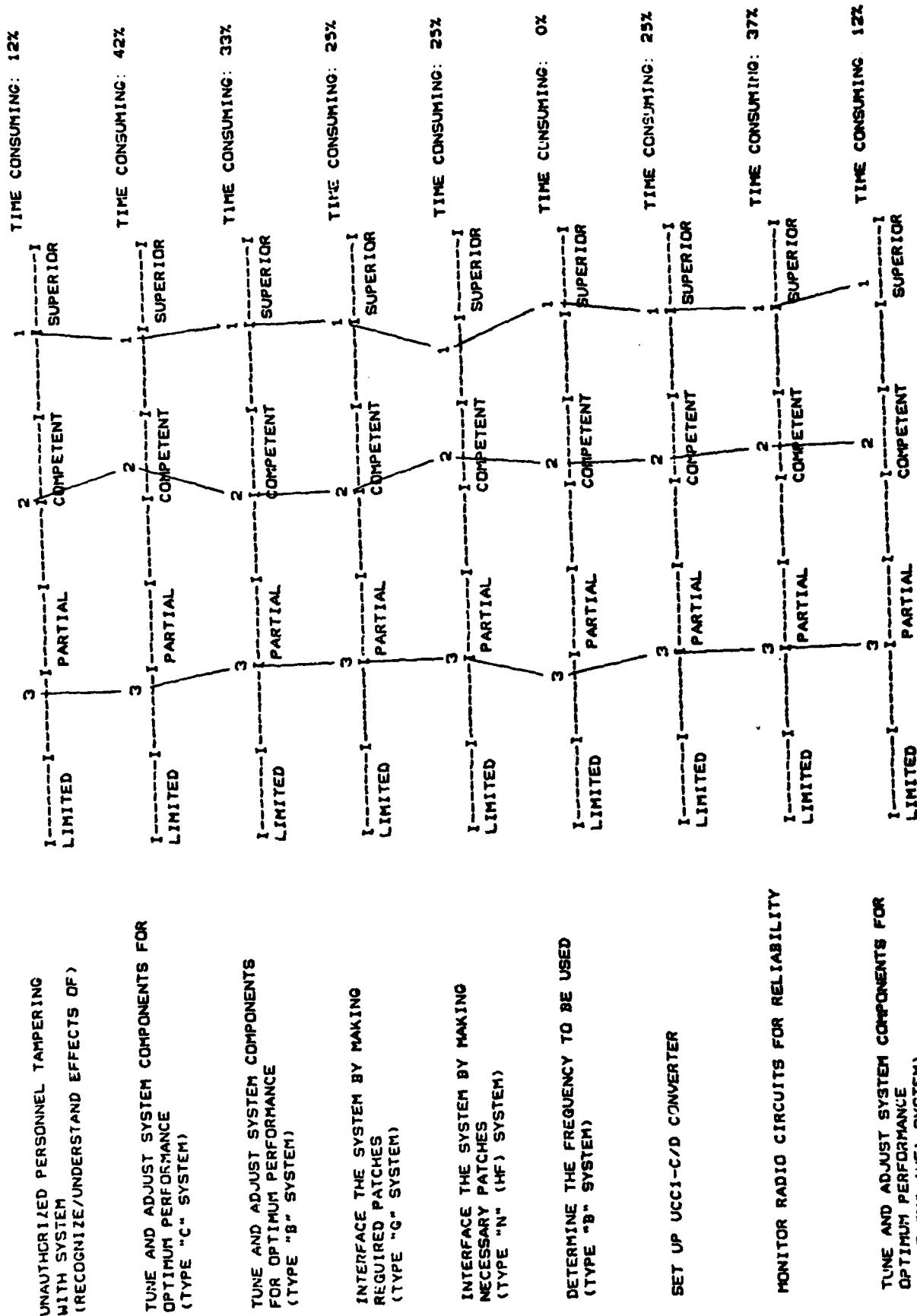
CHECK FREQUENCIES FOR USABILITY (GAP)



OPEN PATCH CORD
(RECOGNIZE/UNDERSTAND EFFECTS OF)



DIFFICULT RM TASKS

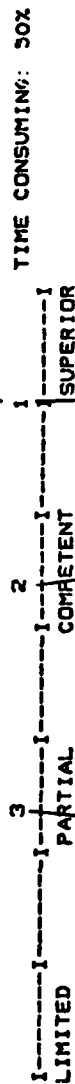


DIFFICULT RM TASKS

ANALYZE EQUIPMENT FRONT PANEL INDICATORS
FOR FAULT DETECTION



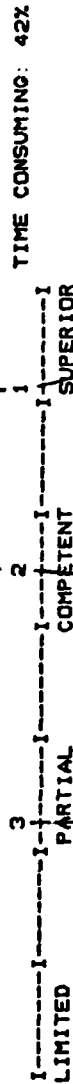
TEST/INSPECT RADIO EQUIPMENT



TUNE TRANSCEIVERS



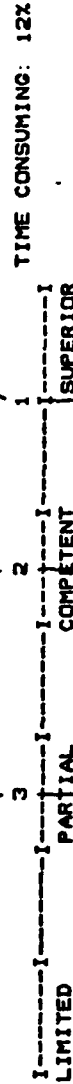
INTERFACE THE SYSTEM BY MAKING
REQUIRED PATCHES
(TYPE "B" SYSTEM)



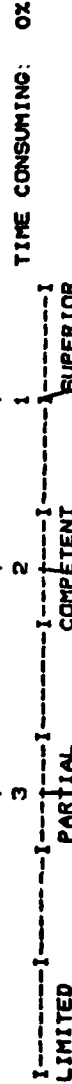
SELECT EQUIPMENTS TO BE USED
(TYPE "D" SYSTEM)



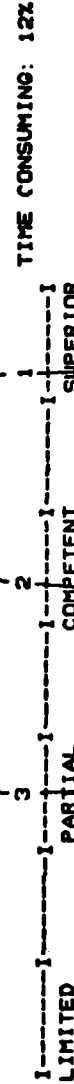
DETERMINE THE FREQUENCIES TO BE USED
(TYPE "Q" SYSTEM)



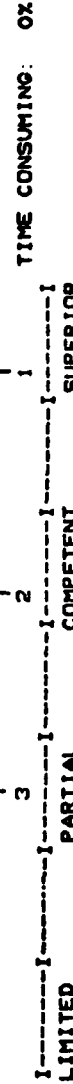
VARIATION IN PRIMARY POWER
(RECOGNIZE/UNDERSTAND EFFECTS OF)



RECEIVE FLEET BROADCAST USING FREQUENCY
DIVERSITY METHODS

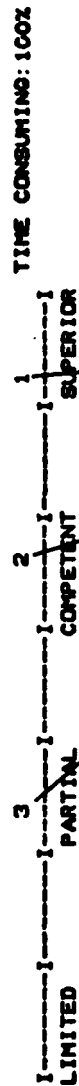


DETERMINE SHIP(S) AND/OR STATION(S) TO
BE TERMINATED WITH
(TYPE "B" SYSTEM)

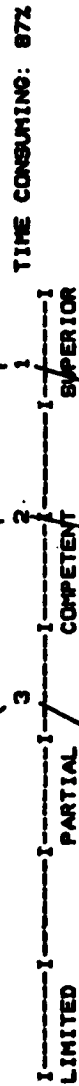


TIME CONSUMING RM TASKS

REMOVE/REPLACE ANTENNA COMPONENTS,
SUCH AS INSULATORS, PEDESTALS, BASES,
CONDUCTORS, ETC.



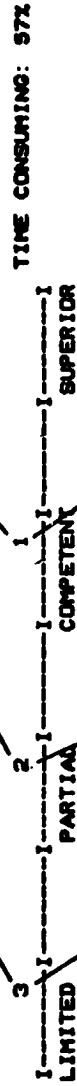
CLEAN/LUBRICATE ANTENNAS



TEST/INSPECT ANTENNAS



RESEARCH TECHNICAL PUBLICATIONS TO FIND
APPROPRIATE SCHEMATICS/LOGIC DIAGRAMS/
TABLES/TROUBLESHOOTING CHARTS/MAINTENANCE
INFORMATION/PART NUMBERS FOR SPECIFIC
PIECES OF EQUIPMENT



LOCALIZE/ISOLATE ANTENNAS MALFUNCTION
TO THE COMPONENT LEVEL, SUCH AS
INSULATORS, PEDESTALS, BASES,
CONDUCTORS, ETC.



CHECK FREQUENCIES FOR USABILITY (QAP)



TEST/INSPECT RADIO EQUIPMENT



PROCESS INCOMING MESSAGES
(TYPE "N" (SATELLITE) SYSTEM)



INTERFACE THE SYSTEM BY MAKING
REQUIRED PATCHES
(TYPE "B" SYSTEM)



TIME CONSUMING RM TASKS

PREPARE OUTGOING MESSAGES IN
CORRECT FORMAT
(TYPE "B" SYSTEM)

TUNE AND ADJUST SYSTEM COMPONENTS FOR
OPTIMUM PERFORMANCE
(TYPE "C" SYSTEM)

PREPARE OUTGOING MESSAGES IN
CORRECT FORMAT
(TYPE "C" SYSTEM)

IDENTIFY STANDARD ELECTRONIC/MECHANICAL
SYMBOLS AS USED ON SCHEMATICS, LOGIC
DIAGRAMS, FLOW CHARTS, ETC.

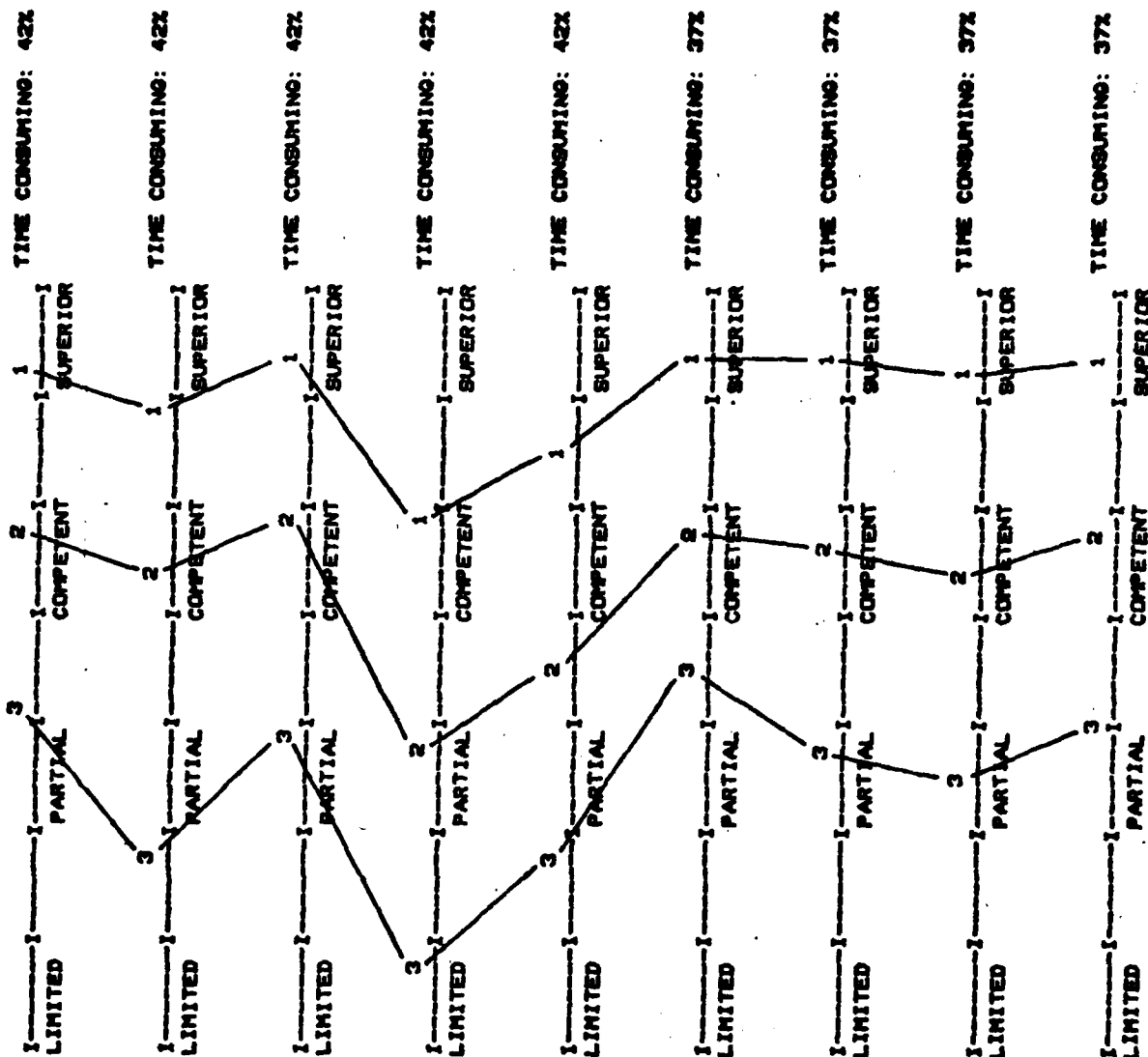
ASSEMBLE/REPAIR CABLES AND TEST LEADS,
SUCH AS CONNECTORS, PROBES, ETC.

PROCESS INCOMING MESSAGES
(TYPE "N" (NF) SYSTEM)

PREPARE OUTGOING MESSAGES IN
CORRECT FORMAT
(TYPE "D" SYSTEM)

TUNE AND ADJUST SYSTEM COMPONENTS FOR
OPTIMUM PERFORMANCE
(TYPE "Q" SYSTEM)

PREPARE OUTGOING MESSAGES IN CORRECT
FORMAT
(TYPE "Q" SYSTEM)



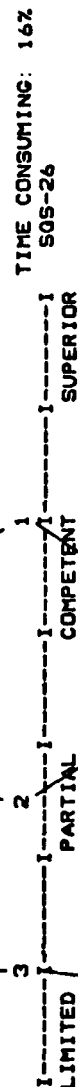
DIFFICULT AND TIME-CONSUMING TASKS
STG

DIFFICULT ST TASKS

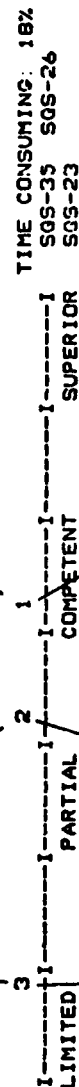
CALCULATES COUNTER-DETECTION RANGES



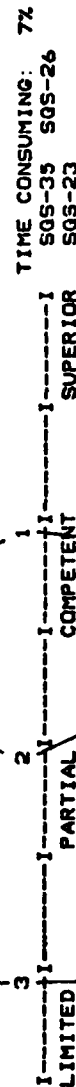
LOCALIZE/ISOLATE CONVERTER B-SCAN MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



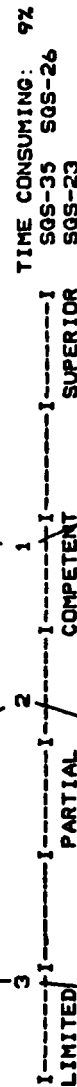
RECOMMENDS USE OF PRAIRIE MASKER SECURING NOISY EQUIPMENTS, AND ADJUSTMENTS IN MANEUVERING TO REDUCE DETECTABILITY



CONNS THE SHIP FROM UNDERWATER BATTERY (UB) PLOT DURING AN ASW ATTACK OR SIMULATED ASW ATTACK



CALCULATES PASSIVE FOM



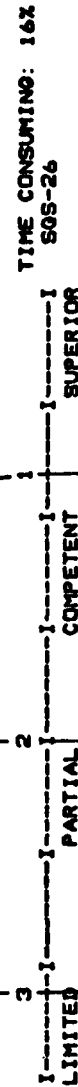
LOCALIZE/ISOLATE CONVERTER B-SCAN MALFUNCTION TO THE MODULE/CARD LEVEL



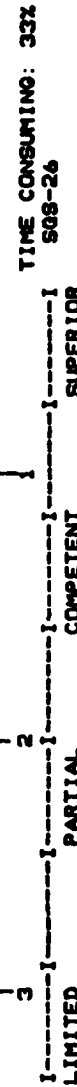
CALIBRATE/ALIGN/ADJUST SONAR MODULATOR-SCANNER



TEST/INSPECT CONVERTER B-SCAN



CALIBRATE/ALIGN/ADJUST CONVERTER B-SCAN



DIFFICULT ST TASKS

LOCALIZE/ISOLATE SONAR MODULATOR-SCANNER
MALFUNCTION TO THE MODULE/CARD LEVEL



LOCALIZE/ISOLATE SONAR MODULATOR-SCANNER
MALFUNCTION TO THE COMPONENT LEVEL, SUCH
AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



TEST/INSPECT SONAR AMPLIFIER-MODULATOR



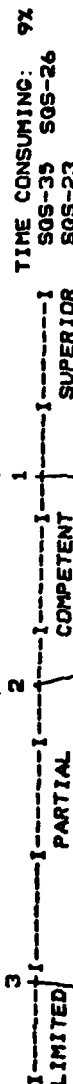
REMOVE/REPLACE CONVERTER B-SCAN
COMPONENTS, SUCH AS SWITCHES, RESISTORS,
CAPACITORS, TRANSISTORS, ICS, ETC.



LOCALIZE/ISOLATE SONAR AMPLIFIER-MODULATOR
MALFUNCTION TO THE COMPONENT LEVEL, SUCH
AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



ESTIMATES PROBABLE LOCATIONS OF
LOST CONTACTS USING TIME-LATE
AND FINAL CONTACT DATA



CHANGE SYSTEM CONFIGURATION BY
PATCHING OR BY SWITCHBOARD CHANGES



CALIBRATE/ALIGN/ADJUST CONSOLE 3



MODIFY EQUIPMENT IN ACCORDANCE WITH
SHIPALTS, ORDALTS, FIELD CHANGE ORDERS
AND ELECTRONIC INFORMATION BULLETINS
(EIBS)



DIFFICULT ST TASKS

LOCALIZE/ISOLATE CONSOLE 2 MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



ALIGN/ADJUST MECHANICAL LINKAGES AND GEAR TRAINS



CALIBRATE/ALIGN/ADJUST SCAN SWITCH CONVERTER



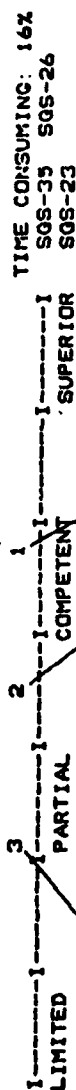
USES PUBLICATIONS CONCERNING OCEANOGRAPHIC AND METEOROLOGICAL CONDITIONS TO DETERMINE THE BEST PROPAGATION PATH TO UTILIZE (SUCH AS DIRECT, BOTTOM REFLECTED, CONVERGENCE ZONE)



DISTINGUISHES BETWEEN MOVING AND NON-MOVING TARGETS USING THE SONAR DISPLAYS ONLY



MAKES PASSIVE SONAR DETECTION RANGE PREDICTIONS USING FOM



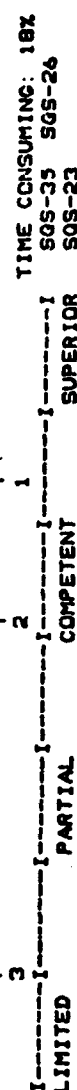
CALIBRATE/ALIGN/ADJUST PHASE CHANGING NETWORK



LOCALIZE/ISOLATE TRANSMITTER-RECEIVER SWITCH MALFUNCTION TO THE COMPONENT LEVEL, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



CALIBRATE/ALIGN/ADJUST SONAR SIGNAL PROCESSOR

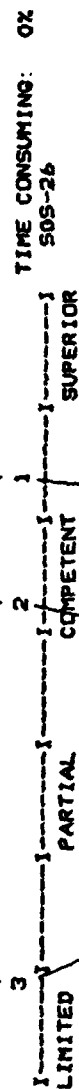


DIFFICULT BY TASKS

LOCALIZE/ISOLATE CONVERTER A-SCAN
MALFUNCTION TO THE MODULE/CARD LEVEL



LOCALIZE/ISOLATE CONSOLE 3 MALFUNCTION
TO THE MODULE/CARD LEVEL



CORRELATES OWN SHIP SONAR DATUM
WITH DATA FROM OUTSIDE SOURCES



CALIBRATE/ALIGN/ADJUST CONVERTER A-SCAN



LOCALIZE/ISOLATE PULSE SWEEP GENERATOR
MALFUNCTION TO THE COMPONENT LEVEL,
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



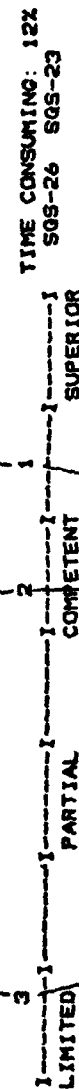
LOCALIZE/ISOLATE AF AMPLIFIER MALFUNCTION
TO THE COMPONENT LEVEL, SUCH AS SWITCHES,
RESISTORS, CAPACITORS, TRANSISTORS,
ICS, ETC.



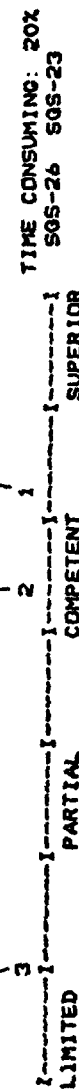
LOCALIZE/ISOLATE CONSOLE 3 MALFUNCTION
TO THE COMPONENT LEVEL SUCH AS
SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



LOCALIZE/ISOLATE TIMER SEQUENTIAL
MALFUNCTION TO THE COMPONENT LEVEL,
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.

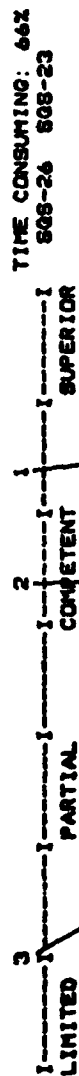


LOCALIZE/ISOLATE TRANSMITTER CONTROL
MALFUNCTION TO THE COMPONENT LEVEL,
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



TIME CONSUMING BT TASKS

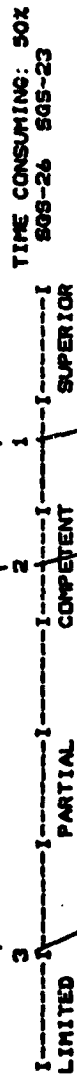
REMOVE/REPLACE PHASE CHANGING NETWORK COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



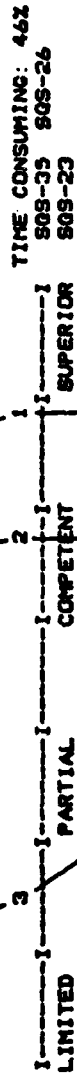
CALIBRATE/ALIGN/ADJUST MOTOR GENERATOR/ALTERNATOR



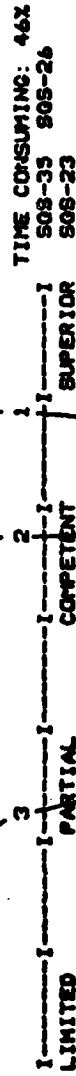
TEST/INSPECT PHASE CHANGING NETWORK



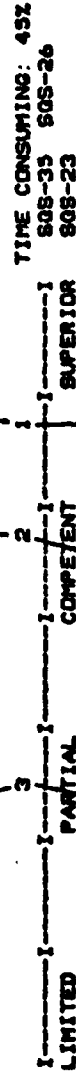
REMOVE/REPLACE POWER SUPPLY ASSEMBLY COMPONENTS, SUCH AS SWITCHES, RESISTORS, CAPACITORS, TRANSISTORS, ICS, ETC.



CALIBRATE/ALIGN/ADJUST POWER SUPPLY ASSEMBLY



CLEAN SONAR AMPLIFIER-SCANNER



CALIBRATE/ALIGN/ADJUST SONAR RECEIVER-SCANNER



CALIBRATE/ALIGN/ADJUST CONVERTER A-SCAN



REMOVE/REPLACE SIGNAL DATA CONVERTER

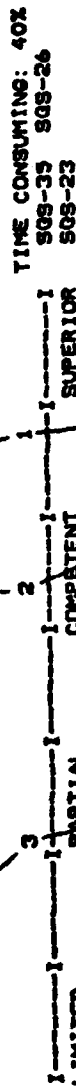


TIME CONSUMING ST TASKS

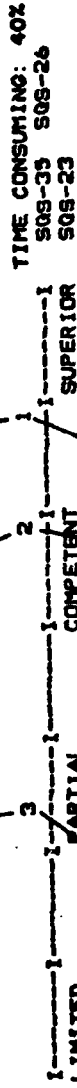
REMOVE/REPLACE AF AMPLIFIER COMPONENTS,
SUCH AS SWITCHES, RESISTORS, CAPACITORS,
TRANSISTORS, ICS, ETC.



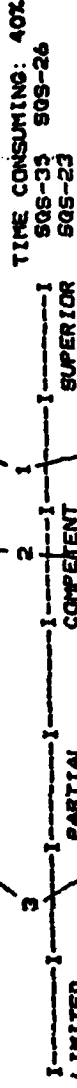
CLEAN TRANSMITTER-RECEIVER SWITCH



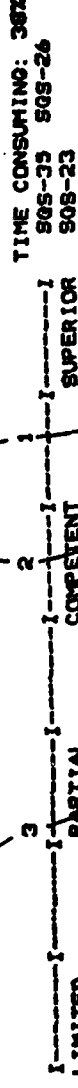
CLEAN/LUBRICATE MOTOR GENERATOR/
ALTERNATOR



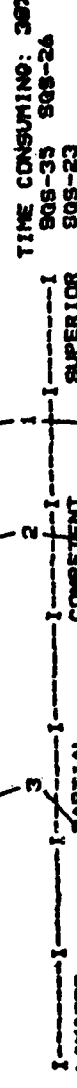
REMOVE/REPLACE MOTOR GENERATOR/
ALTERNATOR COMPONENTS



CALIBRATE/ALIGN/ADJUST CONSOLE I/
CONTROL INDICATOR



CLEAN/LUBRICATE POWER SUPPLY ASSEMBLY



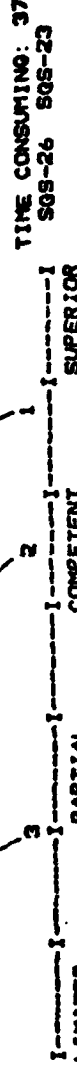
LOCALIZE/ISOLATE MOTOR GENERATOR/
ALTERNATOR MALFUNCTION TO THE
COMPONENT LEVEL



ALIGN/ADJUST MECHANICAL LINKAGES AND
GEAR TRAINS



CALIBRATE/ALIGN/ADJUST TIMER
SEQUENTIAL



SECTION 8

TRAINING REQUIREMENTS AND NECs

ADDRESSING QUESTION 8

What operational and maintenance training requirements are generated by the tasks to be performed? Can these be met by existing resources?

The identification of operational and maintenance training requirements generated by the proposed new system design will be aided by the previously performed task and skill level analyses. However, the question of necessary training resources and associated costs must also be addressed (see Figure 17).

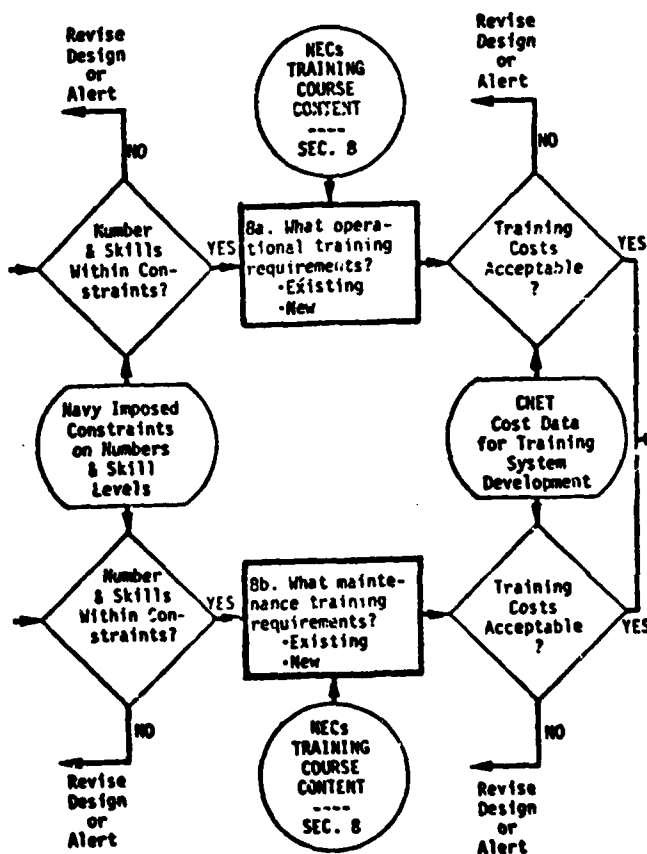


Figure 17. Addressing Question 8.

AD-A104 839 NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER SAN O--ETC F/G 5/8
AN ENGINEER'S GUIDE TO THE USE OF HUMAN RESOURCES IN ELECTRONIC--ETC(U)
JUN 79

UNCLASSIFIED NPROC-TN-79-8

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To the extent that the selected design minimizes the generation of new or more complex tasks, it may be possible to minimize training costs by utilizing existing training resources. The task taxonomies in Section 6 provide a convenient inventory of "old" tasks as a point of departure. Many of these tasks probably will be applicable to the new system as well. Where they do apply, existing training curricula, training aids, devices, and facilities may also be applicable, with resultant savings in cost.

Wherever a task not found in Section 6 is required, a new training requirement exists; and, when the number of new tasks becomes substantial, a requirement for a new NEC, with all its associated costs, is born.

Data on the lifecycle costs of training Navy personnel for new NECs are currently being developed.

The Navy Personnel Research and Development Center is presently sponsoring work aimed at identifying lifecycle NEC costs and methods for estimating the relative costs of new training systems. These data will be added to this section in a future modification to this guide.

A survey of existing NECs and associated training courses will provide some of the information needed to assess the applicability of existing training resources.

The system designer and the project manager should be aware of existing courses, devices, and facilities that can possibly serve to meet, in part at least, the training requirements of the proposed new system. One way of approaching this question is through a review of NECs for existing equipment similar in purpose to that under development, since many NECs have an associated specialized training course. To simplify this process, all current NECs relating to electronic systems operated or maintained by DS, ET, FTM, RM, or STG personnel have been listed on the following pages.

A catalog of all existing Navy training courses is maintained by the Naval Education and Training Command. This information is in a computerized data bank (CANTRAC) which can be accessed by a variety of key words such as type of system, equipment designator, NEC code, and so forth. Through this source, the designer or program manager can quickly obtain a listing of all established training courses, their durations, required prerequisites, etc., that apply to systems similar to the one under development.

Though this information will be of some help, it will not convey needed data on the comprehensiveness of instruction in particular areas of knowledge or skill acquisition. Unfortunately, this much needed information is not available as yet in a form for use by system designers.

SELECTED ENLISTED CLASSIFICATIONS (NECS) (SOURCE: NAVPERS 18068D,
SECTION II, JANUARY 1977)

Data Systems Technician (DS)

- ET-1451 Satellite Metrological Data Terminal (SQM-10) and Navy Transportable Metrological Data Terminal Technician, ET DS
- ET-1471 Navigational Satellite System (SRN-9) TECHNICIAN, ET DS
- DS-1615 Shipboard Tactical Data Systems Technician, DS
- DS-1616 Data Display Equipment Maintenance Technician, DS
- DS-1618 Data Correlation and Transfer System Technician, DS
- DS-1623 Data Link Technician, DS
- DS-1634 Land Based Tactical Support Center Data Systems Technician, DS
- DS-1636 UYK-4(V) Computer System Maintenance Technician, DS
- DS-1645 FLTSATCOM (SSIXS/ISABPS) - OPCONCEN Maintenance Technician, DS
- DS-1653 IOIC Systems Maintenance Technician, DS
- DS-1655 CV-Tactical Support Center Computer Systems Technician, DS
- DS-1665 UYA-4 Data Display Equipment Maintenance Technician, DS
- DS-1666 UYK-5(V) Computer System Maintenance Technician, DS
- DS-1667 UYK-7 Computer and Associated Peripheral Technician, DS
- DS-1668 USQ-20(V) Peripheral Equipment Maintenance Technician, DS
- DS-1669 UYK-5 System and IBM Ancillary Equipment Technician, DS
- DS-1671 FFG-7 Class Computer/Peripheral Technician, DS
- DS-1672 DD-963 Class Computer/Peripheral Technician, DS
- DS-1673 LHA Class Computer and Associated Subsystems Technician, DS
- DS-1681 FFG-7 Class Display Equipment Maintenance Technician, DS
- DS-1682 DD-963 Class Display Equipment Maintenance Technician, DS
- DS-1683 CGN-38 Class Display Equipment Maintenance Technician, DS
- DP-2762 Punched Card Accounting Machine (PCAM) Repairman, DP DS ET

Electronics Technician (ET)

- ET-1403 Communications Equipment (FRT-83/84/85) Technician, ET
- ET-1404 Communications Equipment (TROPO-SCATTER) Technician, ET
- ET-1405 Communications Equipment (FRT-39, URT-19, and URA-30) Technician, ET

ET-1406 Communications Equipment (FRR-60 Radio Receiver & CU-1382/UR Multicoupler) Technician, ET
 ET-1407 Communications Equipment (FTA-15 & FGC-60 Technician, ET
 ET-1408 Communications Equipment (FRC-84 & FCC-17) Technician, ET
 ET-1409 FCG-73 & UGR-14 (Inktronic Page Printer) Repairman, ET
 ET-1411 Digital Subscriber Terminal Equipment Maintenance Technician, ET
 ET-1412 Special Fixed Communications Maintenance Technician, ET
 ET-1413 Meteorological/Oceanographic Equipment Maintenance Technician, ET
 ET-1414 Communications Equipment (VLF/LF) Technician, ET
 ET-1415 Shore Transmitter Facility Maintenance Technician, ET
 ET-1416 Shore Receivers Facility Maintenance Technician, ET
 ET-1417 ASCOMM/TSC Communications Systems Technician, ET
 ET-1421 Communications Equipment (WRT-2) Technician, ET
 ET-1422 Communications Equipment (UCC-1) Technician, ET
 ET-1423 Communications Equipment (SRC-20/21 & URC-9) UHF Technician, ET
 ET-1424 Communications Equipment (VRC-46/SRA-60/VCC-2) Technician, ET
 ET-1426 Communications Equipment (Tactical Data Systems SRC-16/17/23/31) Technician, ET
 ET-1427 Communications Equipment (Tactical Data Systems) Technician (SRC-16/23, URC 85), ET
 ET-1431 Communication Security Devices Equipment (KY-8) Technician, ET CTM RM (SS)
 ET-1432 Communication Security Devices Equipment (KW-37T) Technician, ET CTM
 ET-1433 Communication Security Devices (Steam Valve Maintenance) Technician, ET
 ET-1434 Communication Security Devices Equipment (KG-13) Technician, ET CTM
 ET-1435 Communication Security Devices Equipment (KW-37R, KW-7) Technician, ET RM (SS)
 ET-1436 Communication Security Devices Equipment (KG-14, KW-37R) Technician, ET CTM RM (SS)
 ET-1437 Communication Security Devices Equipment (FW-37R) Technician, ET CTM RM (SS)
 ET-1438 Communication Security Devices Equipment (KW-7) Technician, ET CTM AT RM (SS)
 ET-1441 Communication Security Devices Equipment (KW-26) Technician, ET CTM
 ET-1442 KG-30 Family Limited Maintenance Technician, ET CTM RM (SS)
 ET-1443 KG-30 Family Unlimited Maintenance Technician, ET
 ET-1447 Communication Security Devices Equipment (KY-28) Technician, ET AT RM
 ET-1448 Communication Security Devices Equipment (KY-3) Technician, ET CTM
 ET-1449 NBST Equipment Technician, ET CTM

ET-1451 Satellite Metrological Data Terminal (SQM-10) &
 Navy Transportable Metrological Data Terminal Tech-
 nician, ET DS
 ET-1453 FLTSATCOM (NAVMACS A+ - WSC-3) Shipboard Maintenance
 Technician, ET
 ET-1454 DD-963 Communications Systems Technician, ET
 ET-1455 FLTSATCOM (CUDIXS - WSC-5) Shipboard Maintenance
 Technician, ET
 ET-1456 FLTSATCOM (CUDIXS - NAVCOMMSTA) Maintenance Techni-
 cian, ET
 ET-1461 Special Maintenance (FSC-78/79 SHF Satellite Terminal)
 Technician, ET
 ET-1462 Special Maintenance (MSC-46 Satellite Communications)
 Technician, ET
 ET-1463 Special Maintenance (TSC-54 Satellite Communications)
 Technician, ET
 ET-1464 Special Maintenance (WSC-5 Satellite Terminal) Tech-
 nician, ET AT
 ET-1466 Special Maintenance (SSC-6 Major SHF SATCOM Terminal)
 Technician, ET
 ET-1471 Navigational Satellite System (SRN-9) Technician, ET DS
 ET-1472 Tactical Air Navigation (SRN6/URN3/GRN9) Technician, ET
 ET-1473 Tactical Air Navigation (URN-20) Technician, ET
 ET-1474 Inertial Navigation MK 11 MOD 1 SINS (N7B) Technician,
 ET
 ET-1475 Inertial Navigation MK III MOD 4 SINS Technician, ET
 ET-1476 Inertial Navigation MK III MOD 6 SINS Technician, ET
 LT-1477 Inertial Navigation (SNAIAS) Technician, ET
 ET-1478 Dual Miniaturized Inertial Navigation System (DMINS)
 Technician, ET
 ET-1479 DD-963 Navigation Equipment Technician, ET
 ET-1481 Electronic Warfare Support Measures (ESM) (WLR-1 Series)
 System Technician, ET CTM
 ET-1482 Electronic Warfare System Technician (WLR-6), ET CTM
 ET-1483 Electronic Warfare System Technician (WLR-8(V-2)), ET
 ET-1484 Electronic Warfare System Technician (BRD-7), ET CTM
 ET-1501 Basic Electronics Maintenance Technician, ET
 ET-1502 Radar (SPN-41, SPN-43, & SPN-44) Technician, ET
 ET-1503 Radar (SPS-49) Technician, ET
 ET-1504 Radar (SPS-55) Technician, ET
 ET-1505 Radar (SPS-29C) Technician, ET
 ET-1506 Radar (SPS-29E) Technician, ET
 ET-1512 Radar Systems (SPS-37A & SPS-43A) Technician, ET
 ET-1513 Fixed Array Radar (FAR) Technician, ET
 ET-1514 Radar (SPS-40) Technician, ET
 ET-1515 Radar (SPS-40A) Technician, ET
 ET-1516 Radar (SPS-40B) Technician, ET
 ET-1517 Radar Repeater Systems Maintenance Technician, ET
 ET-1519 Radar (SPS-30) Technician, ET
 ET-1521 Radar (SPN-10) Technician, ET
 ET-1522 Radar (SPN-42) Technician, ET
 ET-1523 Radar (SPN-35/35A) Technician, ET

ET-1524 Radar (SPN-6/12) Technician, ET
 ET-1561 Special Maintenance (Teams) Technician, ET
 ET-1572 AIMS System Technician, ET
 ET-1573 AIMS (TSEC/CRYPTO) Technician, ET AT
 ET-1574 DAIR/GCA (TPX-42, CPN-4) Maintenance Technician, ET
 EW-1717 Electronic Warfare Systems (SLO-20, ALQ-91) Technician,
 EW ET
 DP-2762 Punched Card Accounting Machine (PCAM) Repairman, DP DS ET
 -3301 Fleet Ballistic Missile Weapons & Navigation System
 Technician-Special Category, FTB MT ET TM
 -3325 Inertial Navigation Systems MK II MOD 6 Technician, ET
 -3332 NAVDAC MK II MOD 2/4: SDC MK III MOD 0/1 Technician, ET
 -3333 Central Navigation Computer Technician, ET
 -3337 Navigation Aids Technician, ET
 -3338 ESGM Navigation Aids Technician, ET
 IC-4746 Closed Circuit TV Technician, IC TD ET

Fire Control Technician (FTM)

FT-1101 MK 92 MOD 1 Gunfire Control System Technician, FTM FTG
 FT-1102 MK 92 MOD 2 Gun & Missile Fire Control System Technician,
 FTM FTG
 FT-1105 SPG-55B (Track) Radar Technician, FTM
 FT-1106 AEGIS Fire Control System MK 99//Weapon Control System
 MK 1 Technician, FTM
 FT-1107 AEGIS Radar System (SPY-1A) Technician, FTM
 FT-1108 AEGIS Weapon System MK 7 Technician, FTM
 FT-1109 TERRIER Missile Fire Control System (MK 76 MODS 6, 7, & 8)
 Technician, FTM
 FT-1113 TARTAR WDS MK 4 Technician, FTM
 FT-1118 TERRIER WDS MK 3, 5, & 7 Technician, FTM
 FT-1119 TALOS WDS MK 6 Technician, FTM
 FT-1135 Search Radar (SPS-39, 39A or 42) Technician, FTM
 FT-1136 Search Radar (SPS-48A) Technician, FTM
 FT-1137 Search Radar (SPS-52) Technician, FTM FTG
 FT-1139 Search Radar (SPS-48) Technician, FTM FTG
 FT-1143 TALOS Equipment Maintenance Technician, FTM
 FT-1144 TARTAR/TERRIER Equipment Maintenance Technician, FTM
 FT-1146 Basic Point Defense SMS Technician, FTM
 FT-1148 Improved Point Defense Guided Missile Fire Control
 System MK 91 MOD 0 Technician, FTM
 FT-1153 TARTAR MK 74 Digital Update Weapons Control System
 Technician, FTM
 FT-1154 TARTAR MK 74 MOD 4 WDS MK 11 Weapons System Technician, FTM
 FT-1156 TERRIER MK 76 WDS MK 11 Weapons System Technician, FTM
 FT-1157 TERRIER MK 76 Weapons Control System Technician, FTM
 FT-1158 TALOS MK 77 Weapons Control System Technician, FTM
 FT-1159 TARTAR MK 74 Weapons Control System Technician, FTM
 FT-1161 Fire Control Radar (SPW-2) Technician, FTM
 FT-1163 Fire Control Radar (SPG-49) Technician, FTM
 FT-1164 Fire Control Radar (SPG-51) Technician, FTM
 FT-1165 Fire Control Radar (SPG-55) Technician, FTM

FT-1166 Radar (SPG-51C) (Digital Update) Technician, FTM
 FT-1167 Fire Control Radar (SPW-2, SPG-49) Technician, FTM
 FT-1168 Radar (SPG-51D) Technician, FTM
 FT-1169 TERRIER (SPG-55B) CWAT Radar Technician, FTM
 FT-1183 TARTAR MK 74 MOD 4 & 8 MFCS Computer Complex Technician,
 FTM
 FT-1184 TARTAR Fire Control Computer MK 118 Technician, FTM
 FT-1185 TERRIER Fire Control Computer MK 119 Technician, FTM
 FT-1186 TALOS Fire Control Computer MK 111 MOD 1 Technician, FTM
 FT-1187 TALOS Fire Control Computer MK 152 Complex Technician,
 FTM
 FT-1188 TARTAR Fire Control Computer MK 152 Complex Technician,
 FTM
 FT-1189 TERRIER Fire Control Computer MK 152 Complex Technician,
 FTM

Radioman (RM)

ET-1431 Communication Security Devices Equipment (KY-8) Techni-
 cian, ET CTM RM (SS)
 ET-1435 Communication Security Devices Equipment (KW-37R, KW-7)
 Technician, ET RM (SS)
 ET-1436 Communication Security Devices Equipment (KG-14, KW-37R)
 Technician, ET CTM RM (SS)
 ET-1437 Communication Security Devices Equipment (KW-37R) Techni-
 cian, ET CTM RM (SS)
 ET-1438 Communication Security Devices Equipment (KW-7) Technician,
 ET CTM AT RM (SS)
 ET-1442 KG-30 Family Limited Maintenance Technician, ET CTM RM (SS)
 RM-2301 Enlisted Frequency Manager, RM
 RM-2304 Intermediate Radio Operator, RM
 RM-2305 DCS Sate-lite Communication Terminal Operator (MSC-46
 and/or TSC-54), RM CTO
 RM-2313 Communications Systems Manager, RM
 RM-2314 Cryptographic Machines Repairman, RM CTM CTO
 RM-2318 Communication System Technical Operator, RM CTO
 RM-2319 Communication System Technical Supervisor, RM CTO
 RM-2342 Teletype (MOD 28, UGC-6 & UGC-20) Repairman, RM CTM CTO
 RM-2345 Teletype (UGC-20/25) Repairman, RM CTM CTO
 RM-2351 FLTSATCOM (NAVMACS A+) Shipboard Operator, RM
 RM-2354 FLTSATCOM (SSIXS-OPCONCEN) Operator, RM
 RM-2355 FLTSATCOM (CUDIXS) NAVCOMMSTA Operator, RM
 RM-2359 ASCOMM Operator, RM
 RM-2361 SHF SATCOM Terminal (FSC-78/79) Operator, RM
 RM-2368 FLTSATCOM Technical Control Operator, RM CTO
 RM-2369 FLTSATCOM Technical Control Supervisor, RM CTO
 RM-2371 Automated Communications Systems Operator, RM
 RM-2372 Automated Communication Systems Computer Console Operator,
 RM
 RM-2393 Special Fixed Communication System Operator, RM
 DP-2746 System Programmer (LDMX/NAVCOMMPARS), DP RM

Sonar Technician (STG)

ST-0431 Underwater Fire Control MK 111 ASROC Technician, STG
ST-0434 Underwater Fire Control MK 114 ASROC Technician, STG
ST-0435 Underwater Fire Control MK 114 MOD 9 TERRIER/ASROC Technician, STG
ST-0437 Underwater Fire Control MK 116 ASROC Technician, STG
ST-0438 Underwater Fire Control MK 116 MOD 1 Technician, STG
ST-0439 Underwater Fire Control MK 105 MODS 11-28 Technician, STG
ST-0445 Surface Acoustic Analyst, STG
ST-0446 Acoustic Processor (SQS-54) Technician, STG
ST-0447 Acoustic Processor (SQR-17) Technician, STG
ST-0451 Surface Sonar (SQS-23) Technician, STG
ST-0452 Surface Sonar (SQS-26BX)(EDO) Technician, STG
ST-0453 Surface Sonar (SQS-26AX)(R) Technician, SRG
ST-0454 Surface Sonar (SQS-26CX) Technician, STG
ST-0455 Surface Sonar (SWS-23) H-L Maintenance, STG
ST-0456 Surface Sonar (SQS-35 IVDS)(SQA-13 HOIST) Technician, STG
ST-0457 Surface Sonar (SQS-53) Technician, STG
ST-0458 SQS-56 Sonar Set Shipboard Maintenance Technician, STG
ST-0459 Surface Sonar (SQQ-23 Pair) Technician, STG
ST-0473 Surface Sonar/ASW Fire Control System MK 116 MOD 1 (SQS-53) Technician, STG
ST-0474 Surface Sonar/ASW Fire Control System MK 116 MOD 0 ASROC (SQS-53) Technician, STG
ST-0475 Surface Sonar/ASW Fire Control System MK 111 ASROC (SQQ-23) Technician, STG
ST-0477 Surface Sonar/ASW Fire Control System MK 114 ASROC (SQQ-23) Technician, STG
ST-0478 ASW Fire Control Panel MK 309 Maintenance Technician, STG
ST-0479 SQS-56 Sonar Set Shipboard & ASW Fire Control Panel MK 309 Maintenance Technician, STG
ST-0481 Surface Sonar/ASW Fire Control System MK 114 ASROC (SQS-26AX) Technician, STG
ST-0482 Surface Sonar/ASW Fire Control System MK 114 ASROC (SQS-26BX) Technician, STG
ST-0483 Surface Sonar/ASW Fire Control System MK 114 ASROC (SQS-26CX) Technician, STG
ST-0484 Surface Sonar/ASW Fire Control System MK 114 ASROC (SQS-23) Technician, STG
ST-0487 Surface Sonar/ASW Fire Control System MK 111 ASROC (SQS-23) Technician, STG
ST-0491 Surface Sonar/ASW Fire Control System MK 114 MOD 9 TERRIER/ASROC (SQS-26AX) Technician, STG
ST-0492 Surface Sonar/ASW Fire Control System MK 114 MOD 9 TERRIER/ASROC (SQS-26BX) Technician, STG
ST-0496 Surface Sonar/ASW Fire Control System MK 105 (SQS-23) Technician, STG

SECTION 9
BILLET LIFECYCLE COSTS FOR
REQUIRED PERSONNEL

ADDRESSING QUESTION 9

What are the estimated lifecycle costs for the personnel required to operate and maintain the system? Are these within Navy imposed constraints?

This section provides data for estimating personnel lifecycle costs for selected system lifecycles (1, 5, 10, 15, and 20 years) as a function of required personnel skill levels (pay grade). These data will enable the designer to answer Question 9 as shown in Figure 18.

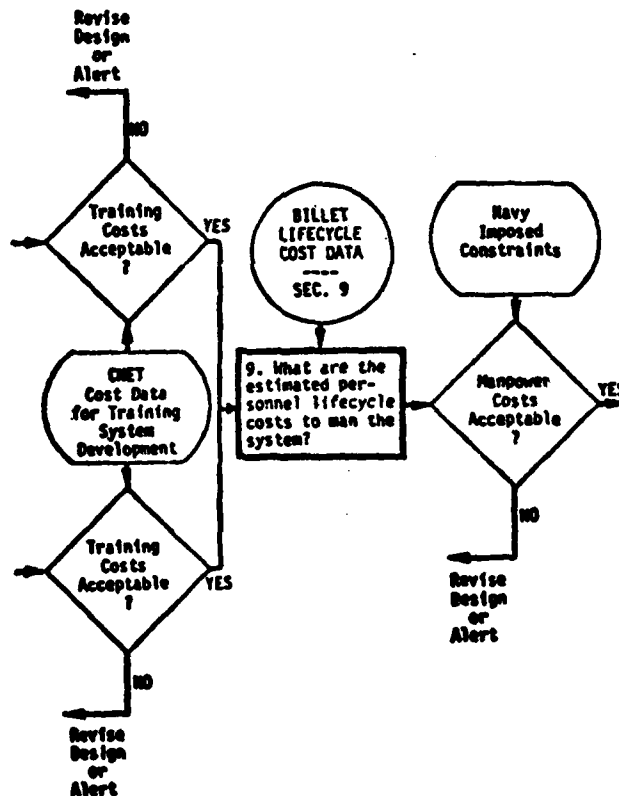


Figure 18. Addressing Question 9.

The cost data, shown separately for DS, ET, FTM, RM, and ST personnel, have been selected from a more comprehensive source document which contains lifecycle costs information for a more general group of Navy ratings.*

SOURCE OF THE DATA

The cost data are derived from the Billet Cost Model.

The cost data presented in this section are based upon information available in the Billet Cost Model, which was developed and is being maintained by OPNAV 135. The structure and format of the data base for the Billet Cost Model were developed in 1966 by the SECNAV Task Force on Personnel Retention. Over the years, adjustments have been made in that data base to cope with changing data sources, formats, and availability and to take advantage of new information as it has become available.

The data elements and sources used in computing the lifecycle costs are itemized in Table 4. As shown, the primary sources of data are the various budget documents that provide information for the past reporting period as well as justification for, and some detail on, money requirements for the upcoming period. After the expenditures have been identified, they are distributed to the ratings wherever possible--a critical step that results in cost differentiation among ratings. Those that are not applicable to a given rating are applied equally across all ratings in the annual cost by year or grade element (Koehler, 1979).

*Koehler, E. A. Life Cycle Navy Enlisted Billet Costs--FY79 (Spec. Rep. 79-13. San Diego: Navy Personnel Research and Development Center, March 1979.

Table 4

Factors Included in Billet Cost Model Computations

Data Element	Action/Source
Base Pay	1 Oct 1978 OASD(MRA&L) MPP
Clothing Allowance	MPN/Pay Manual
Command and Administration	O&MN
Commissary	O&MN
Death Gratuity	MPN
Dependent School	DoD Dependent School Office
Disability	MPN
E-7 Clothing Allowance	MPN
Family Separation Allowance	MPN
FICA	6.02% of first \$17,500 from SSA
Hazard Pay	MPN
Insurance/Housing (FHA)	DoD McClary Report
Medical Costs	BUMED Comptroller; O&MN, Budget Activity 8
Messing Subsistence	MPN/Pay Manual
Overseas Station Allowance	MPN
Prisoner Apprehension	MPN
Procurement Personnel	MPN
Pro-Pay	Not updated, not available from JUMPS yet (small variations in ratings this year)
Quarters Allowance	Imputed value from MPN for MILCON equivalent for base housing; MPN Pay Table for off-base housing In Command/Administration above
Recreation Facilities	O&MN
Recruiting Costs	Computed from JUMPS data by rating ^b
Reenlistment Bonus	Computed from force statistics and entitlements from Pay Manual
Retirement	O&MN
School Costs	MPN
Sea and Foreign Duty Pay	MPN
Severance	MPN
Travel	MPN tied to move patterns by grade

^aMPN/O&MN budgets are from Congressional Submit., January 1978; Pay Manual is DoD Military Pay, Entitlements, Allowance Manual, 1968, as amended.

^bJUMPS is Joint Uniform Military Pay Systems.

DETERMINATION OF SPECIFIC BILLET COSTS

How can the costs of specific personnel requirements be computed?

Using the billet cost information for the applicable ratings, the designer employs his estimate of the number and the rating level (E-2 through E-9) of the personnel needed and the number of years that he anticipates the system will be operational. Most system, especially the kind addresses in this guide, have skill requirements equivalent to pay grades ranging from E-4 (entry level operator or maintainer) to E-7 (highly experienced evaluator).

To illustrate, if it is decided that one 3rd class DS (E-4) will be required and that the system will be operational for 15 years, the analyst should locate that pay grade in the first column of Table 5 and read across the row until he comes to the column for the 15-year period. As shown in the table, the lifecycle billet cost for such a manpower resource would be \$212,721 for each such individual required.

Using this costing information in computing lifecycle costs sometimes leads to counter-intuitive results. The data nevertheless reflect actual cost differences based on fact. For example, within some ratings, there are only slight differences in costs between some of the pay grades or even reversals between two pay grades (e.g., the average billet costs for an FTM at the E-8 level is somewhat more than at the E-9 level). This is because differences in expenditures such as those for training have altered the relative costs.

COMPUTING TOTAL SYSTEM MANPOWER COSTS

How are the costs of all system operator and maintainer personnel computed?

Table 5
Billet Life Cycle Cost Data

Rating	Pay Grade	Years ^a				
		1	5 ^a	10 ^a	15 ^a	20 ^a
DS	E-2	24812.	103463.	167705.	207595.	232363.
DS	E-3	29718.	123920.	200865.	248642.	278308.
DS	E-4	31472.	131234.	212721.	263317.	294734.
DS	E-5	35763.	149127.	241724.	299219.	334919.
DS	E-6	30484.	127114.	206043.	255051.	285482.
DS	E-7	35360.	147447.	239000.	295847.	331145.
DS	E-8	37531.	156499.	253674.	314011.	351476.
DS	E-9	36331.	151496.	245563.	303971.	340239.
ETN	E-2	15738.	65625.	106374.	131675.	147386.
ETN	E-3	16314.	68027.	110267.	136495.	152780.
ETN	E-4	19391.	80858.	131065.	162239.	181596.
ETN	E-5	20299.	84644.	137202.	169836.	190099.
ETN	E-6	21623.	90165.	146151.	180914.	202499.
ETN	E-7	24399.	101741.	164914.	204140.	228496.
ETN	E-8	27150.	113212.	183508.	227156.	254259.
ETN	E-9	29485.	122949.	199290.	246693.	276126.
ETR	E-2	18470.	77017.	124839.	154533.	172971.
ETR	E-3	19055.	79457.	128794.	159428.	178449.
ETR	E-4	22185.	92509.	149949.	185616.	207762.
ETR	E-5	21220.	88485.	143427.	177542.	198725.
ETR	E-6	24051.	100290.	162562.	201228.	225237.
ETR	E-7	26754.	111561.	180831.	223843.	250550.
ETR	E-8	29811.	124308.	201494.	249420.	279179.
ETR	E-9	32214.	134328.	217736.	269525.	301683.
FTM	E-2	28452.	118641.	192308.	238050.	266452.
FTM	E-3	29056.	121160.	196391.	243103.	272108.
FTM	E-4	34384.	143377.	232403.	287681.	322005.
FTM	E-5	31298.	130509.	211544.	261862.	293105.
FTM	E-6	30712.	128065.	207584.	256959.	287617.
FTM	E-7	46573.	194203.	314789.	389663.	436154.
FTM	E-8	46580.	194233.	314836.	389722.	436220.
FTM	E-9	39659.	165373.	268057.	331816.	371405.
RM	E-2	16011.	66764.	108219.	133960.	149942.
RM	E-3	16595.	69199.	112166.	138846.	155412.
RM	E-4	18799.	78389.	127063.	157286.	176052.
RM	E-5	17109.	71342.	115640.	143146.	160225.
RM	E-6	22428.	93522.	151592.	187649.	210037.
RM	E-7	25737.	107320.	173957.	215334.	241026.
RM	E-8	27695.	115485.	187192.	231716.	259363.
RM	E-9	29242.	121935.	197648.	244660.	273850.
STG	E-2	18729.	78097.	126590.	156700.	175396.
STG	E-3	19292.	80445.	130395.	161411.	180669.
STG	E-4	20965.	87421.	141703.	175408.	196336.
STG	E-5	33482.	139282.	225765.	279465.	312809.
STG	E-6	35146.	146554.	237553.	294057.	329141.
STG	E-7	36737.	153188.	248307.	307368.	344041.
STG	E-8	40698.	169705.	275079.	340509.	381135.
STG	E-9	40254.	167854.	272078.	336794.	376977.

^aCost figures for 5, 10, 15, and 20 years reflect a 10 percent discount rate. If discounted costs are not desired, use the "1" year cost multiplied by the number of years.

Table 5 can be used to compute the total manpower costs for the lifecycle of the system. Suppose it is concluded that a communication system design calls for an operator staff of two 3rd class RMs (E-4) and one 1st class RM (E-6). The analyst would make two computations, and add them together to find the total cost per unit.

<u>Rating</u>	<u>Level</u>	<u>15-Year Lifecycle</u>	<u>Number of Men</u>	<u>Lifecycle Costs Per Unit</u>
RM	E-4	127,063	2	\$254,126
RM	E-6	151,592	1	<u>\$151,592</u>
				\$405,718

Next, the analyst must decide how many hours of each day the system must be manned. For example, if the system is to be operated continuously over a 24-hour period, the initial billet cost estimation per shift for the two E-4s and one E-6 (i.e., \$405,718 must be multiplied by three to account for three 8-hour shifts:

$$\text{\$405,718 per shift} \times 3 \text{ shifts} = 1,217,154 \text{ per unit.}$$

Finally, the analyst must decide how much the lifecycle costs of maintenance personnel will add to the total manpower cost of the system. For example, if he estimates that the maintenance of the system will require a Data Systems Technician (DS) at the E-5 level for 8 hours and an Electronics Technician [ET(N)] at the E-4 level for 4 hours a day, he would need to compute these costs and add them to the operational costs to determine the total estimated lifecycle billet costs per unit.

<u>Rating</u>	<u>Level</u>	<u>15-Year Lifecycle</u>	<u>Number of Men</u>	<u>Lifecycle Costs Per Unit</u>
DS	E-5	241,724	1.0	\$ 241,724
ET(N)	E-4	131,065	0.5	\$ 65,533
Operator Costs (as determined from previous example)				<u>\$1,217,154</u>
Total				\$1,524,411

These estimated lifecycle billet costs do not include those cost items relating to systems management personnel, officer assignments,

and external military tasks. The data do, however, permit a more nearly accurate assessment of the lifecycle costs of operator and maintenance personnel than has previously been possible. They have been calculated using a 10% discount rate. If the analyst needs to employ a different rate, he should refer to the previously cited NPRDC report for a method of handling this problem.

SECTION 10

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