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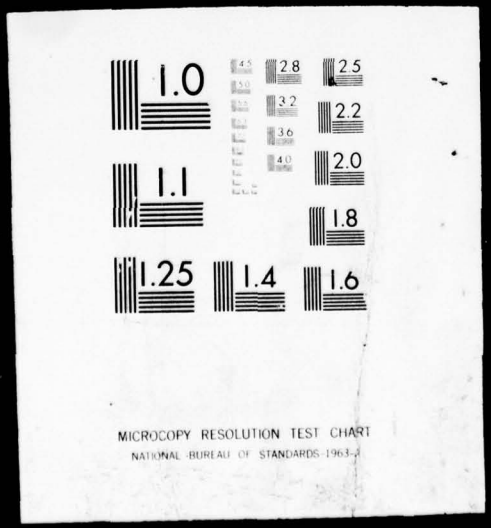


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Prepared for
DIRECTOR, AMPHIBIOUS AND COMBAT SUPPORT
SHIP LOGISTIC DIVISION
NAVAL SEA SYSTEMS COMMAND
WASHINGTON, D.C.
under Contract N00189-77-D-0612

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This report describes the research and engineering effort performed by ARINC Research Corporation during an Amphibious Engineered Operating Cycle (PEOC) Program Initiation Study for the LST-1179, LPD-4, and LHA-1 Class ships. It describes the approach, findings, and conclusions of the study. The alternative PEOC maintenance strategies for these classes are described and evaluated for both effectiveness and resource requirements. Additionally, detailed planning and engineering requirements required to develop and implement the program are described, and a Plan of Action and Milestones for the

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VOLUME II
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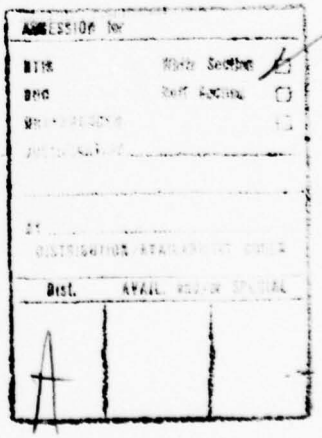
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This report describes the research and engineering effort performed by ARINC Research Corporation during an Amphibious Engineered Operating Cycle (PEOC) Program Initiation Study for the LST-1179, LPD-4, and LHA-1 Class ships. It describes the approach, findings, and conclusions of the study. The alternative PEOC maintenance strategies for these classes are described and evaluated for both effectiveness and resource requirements. Additionally, detailed planning and engineering requirements required to develop and implement the program are described, and a Plan of Action and Milestones for the program is provided.

The results of this study are presented in two volumes: Volume I - Executive Summary and Volume II - Study Report.



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CHAPTER ONE

INTRODUCTION TO THE AMPHIBIOUS ENGINEERED OPERATING CYCLE (PEOC) PROGRAM

1.1 BACKGROUND

In 1973 various ship material inspections and reports indicated that despite increasing maintenance costs, the material condition of many ships of the fleet was below acceptable standards and generally unsatisfactory. This situation clearly demonstrated the need to develop a comprehensive program aimed at achieving an early improvement of the Fleet's material condition. As a result, the Chief of Naval Operations (CNO) initiated an objective (CNO Objective #3) to improve the material condition of ships. In response to this objective, in 1977 the Chief of Naval Material (CNM) directed the establishment of the Ship Support Improvement Project (PMS 306) with a number of interrelated efforts designed to contribute to the formulation of new and more efficient maintenance strategies for Naval ships. The Ship Support Improvement Project has initiated three basic courses of action. These are (1) a Maintenance System Development Program, to make the necessary changes to the Navy maintenance system to foster improved fleet readiness; (2) an Intermediate Maintenance Activity Upgrade Program to provide for increased intermediate maintenance level capability and capacity; and (3) the Engineered Operating Cycle Program to establish a structured engineered approach for maintaining ships of selected classes. The establishment of the Amphibious Engineered Operating Cycle (PEOC) Program, initially for the LHA-1, LST-1179, and LPD-4 classes of ships, would be part of the third effort.

1.2 HISTORICAL DEVELOPMENT OF ENGINEERED OPERATING CYCLE PROGRAMS

Development of new ship maintenance strategies began with the establishment of the SSBN System Maintenance Monitoring and Support (SMMS) Program in 1970. The initial program objectives were to determine the feasibility of extending the interval between shipyard overhauls for SSBN submarines to a time compatible with the period between refuelings of the new long-life reactor cores and to provide the necessary logistic support to ensure the credibility of the resulting Extended Operating Cycle. In February 1974 the CNO approved the SSBN EOC program under the SMMS concept. Full implementation occurred for all SSBNs during 1977. For SSN submarines, the Submarine Extended Operating Cycle (SEOC) Program was instituted in 1972 for all SUBSAFE SSN 594 Class and later SSNs. The operating cycle was extended from 43 to 70 months for these ships.

In 1973, the CNO tasked the Commander, Naval Sea Systems Command (NAVSEA), to investigate the feasibility of adopting extended overhaul cycles for cruiser/destroyer classes of ships. As a result of that study and subsequent tasking by the CNO, the Destroyer Engineered Operating Cycle (DDEOC) Program was undertaken in August 1974 to develop a detailed maintenance strategy and implementation plan to support a lengthened operating cycle, selected at that time to be 54 ± 6 months. The DDEOC Program now includes the FF-1052, DDG-37, CG-16, CG-26, and DDG-2 classes.

The development of EOC programs represents a re-emphasis of the Navy's general policy of performing ship maintenance at the lowest level of maintenance activity consistent with capabilities and resources. Combat readiness and operational needs still require ships to be as self-sufficient as possible, but guidelines and policies governing maintenance strategies have been re-evaluated in the light of degraded ship material condition, increased maintenance and manning costs, and reduced Fleet ship populations. These re-evaluations have generally reaffirmed the appropriateness of the Navy's policies and guidelines, but have also shown the benefits to be derived from increased maintenance management efforts.

The traditional maintenance strategy has been considerably modified for recent new construction ship classes, especially Lo-Mix designated classes such as FFG-7 and PHM-1 with their significantly reduced shipboard manning. Maintenance strategy modifications include a shift in emphasis from piece-part replacement to modular and subassembly replacement with a greater reliance on rotable pools. For the PHM, a significant shift of level of repair from organizational to intermediate level is also apparent.

The EOC programs represent a systematic engineering approach to maintenance management that identifies and schedules periodic maintenance requirements to obtain the greatest benefit per maintenance dollar. Additionally, EOC programs provide for continued real-time review, evaluation, and assessment of the material condition of the ships in the program. The long-range maintenance management function is one of the major advantages of an EOC program.

In the near term, the identification and solution of significant high maintenance burden problems can provide for a marked improvement in material condition. Rigorous engineering review and analysis of maintenance data provide the information to set proper priorities for emerging class problems. Continued monitoring permits the program to properly plan for, rather than react to, the engineering and maintenance needs of a ship class.

1.3 EOC PROGRAM STRUCTURE

A typical surface-ship EOC program consists of a one-year initiation phase, a two-year development phase for each ship class, and an implementation phase that extends through the remaining life of the ship classes involved. New EOC programs are envisioned to be structured along these lines, patterned after already established EOC programs, with exceptions expected to accommodate the special requirements of the new classes of ships.

The objective of each program phase is attained through an engineered, analytical process. During the Initiation Phase ship data are collected and objectives and constraints that will guide the EOC program are defined. The current status of the ship's material condition and its overhaul maintenance strategy are assessed. Alternative maintenance strategies are identified and from them the preliminary EOC maintenance strategy is defined. The existing and proposed maintenance strategies are compared and analyzed and the feasibility of adopting an EOC program is evaluated.

During the Development Phase detailed engineering efforts go into a thorough development and evaluation of the specifics of the approved EOC maintenance strategy. Pertinent, detailed technical, operational, and experience data are assembled and from those data, critical equipments and systems are selected, beneficial technical and Fleet Modernization Program (FMP) alterations are identified, and maintenance requirements for pre-EOC overhauls are developed. Detailed systems engineering analyses are performed on selected critical equipments, with specific restorative and corrective maintenance requirements identified in the development of the class maintenance and modernization plans. Standards of material condition assessment and program effectiveness are developed to permit the analysis of the effectiveness of the EOC program and to modify the efforts as necessary. The EOC Management Plan provides guidance in program administration, planning, execution, and support. Together, these elements constitute the EOC plan that is implemented in the Implementation Phase.

During the Implementation Phase, each ship will be given a pre-EOC overhaul (if required) before entering its Engineered Operating Cycle. EOC support elements and organizations, including the central technical group and site teams, will be formally established to continue the coordination and integration of the EOC program with existing maintenance programs. The program will be continually analyzed on the basis of feedback received from material condition assessments and post-overhaul, trend, and program-effectiveness analyses. The results of these analyses will be used to support the management of the program and show where modification is required.

1.4 CURRENT STATUS OF EOC PROGRAMS

Among the numerous EOC programs scheduled and in various stages of development and implementation, all have common goals and similar support and interface requirements. These similarities and commonalities offer the advantage of established support organizations, plans, techniques, etc., for the establishment of new EOC programs. A general, phased process for development and implementation of EOC requirements for any specified ship class has been produced. Prior experience in submarine and destroyer EOC programs was liberally applied in the structuring of a uniform process to be applied to all candidate ship classes. Present planning provides for engineering maintenance requirements and procedures to improve and maintain material condition via EOC programs for 43 percent of the fleet by the mid-1980s. The remaining 57 percent are surface ships of a variety of ship classes that are potential candidates for the development and implementation of EOC programs. The status of existing EOC programs as of June 1978 is shown in Table 1-1.

Table 1-1. CURRENT EOC PROGRAMS		
Ship Category	Ship Class	Status
SSN	All SUBSAFE SSN 594 Class	First implementation in 1972 Final implementation projected in 1981
SSBN	All Poseidon equipped SSBNs	First implementation in 1971 Final implementation in 1977
DDEOC	FF-1052 DDG-37 CG-16 CG-26 DDG-2	First implementation in 1977 Final implementation in 1984
Lo-Mix	FFG-7 PHM-1	First implementation in 1977 Final implementation in 1988

1.5 THE PEOC PROGRAM

The PEOC Program is a proposed new EOC program whose purpose is a realignment of ship maintenance strategy designed to improve the material condition of designated amphibious ships. Its objective is to maintain combat readiness for ships in the program at an acceptable cost while maintaining or increasing their peacetime operational availability. Initially LHA-1, LST-1179, and LPD-4 Classes have been identified for the PEOC Program. A basic element of the Program will be the establishment of engineered maintenance and modernization plans for each of the designated classes. These class plans identify anticipated maintenance tasks and their frequencies. Class maintenance and modernization plans are used to forecast and assist in scheduling projected maintenance burdens on Fleet resources. The PEOC Program will provide improved planning and engineering tools to effect better maintenance management, including the optimization of ship operating cycles.

The analysis conducted in the Initiation Phase included principal logic and functional elements of reliability-centered maintenance methodology. Maintenance experience and material condition were assessed, considering mission criticality and resource costs, and then used to review and select appropriate alternative maintenance strategies. Similarly, in the Development and Implementation Phases these same considerations will be used to define and document maintenance requirements for the selected critical equipments and systems. The consistent use of this methodology helps provide assurance that the most essential and cost-effective class maintenance strategy revisions will be accomplished.

This study investigates the feasibility of adopting a PEOC Program, identifies the planning and resource requirements for the Program, and develops a detailed Plan of Action and Milestones (POA&M) for the Program. It also develops detailed engineering requirements which identify the engineering efforts to be accomplished during the development (next) phase of the PEOC Program.

CHAPTER TWO

STUDY APPROACH

2.1 INTRODUCTION

This chapter describes the approach to the Initiation Phase Study for the PEOC Program. During this phase, ship data were collected and objectives and constraints that will guide the PEOC Program were defined. The current status of the PEOC ship's material condition and the overall maintenance strategies of these ships were assessed. Alternative maintenance strategies were identified and from them, the preliminary PEOC maintenance strategy was defined. The existing and alternative PEOC maintenance strategies were compared and analyzed and the feasibility of adopting a PEOC Program was evaluated. The product of these activities is this Initiation Study, which is forwarded to support, if appropriate, approval of development of the PEOC Program. The study contains the preliminary PEOC maintenance strategy, presents PEOC Program engineering and resource requirements, and recommends a plan of action and milestones for developing and implementing the PEOC Program.

2.2 INITIATION PHASE PROCESS

The PEOC Program was initiated with a Navy task to investigate the feasibility of an EOC type program for the LST-1179, LPD-4, and LHA-1 Classes of ships. An outline of the Initiation Phase of the PEOC Program is illustrated in Figure 2-1. (The figure has been placed at the end of the chapter as a fold-out page so it can be kept in view while the rest of this chapter is being read.) This figure portrays the Initiation Phase study process utilized. The initiation study process was adapted from that outlined in the Engineered Operating Cycle Program Development Manual (draft) - February 1978.

2.2.1 Outline of Process

The PEOC Program Initiation Study consisted of identifying specific PEOC program objectives and constraints in terms of operational requirements, material condition, cost, etc. As shown in Figure 2-1, the ship class data required to determine ship class configuration and to assess the ship class status, relative to the objectives and constraints, were identified and gathered. The data were compiled and summarized to determine the current

maintenance strategy and to assess the resultant material condition of the class, considering the effect of the Fleet Modernization Program and the expected ship class life.

In addition, the data were analyzed to determine the cost and effectiveness of the current maintenance strategy. Alternatives were examined and evaluated and a preliminary PEOC strategy was selected. Its resource requirements and effectiveness were also estimated, then compared to those of the current strategy. The feasibility of the PEOC strategy was then determined on the basis of the benefits gained versus the resources required. The PEOC Development Phase Requirements were developed for the recommended preliminary PEOC maintenance strategy, and Program Objectives Memorandum (POM) estimates were generated. The proposed PEOC Program was then documented in the report of the Initiation Study and the results are submitted to OPNAV for approval.

2.2.2 PEOC Initiation Phase Schedule

The schedule of milestones for the PEOC Initiation Phase is shown in Figure 2-2. A plan of action and milestones for the PEOC Program, developed as part of the initiation study, is contained in Chapter Ten. The remaining paragraphs of this chapter describe the elements of the process of developing the initiation phase study.

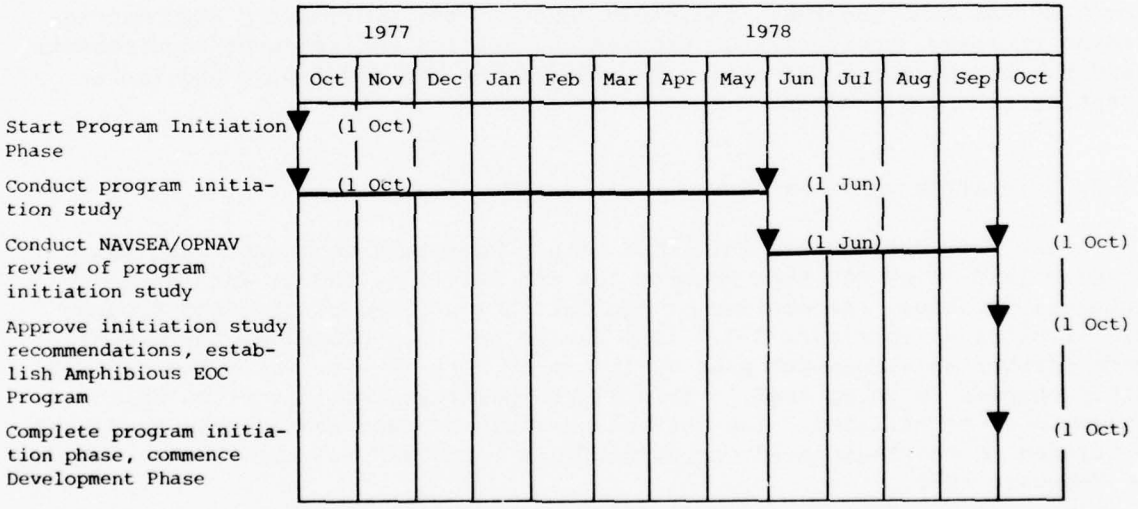


Figure 2-2. PEOC INITIATION PHASE SCHEDULE

2.2.3 Program Objectives and Constraints

To investigate the feasibility of adopting a PEOC maintenance strategy, initial program objectives and constraints were defined. The guidance was general in nature (e.g., "Improve material condition of the class, maintaining present operational availability at acceptable costs"). The specificity of the initial objectives and constraints may vary from one ship class to another. It is important for newly emerging EOC programs that initial program objectives and constraints remain general enough to permit program flexibility in order to investigate feasible engineering alternatives to maintenance strategies.

2.2.4 Data Characteristics and Collection

Generally, all maintenance data available can be useful during the development of an EOC Program. Specific types of data required tend to be dictated by the analyses to be performed. For example, for ship availability analyses, data relative to ship operating time, scheduled maintenance time, etc., were required; for material condition analyses, data associated with equipment and system failures, the amount and timing of the required corrective maintenance, etc., were required as suitable indicators.

EOC programs are developed by ship classes. Therefore, any analysis performed and conclusions drawn must derive from the entire class. It follows that the associated data going into the analysis must also be representative of the class; in addition, the data must be accurate and valid. These characteristics were considered and verified during the data identification, selection, and collection process. Due to changing conditions and human error, not all reported data are valid, accurate, and representative.

Collection of ship class data encompassed identification, selection, and collection of those data required to support the entire Initiation Phase process. To the extent specified in the program objectives and constraints, three separate applications were considered and provided for in this process. They were the determination of the current status of maintenance strategy and material condition, selection of a preliminary PEOC strategy, and measurement of the resource requirements for both the current and preliminary PEOC maintenance strategies.

2.2.5 Current Ship Status Assessment

During this portion of the Initiation Study, to the extent specified in the program objectives and constraints, the data that had been gathered were summarized and analyzed to determine the maintenance strategy and material condition. The analyses also provided a basis for recognizing improvements required in the current maintenance strategy and for selecting an appropriate preliminary PEOC strategy.

The process began with the identification of the current class maintenance strategy as defined in the EOC Program Development Manual. This

included the relative amount of maintenance performed at each echelon, or Level of Repair (LOR), the method employed in performing corrective maintenance, or Method of Repair (MOR), and the schedule for performing maintenance, or Timing of Repair (TOR). In addition, related items such as overhaul cycle and operating cycle were also described.

Current class material condition was assessed through analysis of suitable material condition indicators. Indicators of corrective and restorative maintenance were used to identify Equipment Identification Codes (EICs) which represented the greatest maintenance burden using the current maintenance strategy. To accomplish this, the indicators were selected to reflect the relative amount and importance of maintenance experienced by the Navy as a whole. This maintenance burden is a function of the maintenance man-hours and parts dollars experienced at the ship level, the Intermediate Maintenance Activity (IMA) level, and the depot level combined with the relative importance of that maintenance to ship operations. Therefore, a Maintenance Data System (MDS) factor was derived to determine the relative maintenance burden at the organizational and IMA levels of each EIC. Similarly, a Material Condition Readiness Index (MCRI) factor was derived, based on CASREPs, to determine the relative importance of maintenance, by EIC. A third factor or indicator was derived to account for depot level burden. Significant EICs were identified from each factor, then compared to determine commonality of results. The results of these comparisons were a determination of class material condition by EICs and preparation of a list of critical EICs (systems and equipments) that were responsible for a significant amount of the most important maintenance performed on the ships of the class.

When the critical EICs had been identified in terms of maintenance burden, the class modernization plans were reviewed to determine the extent of solutions already proposed for the problems identified and the extent of change contemplated.

The Initiation Phase is concerned with systems and equipments primarily at the EIC level. Therefore, detailed configuration information at the APL level will be established during the Development Phase.

Unlike many EOC programs, the PEOC program is not particularly sensitive to, or affected by, the expected life of each ship class, because no ship has yet exceeded half of its life expectancy and the current life expectancies for all classes extend beyond the year 2000.

2.2.6 Preliminary PEOC Maintenance Strategy Definition

Maintenance-critical EICs were identified in the current ship class material condition and probable improvements were then defined and classified. Alternative maintenance strategies were then investigated to determine the extent to which each could improve the ship's operational availability. The alternative selected was a new strategy created by selecting each strategy element to best improve material condition and to satisfy each PEOC Program objective within the specified program constraints. This then was identified as the preliminary PEOC strategy.

2.2.7 Program Effectiveness and Resource Requirements Estimate

This portion of the Initiation Study evalutes the effectivenss of the current and preliminary PEOC maintenance strategies and estimates the cost of that effectiveness. The objective of any maintenance strategy is to maximize the time that a ship is ready (or available) to perform its assigned missions. Accordingly, the effectiveness of a maintenance strategy was measured in terms of availability, defined as that percentage of time a ship class is either fully or substantially ready to perform its primary mission. States of readiness and the events assumed for each state are explained in Chapter Seven and correspond to the FORSTAT readiness and reporting system. This availability factor was transformed into the average number of ships (in a class) available for operations. This factor is a useful concept for comparing the effectiveness of maintenance strategies.

Information about resource requirements for maintenance strategies was generally available and documented. Requirements for organizational, IMA, and depot level maintenance were summed, including the cost of labor and of materials, and projected over the remainder of the expected life cycle of the ships.

2.2.8 Comparative Analysis

The previous analyses have measured the effectiveness of the current and of the preliminary PEOC strategies and the resource requirements of each. During this part of the Initiation Study, the effectiveness and resource requirements of each strategy were compared and conclusions were drawn relative to the feasibility of implementing the preliminary PEOC strategy. Two methods of comparison were used.

The first method related the total strategy maintenance cost to the resulting ship class availability for each strategy. It was calculated by dividing the total maintenance cost (in dollars) by the number of Ships Available for Operation (SAFO). The difference in costs between the two strategies was then compared for significance.

The second method consisted of comparing the cost of a PEOC strategy with the cost of acquiring and operating additional ships to give the same increased ship availability as would result from the PEOC strategy.

It was determined by predicting the increase in ship availability that would result from implementation of the PEOC maintenance strategy, converting that increase to an equivalent number of additional ships (based on current availability), then calculating the cost of acquiring and maintaining those additional ships. Acquisition costs were based on current experience for comparable ships. Average annual direct operating costs were obtained from the current Navy Program Factors Manual*. To determine the value of the PEOC maintenance strategy, the operational and maintenance cost of the hypothetical larger fleet (without PEOC) was compared to that of the existing fleet (with PEOC). That calculation did not completely take into

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Navy Program Factors Manual, Volume 1, OPNAV-90P-02A (revised 31 Aug. 1977).

account improved ship material condition resulting from more frequent depot availabilities (ROHs and SRAs) keeping the ships closer to optimum condition. (Current strategies require more time between, but longer duration of, depot availabilities.)

2.2.9 PEOC Program Development and Implementation

This part of the Initiation Study identifies the planning and engineering requirements of the Development Phase and the PEOC Program Plan of Action and Milestones. The planning and engineering requirements were obtained from a review of the Development Phase requirements identified in the EOC Program Development Manual in light of the special requirements of the PEOC Program. The POA&M was also developed from guidance provided in the EOC Program Development Manual.

2.2.10 Conclusions and Recommendations

The results of the PEOC Program Initiation Study are presented in summary form with recommendations which should be considered in the implementation of these results.

2.2.11 Initiation Study Review and Approval Process

During the Initiation Phase, the Amphibious and Combat Support Ship Logistic Division, Naval Sea Systems Command (NAVSEA 941), has provided PEOC program direction, while engineering support and technical coordination has been provided by PERA (ASC), the Amphibious Ships and Craft Planning and Engineering for Repairs and Alterations activity.

The Initiation Study will be forwarded to OPNAV for review and approval. Once the PEOC program is approved, the report of resource requirements and the projected POA&M should be utilized to update the Navy POM to provide budgetary planning. Approval of the program by OPNAV should provide authority to proceed with the Development Phase of the PEOC Program.

If the proposed strategy is disapproved, the reasons for disapproval will be analyzed and will be used as directed to modify the proposed PEOC program. The preliminary PEOC maintenance strategy selection process involving engineering and cost effectiveness tradeoffs will then be repeated to identify a more suitable alternative. If a suitable alternative strategy is found, the Initiation Study report can be resubmitted to OPNAV for approval.

2.3 STUDY FORMAT

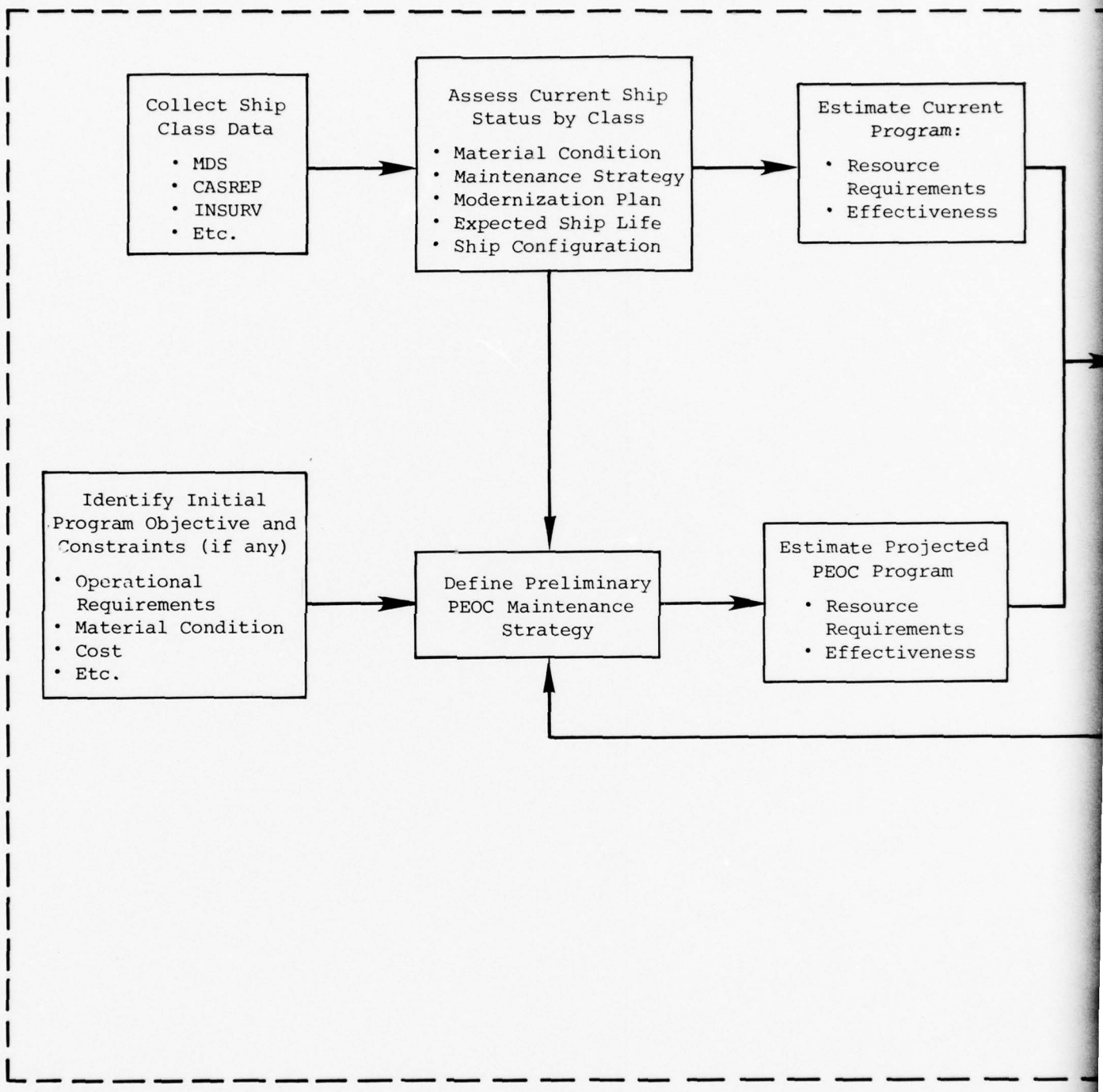
This report is structured to document and present the results of the approach that has been outlined in this chapter. The study identifies program objectives, current maintenance strategies, and areas with significant maintenance improvement potential. From this information, alternative

maintenance strategies are selected and constrasted with current strategies to measure the feasibility of alternative maintenance strategies for the LST-1179, LPD-4, and LHA-1 classes of amphibious ships. Each chapter of the study notes the basic differences, in an EOC program sense, between the LHA-1 Class, a new ship construction class, and the LST-1179 and LPD-4 classes, mature in life cycle, ship classes.

The remainder of the study consists of the following:

- Chapter Three, (PEOC Program Objectives and Constraints) identifies the objectives of the program and of the Initiation Phase as well as the nature of constraints or limiting conditions affecting the PEOC classes.
- Chapter Four (Data Characteristics and Collection) reviews the data applications required for the Initiation Phase, and the characteristics and data sources selected to support these applications. This chapter introduces the differences in historical data between the older (LST-1179 and LPD-4) classes and the newer LHA-1 Class. For the LHA-1 Class, greater emphasis was placed on the more plentiful design data.
- Chapter Five (Current Ship Status Assessment) describes the current maintenance strategy and material condition for the PEOC classes. Areas requiring significant maintenance efforts are identified to focus attention on those areas where improvements in maintenance strategy would produce the greatest benefits.
- Chapter Six (Definition of Preliminary PEOC Maintenance Strategy) investigates those areas that require significant maintenance effort and considers alternative maintenance strategies to improve them. Identified areas where material condition degraded with time were reviewed to point up their implications for a revised maintenance strategy. Maintenance-critical systems for the LHA-1 Class were assessed, primarily in terms of off-ship man-hour requirements. Primary focus for alternative maintenance strategies was placed on cycle length revisions, and maximum deployment considerations were addressed. Finally, alternative maintenance strategies were selected for each class.
- Chapter Seven (Current Maintenance Strategy Effectiveness and Resource Requirements) evaluates the effectiveness of the current maintenance strategies and estimates the cost of that effectiveness.
- Chapter Eight (Preliminary PEOC Maintenance Strategy Effectiveness) measures these values for the selected alternative maintenance strategies.
- Chapter Nine (Comparative Analysis Between Current Strategy and Preliminary PEOC Strategy) compares the measured effectiveness and resource requirements for the current and preliminary PEOC maintenance strategies and determines the feasibility of the preliminary PEOC strategies.

- Chapter Ten (PEOC Program Development and Implementation) identifies the necessary planning and engineering efforts to develop and implement the PEOC Program and contains an overall PEOC Program Plan of Action and Milestones.
- Chapter Eleven (Conclusions and Recommendations) summarizes the results of the PEOC Program Initiation Study and provides recommendations for implementation of the study results.


Collect Ship Class Data
• MDS
• CASREP
• INSURV
• Etc.
Assess Current Ship Status by Class
• Material Condition
• Maintenance Strategy
• Modernization Plan
• Expected Ship Life
• Ship Configuration
Estimate Current Program:
• Resource Requirements
• Effectiveness
Identify Initial Program Objective and Constraints (if any)
• Operational Requirements
• Material Condition
• Cost
• Etc.
Define Preliminary PEOC Maintenance Strategy
Estimate Projected PEOC Program
• Resource Requirements
• Effectiveness

Figure

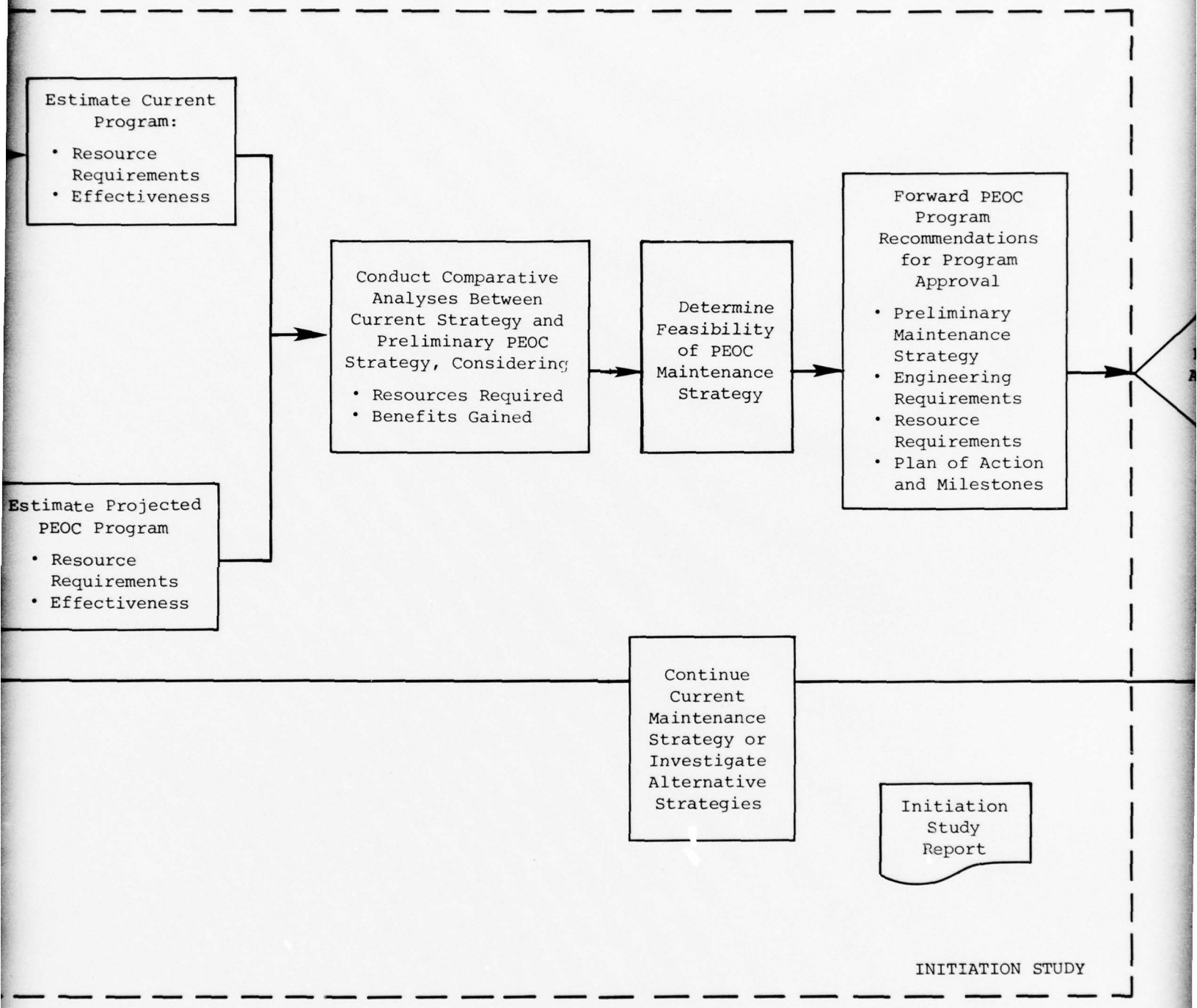
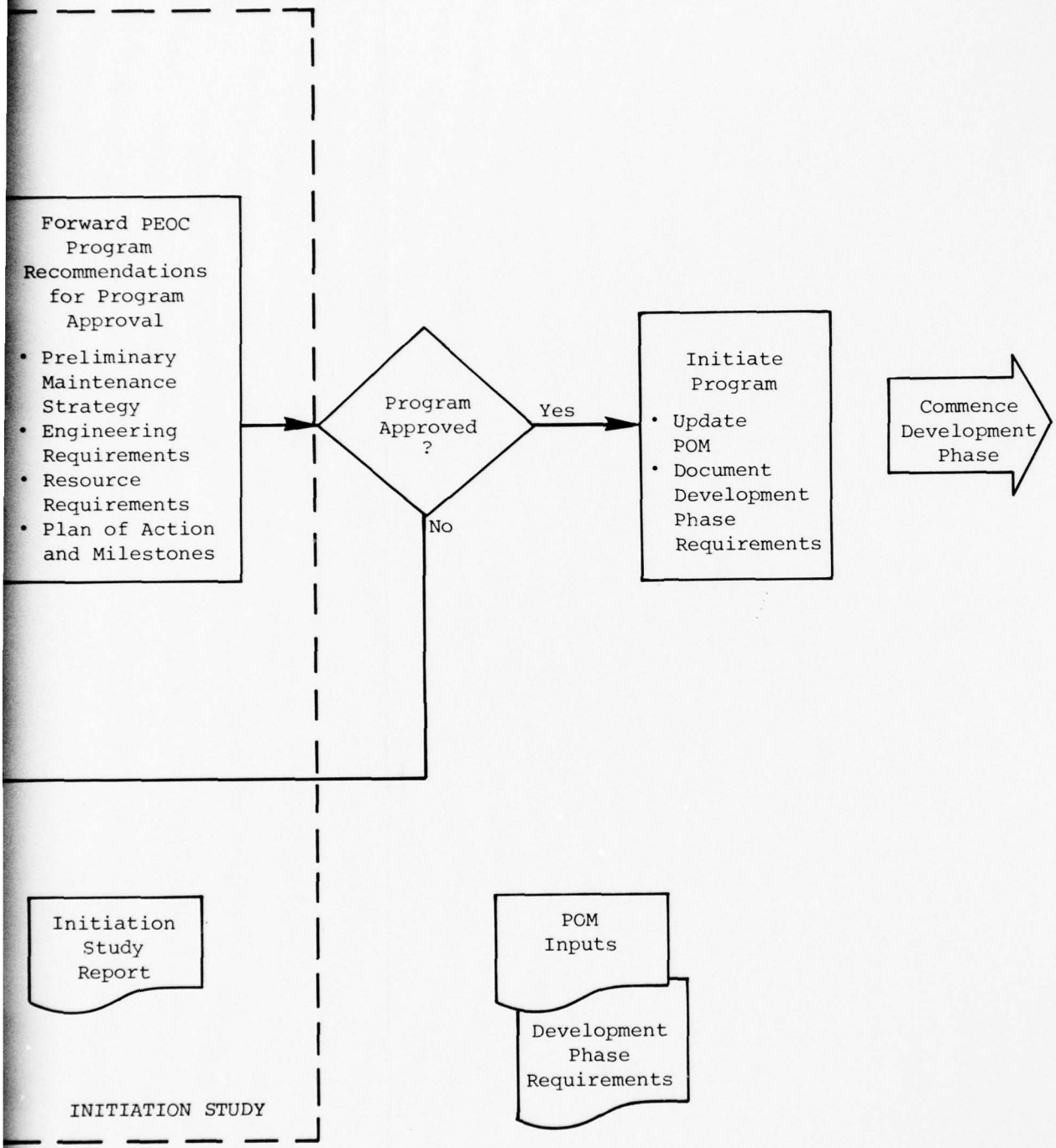


Figure 2-1 PROCESS DIAGRAM: PEOC PROGRAM INITIATION PHASE

3


Forward PEOC Program Recommendations for Program Approval
• Preliminary Maintenance Strategy
• Engineering Requirements
• Resource Requirements
• Plan of Action and Milestones
Program Approved ?
Yes
No
Initiate Program
• Update POM
• Document Development Phase Requirements
Commence Development Phase
Initiation Study Report
POM Inputs
Development Phase Requirements
INITIATION STUDY

CHAPTER THREE

PEOC PROGRAM OBJECTIVES AND CONSTRAINTS

The first two chapters of this study have provided background and a study approach to the PEOC Program. This chapter presents the overall objectives of the entire program, as well as the specific objective and constraints of the program's Initiation Phase.

3.1 PROGRAM OBJECTIVES

The principal goal of the PEOC program is to develop a long-range maintenance strategy designed to effect an early improvement in the material condition of designated amphibious ships, then maintain their combat readiness at an acceptable cost while maintaining or increasing their peacetime operational availability. A characteristic of the PEOC program will be the definition and establishment of engineered maintenance and modernization plans for the designated classes. Initially, the LHA-1, LST-1179, and LPD-4 classes have been identified for induction into this program.

3.2 PEOC PROGRAM INITIATION PHASE OBJECTIVE

The objective of the PEOC Program Initiation Study, the principal effort of the Program's Initiation Phase, is to determine if a revised maintenance strategy could deliver improved class material condition and availability in accordance with the program objectives of maintained combat readiness at an acceptable cost with no reduction in peacetime operational availability. To this end, the current maintenance strategy, operational availability, and material condition must be identified as a basis for measuring any improvements.

The focus of the material condition analysis is to assess current ship material condition and to identify areas that impose significant class maintenance burdens. These constitute noteworthy deficiencies in the current maintenance strategy and the greatest potential areas of improvement under a PEOC maintenance strategy. The maintenance burden of equipments in these areas is ranked by compiling parts costs, man-hours, and labor transactions from MDS data, modified to consider maintenance severity from CASREP data. Such equipments are termed maintenance-critical equipments.

The percentage of time a class is either fully or substantially ready to perform its primary mission is a measure of the current maintenance effectiveness. The resource requirements to continue the current maintenance strategy are projected over the class lifespan to provide a basis for comparing the cost of the current and projected PEOC maintenance strategies.

With the current class availability, material condition, maintenance strategy and maintenance strategy effectiveness, and resource requirements now defined, development of a proposed PEOC maintenance strategy may proceed. Since areas of high maintenance burden are associated with degraded material condition and maintenance periods that limit class availability, such areas should be investigated to achieve the program's objectives. The maintenance-critical equipments ranking greatly facilitates this investigation by identifying just such areas. The revised (PEOC) maintenance strategy will be selected to reduce experienced class maintenance burden.

After definition of the preliminary PEOC maintenance strategy, an estimate of its projected effectiveness and resource requirements will permit measurement of the cost effectiveness of improvements resulting from the revised maintenance strategy. The effectiveness and resource requirements estimates will be obtained using the same procedures used to obtain the current maintenance strategy estimates. Direct comparison of these estimates will permit a conclusion regarding the feasibility of the PEOC Program.

3.3 PROGRAM CONSTRAINTS

The inititation study was unconstrained by any external influence or decisions. This feature significantly improved the study's objectivity, and resulted in the development and recommendation of alternatives derived from consideration of the program objectives and actual constraints or limiting conditions found within the PEOC classes.

While the study was unconstrained, there are several limiting factors that have a direct effect on the practicality of the PEOC Program achieving program objectives. Factors to be considered include engineering, planning, and operations:

- Engineering - Determination of current maintenance strategy effectiveness can only be as accurate and complete as the data available on material condition, repair standards, and cost.

- Planning - Alterations that improve class reliability and maintainability will require early identification for possible pre-EOC accomplishment. This would become imperative to ensure the ship could, in fact, attain the projected reliability on which the class maintenance and modernization plans were developed during the development phase.

- Operations - Deployment committments and normal operating schedules must be considered when determining maintenance availabilities and cycle lengths. Additional intermediate and depot level availabilities might appear attractive if material condition were the sole consideration; however, operational considerations argue against this alternative.

CHAPTER FOUR

DATA CHARACTERISTICS AND COLLECTION

This chapter describes the principal data gathered to support the Initiation Phase Study. A summary of the data characteristics and sources utilized for each class is presented. The nature of the available data varied considerably between the older (LST-1179 and LPD-4) classes and the newer LHA-1 Class.

General descriptive information for the LST-1179, LPD-4 and LHA-1 ship classes is contained in Appendix D.

4.1 DATA CHARACTERISTICS

The type of data required during the development of the PEOC program is dictated by the PEOC objectives and constraints and the associated analyses to be performed. The sources of those data, however, depend on the availability of operational history of the ship's class. The objectives and constraints of the PEOC Program as defined in the preceding chapter require an analysis of reliability, maintainability, and availability (RMA) data to determine if the ship's systems and equipments are inherently capable of supporting these objectives and constraints. For ships with a significant operational history, the actual ship operational and maintenance data are usually the best source of RMA data. For new ships with little or no operational data, the prime source of RMA data is design data, available in the form of RMA evaluations performed by the ship design activity.

4.1.1 LST-1179 and LPD-4 Classes

Both ship classes have had a significant operational history, so actual ship operational and maintenance data were utilized. Since the PEOC Program is developed for a ship's class, these data must be representative of that class. In addition, they must give a true picture of the actual present condition of that class. To accomplish this, operational data were summarized and compared for consistency, and maintenance data were screened to ensure that only corrective (repair) maintenance was included. Analysis of data that have lost their significance because of past or planned alterations to a ship's class could result in the identification of a maintenance problem to which a solution has already been planned. Also, such varied elements as main propulsion plants or nature of operations (East Coast vs. West Coast, wartime vs.

peacetime) within a class may vary. Conclusions must therefore be based on data which are representative of these differing conditions. Data were collected for both Atlantic and Pacific fleet units, and Maintenance Data System information did include data collected during the Vietnam period.

4.1.2 LHA-1 Class

Due to the lack of substantial LHA-1 Class operational history, design data were mainly utilized. Where historical and design data were both available, comparisons were made to provide evidence in verifying design data accuracy.

4.2 DATA COLLECTION

Collection of ship class data encompasses identification, selection, and collection of those data required to support the entire Initiation Phase process. To the extent specified in the program objectives and constraints, three separate applications need to be considered and provided for in this process. They are the determination of the current status of maintenance strategy and material condition, selection of a preliminary PEOC strategy, and calculation of the resource requirements for both the current and preliminary PEOC maintenance strategies.

The data required to determine maintenance strategies must quantify the level, method, and timing of repair (LOR, MOR, TOR) and define the Ship Operating Cycle. The data must therefore include the amount of maintenance performed, the level (organization, IMA, or depot) at which it is performed, the method of its performance, and the method of scheduling its performance. Ship class historical data are the preferred source of information. If, however, the maintenance history is insufficient to provide those data, ship class design data may be studied instead.

The data required to determine material condition consists primarily of RMA type data, i.e., number of failures, amount of downtime, time to repair, etc. Again, ship class historical data are the preferred source of information. If, however, the maintenance history is insufficient to provide those data, ship class design data may be studied instead.

To determine resource requirements, the data must specify the number of men and the amounts of money and time required to maintain the specified ships. The sources must include those at each maintenance level - organization, IMA, and depot. Here again, ship class historical data are preferred. However, planning yard design data coupled with TYCOM and Headquarters planning data may be substituted.

Data sources that give these kinds of historical information are the Ship employment schedules, Maintenance Data System, Casualty Reporting System (CASREPs), Ship Alteration and Repair Packages (SARPs), and Inspection and Survey (INSURV) Reports. The following sections identify data available and used in this study.

4.2.1 Maintenance Data System Data

MDS data tapes containing all the corrective maintenance reports submitted on the LST-1179, LPD-4, and LHA-1 Classes were obtained from the Maintenance Support Office (MSO). The data period covered for the LST-1179 and LPD-4 classes was from 1 January 1970 through 30 September 1977. The LHA-1 data period was 1 January 1974 to 8 December 1977. These records were then screened (as previously mentioned) and summarized by means of computer programs specifically designed to extract this information. These programs summarized the Ship's Force corrective-maintenance effort in four-digit Equipment Identification Codes by such parameters as total maintenance events, total maintenance man-hours, and total material or parts dollars expended. The data consisted of approximately 538,000 records for the LST-1179 Class; 521,000 records for the LPD-4 Class, and 58,897 records for the LHA-1 Class. The LHA-1 Class had only two ships reporting during this period.

4.2.2 Casualty Report Data

CASREP data for the LST-1179, LPD-4, and LHA-1 Classes for the period 1 January 1974 through 30 November 1977 were utilized. The data consisted of 2,782 CASREPs for the LST-1179 Class, 3,037 CASREPs for the LPD-4 Class, and 294 CASREPs for the LHA-1 Class. This information was obtained from the Consolidated Casualty Reporting System and included to ensure proper consideration of experienced serious failures.

4.2.3 Ship Alteration and Repair Package Data

The SARPs in Table 4-1 were utilized in the conduct of this study. For the LST-1179 Class, the LST-1194 Baseline SARP contained representative information for LST-1182 through LST-1198. No LHA-1 Class SARPs were available since none of the class has yet been overhauled nor required preparation of a SARP.

Table 4-1. LST-1179 AND LPD-4 CLASS OVERHAUL SARPS USED

Hull Number	Ship Name	Report Dated
LST-1194	USS La Moure County (Baseline SARP for 17 ships, LST-1182 through 1198)	Covers period from 28 July 1976 to present
LST-1190	USS Boulder	5 April 1976
LST-1195	USS Barbour County	12 December 1975
LST-1198	USS Bristol County	30 April 1976
LPD-4	USS Austin	23 July 1976
LPD-7	USS Cleveland	7 December 1976
LPD-8	USS Dubuque	21 December 1976
LPD-9	USS Denver	25 February 1977
LPD-13	USS Nashville	16 March 1977

4.2.4 Inspection and Survey Data

INSURV data in the form of Preliminary Acceptance Trial and Final Contract Trial Reports as specified in Tables 4-2 and 4-3 were utilized to ensure that the analysis had identified areas where unsatisfactory material condition was being experienced.

Table 4-2. PRELIMINARY ACCEPTANCE TRIAL REPORTS LST-1179 AND LPD-4 CLASS SHIPS

Hull Number	Ship Name	Report Dated
LST-1185	USS Schenectady	17 April 1970
LST-1189	USS San Bernadino	29 January 1971
LST-1196	USS Harlan County	29 March 1972
LPD-11	USS Coronado	4 May 1970
LPD-6	USS Duluth	31 May 1966
LPD-14	USS Trenton	25 January 1971

Table 4-3. FINAL CONTRACT TRIAL REPORTS LST-1179 AND LPD-4 CLASS SHIPS

Hull Number	Ship Name	Report Dated
LST-1180	USS Manitowic	20 July 1970
LST-1185	USS Schenectady	4 November 1970
LST-1189	USS San Bernadino	22 July 1971
LST-1196	USS Harlan County	28 September 1972
LPD-6	USS Duluth	26 September 1966
LPD-11	USS Coronado	6 November 1970
LPD-4	USS Trenton	13 September 1971

4.2.5 Operational and Financial Data

Operational data for the study was compiled from OPNAV policy guidance, TYCOM scheduling templates and Quarterly Employment Schedules. Financial data was extracted from shipyard departure reports, TYCOM records, the Maintenance Data System, the Navy Resource Model and discussions with cognizant class maintenance personnel. Use of this wide variety of data sources provides more complete information and permits development of more complete and consistent study results.

4.2.6 Unique LHA-1 Class Data

In addition to the operational data for this class identified in the MDS and CASREP sections, additional information was obtained in order to ensure that current maintenance strategy and material condition were properly identified, and that the preliminary PEOC strategy was developed from comprehensive information sources. The listing in Table 4-4 tabulates the principal sources of this additional information. A detailed list of the builder's Plans For Maintenance (with associated EICs) is contained in Table 4-5. This table groups the Plans For Maintenance (PFM) in such a way that each EIC applies to one and only one system.

Table 4-4. ADDITIONAL LHA-1 CLASS DATA SOURCES

1. LHA Plan for Maintenance, Ingalls Shipbuilding Contract: No. N0024-69-C-0283, CDRL No. L001AA of August 1976.
2. Supplementary Data to LHA Plans For Maintenance, Ingalls Shipbuilding Contract No. N0024-69-C-0283, CDRL No. L001AA (Preliminary).
3. LHA-2 Plan For Maintenance, Ingalls Shipbuilding Contract No. N0024-69-C-0283, CDRL No. L001AA of July 1977.
4. Ship Manning Document LHA-1 Class Ship (PSMD), Ingalls Shipbuilding Contract No. N0024-69-C-0283, ID No. 02-101, Issue No. 5, CDRL No. Q001AB of 1 November 1973.
5. Manning Adequacy Assessment Report for LHA-1 Class Ship, Ingalls Shipbuilding Contract N00024-69-C-0283, 1 July 1977, Part of OPEVAL Report CDRL No. T001AK.
6. Draft Ship Manpower Document (DSMD) USS Tarawa LHA-1, C.O. NAVMACPAC Ltr. 5310, Ser. 741 of 14 July 1977.
7. SEA 941 Memo to PMS-377, LHA-1 C1/4728 Ser. 3078 of 4 August 1977 re: LHA Alterations for FY 78 RAV.
8. COMNAVSURFLANT Ltr. 4710, Ser N4114/12567 of 5 December 1977 re: LHA Class Corrective Action Plan.
9. Status Report on LHA Technical Problems Presented by Amphibious Ship Acquisition Project, PMS-377 of January 1978.
10. CNO Memo for (OP-03) Ser. 124E1/195871 of November 28, 1977 re: Assessment of Manpower Recommendations on the Report of the Senior Navy Steering Board (SNSB).
11. CNO Ltr. Ser. 03/212339 of 28 December 1977 re: Automatic Propulsion Control and Assault Systems Manpower Actions.
12. Chairman, Senior Navy Steering Committee Ltr. SEA 94/JRM/lt, Ser. 7 of January 13, 1978 re: Minutes of SNSB meeting held 6 January 1978.
13. COMNAVSEASYSCOM Ltr. SEA 94/JRM/CT, Ser. 16 of 23 January 1978 re: Findings and Recommendations of SNSB Concerning Automatic Propulsion and Assault Systems.
14. Chairman, Senior Navy Steering Committee Ltr. SEA 94/JRM/ag Ser. 24 of 26 January 1978 re: Minutes of SNSB Meeting held 24 January 1978.
15. USS Tarawa (LHA-1) INSURV Report of 8 March 1976.

Table 4-5. LHA-1 CLASS LISTING OF BUILDERS PLANS FOR MAINTENANCE CORRELATED TO EICS

PFM Description	EICs Reported Against
A01 Boilers	F100-F103
A02 Propulsion	BAA3, D801-FA01, FC01, FE00-F001
A03 Main Steam	F700-F705, K700-K703
A04 Feed and Condensate	F30B-F309, K30K
A05 Main Circ. Water	AB00-AB03, FB09
A06 Fuel Oil	F500-F507, F601
A07 Lube Oil	FD00-FD07
A08 Combustion Air	F400-F403
B12 Ship Service and Emerg. Power Gen.	B004-B301, CB03, 3000-310E, 310G-3111, 3300-3406
B13 60 Hz Power Distribution B17 Lighting	4000-410D, 410G-4507 4804-4807, 7DF1
B14 D.C. Electrical Systems	N40K-N504, 3115-330L, 4600-470F
B15 400 Hz Power Distribution	310F, 470M-4704
C19 D.C. Monitoring C22 I.C. Systems LLA 401 Interior Voice Communications	M000-M733, 410E
C27 Non-Electronic Navigation Systems	LB0M-KL08
D29 Auxiliary Steam and Drain Systems	TE01-TE03, TH00-TH04, T10A-T105
D30 Gasoline Systems	TD0A-TD30, T60A-T607
D33 Ballast Systems E48 Salt Water Systems	AC00, TA00-TA04, T800-T806 T903-T904, T908-T909
D34 Ship Control and Steering	TL0C-TL07
D35 Fresh Water Systems D40 Comm. and Cont. Cooling	TB00-TB07, TK01-TK04
D37 Compressed Air and Gas	TF01-TG07
D45 Ventilation Systems	T106-T309
D46 Air Conditioning Systems	T40B-T409
F10 Deck Equipment	TM00-TM06, TT00-TT09, YA00-Y406, 180A, 1808
F69 Hull and Hull Fittings	AD00-AD01, AD05-A908, TC00-TC07, UF05-UG03, UH05, U101, 1107-1701
G43 Waste Disposal	T70B-T708
G54 Supply Dept. Systems	T500-T504, 1A00-1B03
G56 Medical and Dental	1D00-1D08
H59 Aircraft Handling H61 Assault Systems	AD03-AD04, TN00-TN05, TS00-TTOC, TU01-TU05, Z2E4-Z231, TF10-7000
J64 Ordnance	GC11-GDU2, GWCE-GWHK, JF03-JF05, 8AC1-8992
J76 Ship Shops K57 Aviation Shops	190N-1930
H36 PCB Repair J87 Qualif. Standards Lab. LLA C & CS Comm. & Cont. Support LLA 610 Support Equipment E52 Damage Control	WA0G-W900, T900-T901, T906
LLA 402 Gunfire Control	GY2B-G7J8, GPCA-GPEA
LLA 404 Electronic Countermeasures	NA10-ND04, N80K-N90T
LLA 405 Guided Missile Fire Control	5BEA-5ZEB
LLA 408 Surveillance Systems LA1 Waveguides	PD00-P90V
LLA 409 Radio Communications LLA 413 ITAWDS	HADA-H100, QAOM-Q984
LLA 410 Electronic Navigation	LL00-L900, R50Z, R502

CHAPTER FIVE

CURRENT SHIP STATUS ASSESSMENT

5.1 INTRODUCTION

This chapter describes the research and analyses performed to identify the current maintenance strategy and material condition of the LST-1179, LPD-4, and LHA-1 classes of ships. In addition, critical ship systems and equipment, by EIC, that represent the most significant maintenance resource burdens were identified as the areas to concentrate on in revising the current maintenance strategy. Improvements in these areas would result in the greatest achievable benefits. The effects of class modernization and of expected ship life were also assessed.

Section 5.2, Current Ship Class Maintenance Strategy, discusses the elements of, and possible variations in, ship maintenance strategies. These strategies identify (for each PEOC class) what level of maintenance organization is responsible for the majority of ship maintenance, what method of repair is generally employed in performing corrective maintenance, on what schedule maintenance is generally performed, and what operating cycle the maintenance supports.

Section 5.3, Material Condition, provides an assessment of ship material condition resulting from the current ship maintenance strategy.

Section 5.4, Maintenance-Critical Systems, develops a list of maintenance-critical systems, reflecting the combined importance of the analysis of material condition indicators.

5.2 CURRENT SHIP CLASS MAINTENANCE STRATEGY

5.2.1 General

The EOC Program Development Manual discusses at some length the elements of, and possible variations in, ship maintenance strategies. These elements were considered for this study. They traditionally identify which level of maintenance organization is responsible for the majority of the ship maintenance, what method of repair is generally employed in performing

corrective maintenance, on what schedule maintenance is generally performed, and what operating cycle the maintenance supports. These elements can be identified as LOR (Level of Repair), MOR (Method of Repair), TOR (Timing of Repair), and Operating Cycle, respectively:

- Level of Repair - As a general policy,* in order to maximize operational readiness of the Fleet units and to minimize costs, ship maintenance is performed at the lowest level of maintenance activity consistent with capabilities and resources. Repairs to ships and their equipment not requiring the facilities of a shore-based activity are performed by Forces Afloat. Navy policy requires ships to be as self-sufficient as possible. For each ship class, responsibility for maintenance is assigned to one of the following three LORs, as appropriate.
  - Organizational (Shipboard) Maintenance - Maintenance that is the responsibility of and performed by the Ship's Force on assigned equipment.
  - Intermediate Maintenance - Maintenance normally performed by Navy personnel on tenders, repair ships, aircraft carriers, Fleet support bases, and FMAGs. It normally consists of calibration, repair, or replacement of damaged or unserviceable parts, components, or assemblies; the emergency manufacture of unavailable parts; and provision of technical assistance to using organizations. Additional Shore IMAs (SIMAs) are programmed for operational use in the early 1980s to augment existing facilities.
  - Depot (Shipyard) Maintenance - Maintenance performed by industrial activities on material requiring major overhaul or a complete rebuild of parts, assemblies, subassemblies, and end items, including parts manufacture, modification, testing, and reclamation as required. This is normally accomplished at commercial facilities or Naval shipyards, including ship repair facilities, during restricted availabilities, technical availabilities, and Regular Overhauls (ROHs).
- Method of Repair - Three principal methods of repair are available for performing corrective maintenance:
  - Piece Part Replacement - Replacement of the individual failed piece or part as identified on the manufacturer's drawing. It is the most common method of repair.
  - Modular/Subassembly Replacement - Replacement of the entire module or subassembly, if the failed part itself is not easily removable, but is part of a module or subassembly that is easily replaceable. The removed module or subassembly can be discarded or returned to a repair facility, reconditioned, and returned to stock. This method of repair is most commonly used for electronic equipment such as circuit boards.

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*OPNAVINST 4700.7E

- Rotable Pool Replacement - This method of repair is limited to major assemblies that have been identified for maintenance management as part of a specific Rotable Pool Program. This method is generally employed only when major corrective or restorative maintenance is required. It consists of replacing the entire assembly with a new or refurbished one, sending the replaced assembly to a designated repair facility for maintenance, then returning the repaired assembly to stock. The principal advantage is the reduced downtime of shipboard equipment. The principal disadvantage is the additional cost of establishing the initial supply of ready spare equipment.

- Timing of Repair - Although the need for maintenance can be determined in several different ways, the timing of repair is generally dictated by one of the following three means:

  - Periodic - This method requires that some maintenance be performed at specific intervals, regardless of equipment material condition. The extent of the maintenance may, however, depend on the material condition, e.g., "clean and inspect strainer every 6 months; repair or replace as necessary". This method of maintenance timing is generally invoked when the equipment wear-out rate is predictable and is a function of time (usually operating time of equipment utilized at a relatively constant rate).

  - On-Condition or Condition Dependent - This method requires that the equipment material condition be monitored regularly through the operating cycle and that maintenance be performed only when the material condition deteriorates beyond certain specified limits, e.g., "Replace journal bearing when clearance exceeds 0.008 in.". This method of maintenance timing is generally specified when deteriorated material condition is readily discernible, unacceptable limits are definable, and wear-our rate may or may not be constant.

  - Run-to-Failure - Some equipments exhibit no characteristics that can be interpreted as indicating a need for maintenance or imminent failure. Furthermore, their periods of satisfactory operation have no apparent correlation with time. They, therefore, do not lend themselves to either periodic or on-condition maintenance and the most practical policy is to run them to failure.

- Operating Cycle - The CNO, in OPNAVINST 4700.7, establishes the length of the operating and of the overhaul cycles, but delegates responsibility for adjusting those cycles to the Fleet Commanders-In-Chief. Adjustments may be necessary to meet operational commitments or to remain within assigned resource limitations.

The Type Commanders (TYCOMs) are responsible for developing the detailed ship employment schedules. In so doing, they use planning guides (called scheduling templates) to specify allotments of time in a cycle to

ship operations, maintenance, training, inspections, and overhauls. Within this Initiation Study, it was found useful to use the sequence of ship cycle events as described by these templates when considering alternative operating cycle lengths for each ship class. Although recent ROH durations have exceeded lengths established by OPNAV policy, OPNAVINST 4700.7 values were used in this study to ensure a consistent reference for both the current and alternative maintenance strategies.

5.2.2 LST-1179 Class Maintenance Strategies

Maintenance strategies, as such, are seldom sufficiently defined and documented to permit quantitative specifications of the amount of maintenance to be performed at each LOR by each MOR or on the basis of each TOR for individual ship classes. Instead, information on maintenance strategies must be collected and correlated from various Navy sources - maintenance data, class maintenance managers, provisioning documentation, etc. This was the method used for the LST-1179 Class. Inspection of maintenance histories and data, review of provisioning technical documentation, and discussions with the NAVSEA Ship Logistic Division and PERA (ASC) personnel all confirm that the majority of the maintenance during the operating cycle is performed at the organizational level, utilizing piece-part replacement on a periodic basis. Except for some electronic equipment, very little modular/subassembly replacement has been performed. No rotable pool replacement program has been in effect except for special "turn-around" programs (such as those for gun sights, communication antennas, etc.).

A review of the Ship's Force manning for the LST-1179 Class indicated that personnel are adequate in quantity with some improvement in skill levels desirable; however, existing levels are representative of current fleet standards.

The operating cycle length, per the TYCOM templates, is scheduled at approximately 37 months for Atlantic Fleet ships and approximately 36 months for Pacific Fleet ships with two deployments per cycle. A 4.00 month regular overhaul is scheduled, per OPNAVINST 4700.7, after each (two-deployment) operating cycle. Figure 5-1 displays the current two-deployment cycle for

Post Overhaul	Deploy	Training/ Upkeep/ Operations	Deploy	Pre-Overhaul	ROH
7.46	5.05	14.70	5.13	3.93	4.00

(all values in months)

Overhaul Cycle Length 40.27 months
Operating Cycle Length 36.27 months

Figure 5-1. LST-1179 CLASS CURRENT CYCLE

- Rotable Pool Replacement - This method of repair is limited to major assemblies that have been identified for maintenance management as part of a specific Rotable Pool Program. This method is generally employed only when major corrective or restorative maintenance is required. It consists of replacing the entire assembly with a new or refurbished one, sending the replaced assembly to a designated repair facility for maintenance, then returning the repaired assembly to stock. The principal advantage is the reduced downtime of shipboard equipment. The principal disadvantage is the additional cost of establishing the initial supply of ready spare equipment.

- Timing of Repair - Although the need for maintenance can be determined in several different ways, the timing of repair is generally dictated by one of the following three means:

  - Periodic - This method requires that some maintenance be performed at specific intervals, regardless of equipment material condition. The extent of the maintenance may, however, depend on the material condition, e.g., "clean and inspect strainer every 6 months; repair or replace as necessary". This method of maintenance timing is generally invoked when the equipment wear-out rate is predictable and is a function of time (usually operating time of equipment utilized at a relatively constant rate).

  - On-Condition or Condition Dependent - This method requires that the equipment material condition be monitored regularly through the operating cycle and that maintenance be performed only when the material condition deteriorates beyond certain specified limits, e.g., "Replace journal bearing when clearance exceeds 0.008 in.". This method of maintenance timing is generally specified when deteriorated material condition is readily discernible, unacceptable limits are definable, and wear-our rate may or may not be constant.

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The operating cycle length, per the TYCOM templates, is scheduled at approximately 37 months for Atlantic Fleet ships and approximately 36 months for Pacific Fleet ships with two deployments per cycle. A 4.00 month regular overhaul is scheduled, per OPNAVINST 4700.7, after each (two-deployment) operating cycle. Figure 5-1 displays the current two-deployment cycle for

Post Overhaul	Deploy	Training/ Upkeep/ Operations	Deploy	Pre-Overhaul	ROH
7.46	5.05	14.70	5.13	3.93	4.00

(all values in months)

Overhaul Cycle Length 40.27 months
Operating Cycle Length 36.27 months

Figure 5-1. LST-1179 CLASS CURRENT CYCLE

the LST-1179 Class. The operating cycle length represents an average of SURFLANT and SURFPAC template values. The overhaul cycle length is obtained by adding the ROH duration to the operating cycle.

5.2.3 LPD-4 Class Maintenance Strategy

The investigation of the LPD-4 Class paralled that of the LST-1179 Class, with similar results obtained. For this class also the majority of the maintenance during the operating cycle is performed at the organizational level, utilizing piece-part replacement on a periodic basis. Except for some electronic equipment, very few modules or subassemblies are replaced for this class. No rotable pool replacements have been specified except for previously mentioned special "turn-around" programs.

On the basis of discussions with fleet personnel and a review of class maintenance data, LPD-4 Class manning appeared satisfactory in quantity and quality.

The operating cycle length, according to the TYCOM templates, is scheduled at approximately 37 months for SURFLANT ships and approximately 36 months for SURFPAC ships with two deployments per cycle. A 4.50 month regular overhaul is scheduled, according to OPNAVINST 4700.7, after each (two-deployment) operating cycle. Figure 5-2 displays the current two-deployment cycle for the LPD-4 Class.

Post Overhaul	Deploy	Training/ Upkeep/ Operations	Deploy	Pre-Overhaul	ROH
7.46	5.05	14.70	5.13	3.93	4.50

(all values in months)

Overhaul Cycle Length 40.77 months
Operating Cycle Length 36.27 months

Figure 5-2. LPD-4 CLASS CURRENT CYCLE

5.2.4 LHA-1 Class Maintenance Strategy

The current maintenance strategy for the LHA-1 Class, like that for the LST-1179 and LPD-4 Classes, is not well defined and documented, although the shipbuilder's designed maintenance strategy is well documented. In addition to the information from maintenance histories and data, provisioning technical documentation, and NAVSEA Ship Logistic Division and PERA (ASC) personnel, insight into the planned maintenance strategy was available from a review of the LHA Plans For Maintenance (PFMs). These documents, developed during ship construction, analyze the maintenance requirements for most of the ship's mission-critical equipment and assign the LOR, MOR, and TOR for each. These various information sources confirm that the majority of the maintenance is performed at the organizational

level, utilizing piece-part replacement on a periodic basis. Very little modular or subassembly replacement is performed except on some electronic equipment. No rotable pool replacements have been specified nor anticipated except for special "turn-around" programs mentioned previously.

LHA-1 Class manning has been the topic of a prolonged controversy. Final results of the issue of increased shipboard manning can be evaluated only after options affecting shipboard automation design problems have been chosen. Analysis of design and historical data indicated that current manning for this class, reflecting considerable increase since commissioning, is now satisfactory.

The LHA-1 Class operating cycle length, according to the TYCOM templates, is scheduled at approximately 37 months for SURFLANT ships and approximately 36 months for SURFPAC ships with two deployments per cycle. A 6.00 month regular overhaul is scheduled, according to OPNAVINST 4700.7, after each (two-deployment) operating cycle. Figure 5-3 displays the current two-deployment cycle for the LHA-1 Class.

Post Overhaul	Deploy	Training/ Upkeep/ Operations	Deploy	Pre-Overhaul	ROH
7.46	5.05	14.70	5.13	3.93	6.00

(all values in months)

Overhaul Cycle Length 42.27 months
Operating Cycle Length 36.27 months

Figure 5-3. LHA-1 CLASS CURRENT CYCLE

5.3 MATERIAL CONDITION

An important aspect of the current ship status is the assessment of the ship material condition achieved by using the current ship maintenance strategy. A good measure of the success of a maintenance strategy is the resulting material condition of the ship's equipment and systems. Material condition is best determined through analysis of suitable material-condition indicators.

5.3.1 Material-Condition Indicators

One indicator of material condition is the number of failures experienced for a piece of equipment or system, by EIC, over a period of time. A measure of the severity of each failure is necessary to differentiate between serious and less serious failures. Identification of occurrence

of system and equipment "failures" and classification as to seriousness from existing data bases is very difficult. Identification and classification of the resulting corrective maintenance is, however, considerably easier. Maintenance Data System data can be used to identify the number of times corrective maintenance is performed and the associated man-hours expended. The ratio of corrective maintenance transactions for a specific EIC compared to the total for the entire ship can be used as an indicator of material condition for that EIC. Likewise a similar ratio for repair parts dollars and for corrective maintenance man-hours expended can be used as indicators. Similarly, CASREP summaries can be used to indicate the severity of failures and to determine the percentage of total ship CASREPs attributable to a specific EIC.

Four-digit Equipment Identification Codes* have been used throughout this study to identify and compare equipments and systems reporting maintenance action and repair parts usage. Although items of varied size and importance are described by these "equipment" level codes, they are very helpful in consolidating the large data base gathered for this study. The EIC level of data summarization was selected in order to omit overwhelming detail while conducting analyses at the ship class level. This level aggregates the data reported by specific equipments [identified by nine-digit numbers from the Allowance Parts List (APL)], and localizes areas of high resource consumption to facilitate further detailed analysis. While individual EICs varied greatly in technical details, for purposes of this study their material-condition indicators were found to be comparable.

Maintenance-Critical Indicators were used to identify EICs that experienced significant or moderate material condition degradation. These EICs were then considered as maintenance-critical systems. These maintenance-critical systems were ranked, as described in Section 5.4, to provide identification of the EICs offering the greatest potential benefit from a revised maintenance strategy.

5.3.1.1 Maintenance Data System Factor

A Maintenance Data System Factor summarizes the following four MDS indicators of material condition:

1. Ship's Force parts dollars
2. Ship's Force man-hours
3. Intermediate Maintenance Activity man-hours
4. Number of Ship's Force labor transactions

Ship's Force parts dollars were used to give an indication of maintenance parts costs. The Ship's Force man-hours and IMA man-hours were used because they show the Forces Afloat effort required to maintain an equipment. The number of Ship's Force labor transactions was used because it

*Navy Maintenance and Material Management Information System Equipment Identification Code Master Index, MSO 4790.E2579, December 1976.

provides an indication of the total number of times manpower was expended on an equipment.

These four categories represent the full range of Forces Afloat maintenance techniques that different types of equipments require. For example, some equipments are modular in construction and their maintenance requires wholesale replacement of assemblies. The net result is a high parts cost and, often at the Ship's Force level, a relatively low manpower expenditure. Other equipments require high manpower expenditures, but little or no parts cost (e.g., a leaking valve bonnet that needs to be lapped). Some equipments can be repaired only at an IMA facility and other equipments, while not requiring large amounts of parts dollars or manpower, require maintenance attention often enough to be a burden.

In the total maintenance reported against an EIC, if any of the four indicators of maintenance condition was significant in relation to the entire class data base, the EIC was designated for further analysis. For purposes of this study, one-tenth of one percent (0.1 percent) of the data base total for the indicator was set as the Significance Threshold (e.g., $14.3 million spent for repair parts by the class during the data period makes the Significance Threshold for parts expenditure $14,300). If any equipment or system (represented by an EIC number) had $14,300 in parts cost reported against it, the EIC was designated for further analysis. Thresholds for the LST-1179 and LPD-4 Classes are shown in Tables 5-1 and 5-2 respectively. Because of the relatively small historical data base for the LHA-1 Class, this refinement step in the procedure was omitted and all EICs were analyzed further.

Table 5-1. LST-1179 CLASS MDS MAINTENANCE INDICATOR SIGNIFICANCE

Maintenance Indicator	LST-1179 Total Class Expenditure*	Maintenance-Critical Significance Threshold
Ship's Force Parts Dollars (Includes reported IMA Parts Dollars)	$14,348,234	$14,348
Ship's Force Man-Hours	1,042,632	1,043
IMA Man-Hours	428,615	429
Ship's Force Labor Transactions	168,443	168

*Data Base: 1 January 1970 through 30 September 1977.

Table 5-2. LPD-4 CLASS MAINTENANCE INDICATOR SIGNIFICANCE		
Maintenance Indicator	LPD-4 Total Class Expenditure*	Maintenance-Critical Significance Threshold
Ship's Force Parts Dollars (Includes reported IMA Parts Dollars)	$16,226,307	$16,226
Ship's Force Man-Hours	1,292,459	1,292
IMA Man-Hours	393,343	393
Ship's Force Labor Transactions	154,940	155
*Data Base: 1 January through 30 September 1977.		

For each EIC identified for further analysis, a total equipment maintenance burden was calculated for each of the four MDS indicators (i.e., Ship's Force parts dollars, Ship's Force man-hours, Ship's Force labor transactions, and IMA man-hours). To obtain, for each EIC, a single factor that provides an indication of the material condition, an "MDS Factor" was computed. The MDS Factor is the sum of the ratios of each of the four MDS indicators of the EIC to the total of the indicator for the class. Expressed symbolically

$$MDS_{EIC} = \left[\frac{(PC)_{EIC}}{(PC)_{Total}} + \frac{(SFMH)_{EIC}}{(SFMH)_{Total}} + \frac{(IMAMH)_{EIC}}{(IMAMH)_{Total}} + \frac{(SFLT)_{EIC}}{(SFLT)_{Total}} \right] \times 100$$

where

MDS_{EIC} = MDS Factor for a specific EIC

$(PC)_{EIC}$ = Total parts costs for that EIC

$(PC)_{Total}$ = Total parts costs for the class

$(SFMH)_{EIC}$ = Total Ship's Force man-hours expended for that EIC

$(SFMH)_{Total}$ = Total Ship's Force man-hours expended for the class

$(IMAMH)_{EIC}$ = Total IMA man-hours expended for that EIC

$(IMAMH)_{Total}$ = Total IMA man-hours expended for the class

$(SFLT)_{EIC}$ = Total Ship's Force labor transactions for that EIC

$(SFLT)_{Total}$ = Total Ship's Force labor transactions for the class

The data base from which these MDS indicators were calculated included information from all maintenance action form (OPNAV 4790/2K) reports submitted by the class during the data base periods. The Maintenance Support

Office Department, Mechanicsburg, Pennsylvania, provided the data on magnetic tape.

5.3.1.2 Material Condition Readiness Index Factor

To provide an indicator of the severity of failures by EIC, the MCRI as published in the CASREP Material Condition Index (MCI) Report was utilized. This index is a mathematical product of three factors that have a bearing on the degree of unreadiness of ships experiencing casualties. These factors are as follows (for each EIC):

1. The number of times casualties were corrected within a given time period (total CASREPs).
2. The severity of the casualties in terms of performance loss to the ship for each occurrence (identified by severity codes - see Table 5-3).
3. The time required to correct the casualties (total downtime of system or equipment).

Table 5-3. CASREP SEVERITY CODES

C-2 - (Substantially Ready) Minor degradations exist in mission-essential equipment/material condition which affect ability to perform in one or more mission areas; however, they do not appreciably reduce effectiveness and/or ability to conduct sustained operations because backup equipment is available; or, using its own resources or immediately available assistance, the unit is able to effect repairs within 24 hours.

C-3 - (Marginally Ready) Substantial degradations exist in mission-essential equipment/material condition which significantly reduce ability to perform effectively and/or to conduct sustained operations but do not result in the total loss of capability in more than one primary mission area. Backup equipment is not available, but using its own resources or immediately available assistance, the unit is able to effect repairs within 96 hours.

C-4 - (Not Ready) The condition of equipment/material precludes the unit's capability to perform in two or more of its primary mission areas. Backup equipment is not available, or using its own resources, the unit is unable to effect repairs within 96 hours.

The Material Condition Readiness Index is calculated for each EIC in the MCI Report as follows:

$$MCRI = (C_4 + 0.5C_3 + 0.1C_2) \frac{\text{Total Downtime}}{\text{Total CASREPs}}$$

where

C_4 = Total Days Downtime for C-4 CASREPs

C_3 = Total Days Downtime for C-3 CASREPs

C_2 = Total Days Downtime for C-2 CASREPs

Total Downtime = $C_4 + C_3 + C_2$

Total CASREPs = Total number of C-4, C-3, and C-2 CASREPs reported

The preceding equation utilizes severity codes weighted by factors of 1, 0.5, and 0.1 for C_4, C_3, and C_2 CASREPs respectively. This mathematical expression thus takes into account the importance of each casualty that is experienced by the ship, giving greater emphasis to the more serious casualties. The length of time needed to repair the casualty is also represented so that the magnitude of the maintenance action is also taken into account. The resulting numerical value thus gives a good relative representation of how a particular system/equipment casualty affects the capability of a ship to perform its mission.

The Material Condition Index Report used to indicate the severity of reported failures was provided by the Navy Fleet Material Support Office, Mechanicsburg, Pennsylvania.

5.3.1.3 Additional Maintenance Factors

For the LST-1179 and LPD-4 classes, a third indicator of material condition by EIC is the amount of depot maintenance required during the regular overhauls at the end of each operating cycle. This indicator was termed the Regular Overhaul (ROH) Factor. Maintenance Man-Days (MMD) were selected as the measure of this indicator since the more degraded the material condition, the more maintenance is required. The depot level maintenance man-hours were extracted from ROH SARPs provided by PERA (ASC) and averaged by EIC.

For the LHA-1 Class, a third indicator of material condition was provided by the Negative Man-Hour Differential (NMHD). The NMHD is the excess of Ship's Force and IMA man-hours expended on a system above design data projected values, and was used to evaluate the accuracy of the projected design values. Like the ROH Factor, this indicator, too, is used to ensure that off-ship as well as shipboard maintenance was adequately considered in the development of maintenance-critical systems.

In this study, the NMHD is a factor to aid in identifying and planning for revised maintenance strategy requirements. In light of the limited amount of historical data available, this factor has been estimated

conservatively to show all man-hours expended over design values. This procedure will ensure identification of any special usage maintenance requirements that should be incorporated into the LHA-1 Class maintenance strategy. Since the reported data period had not yet exceeded the predicted interval of failure on a number of equipments, ship man-hour experience should be regarded with some caution, although reductions in predicted maintenance requirements may be appropriate in some cases. The additional historical data accumulated during the next (development) phase will permit validation of these maintenance requirements.

5.3.1.4 Graphical Representation

The resulting material condition indicators were graphically displayed to assist in evaluating the relative magnitudes of each indicator's values, and also to point out the consistency of the results, both within and between individual indicators.

Values were calculated for each indicator by applicable ship classes. EICs were ranked in order of descending indicator values and then plotted on a graph, giving three graphs for each ship class. Each graph displayed the same characteristic curve, which could be divided into groups, as shown in Figure 5-4.

Significant material degradation was indicated for the first group of EICs (▲) with high values of the material-condition indicator; moderate material degradation was indicated for the second or middle group (○) with somewhat lesser values of the material-condition indicator; and only slight degradation was indicated for the remaining group (●) of EICs. The slope of the curve for this group indicated only minimal variation and significance associated with the majority of the three to four thousand EICs per ship class.

Section 5.4 describes how the resulting material-condition indicators were combined to identify critical ship systems on which to concentrate to achieve the greatest benefits from a revised maintenance strategy.

5.3.2 LST-1179 Class Material Condition

The LST-1179 Class MDS data were analyzed to assess the class material condition resulting from use of the current maintenance strategy. Some 283 EICs were identified as exceeding one or more of the MDS Factor Indicator Significance Thresholds and, therefore, requiring further analysis. MDS Factor values were computed, a list was prepared ranking EICs by MDS Factor in descending order, and the results were plotted. Figure 5-5 clearly displays the characteristic groupings discussed above, with 11 EICs indicating significant material degradation and 11 additional EICs indicating moderate degradation.

In a similar manner, the MCRI Factors for the various EICs were analyzed. The listing of EICs ranked by MCRI Factor in descending order is documented in the 30 November 1977 Consolidated CASREP Reporting System

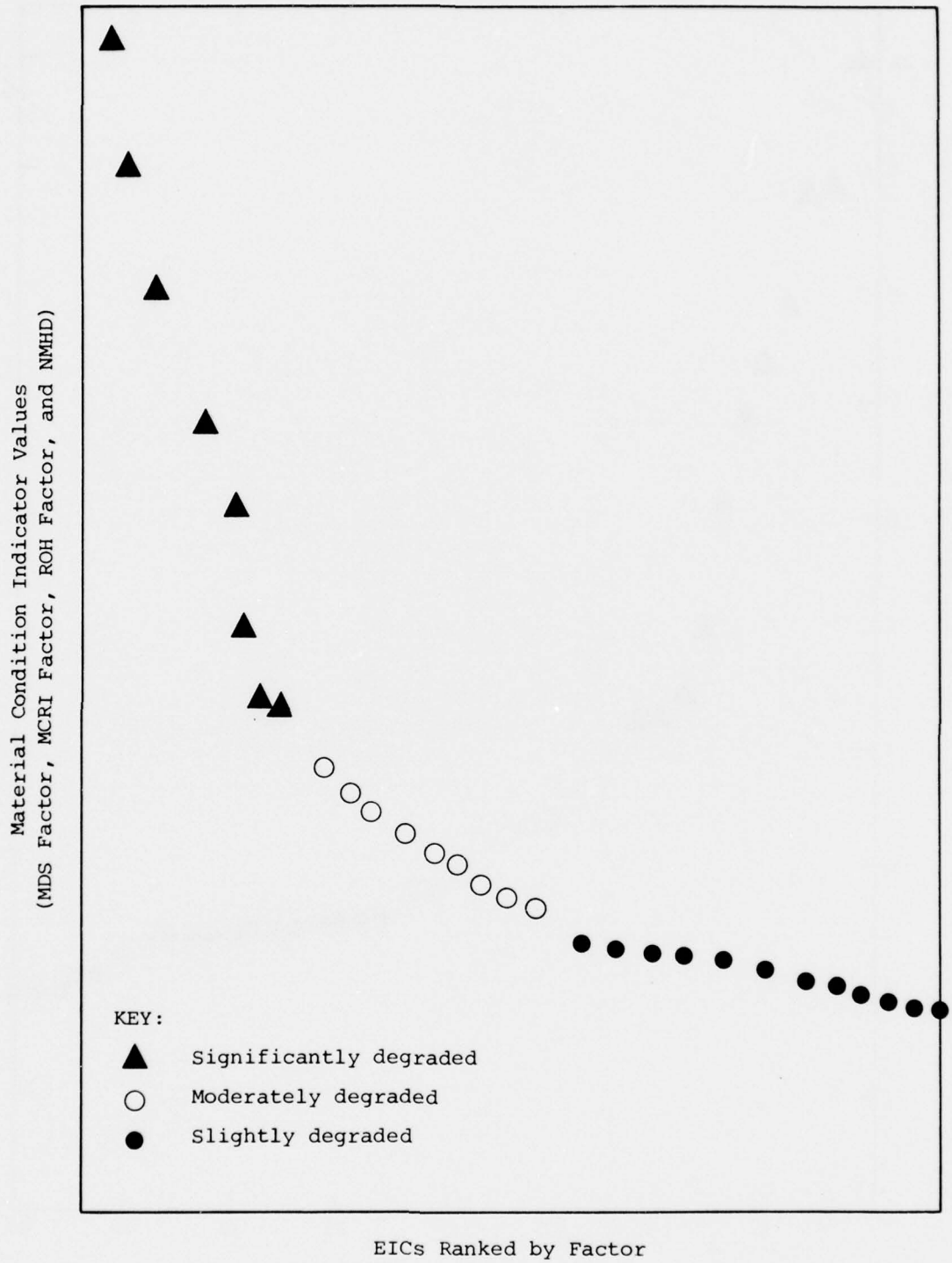


Figure 5-4. MATERIAL CONDITION EVALUATION

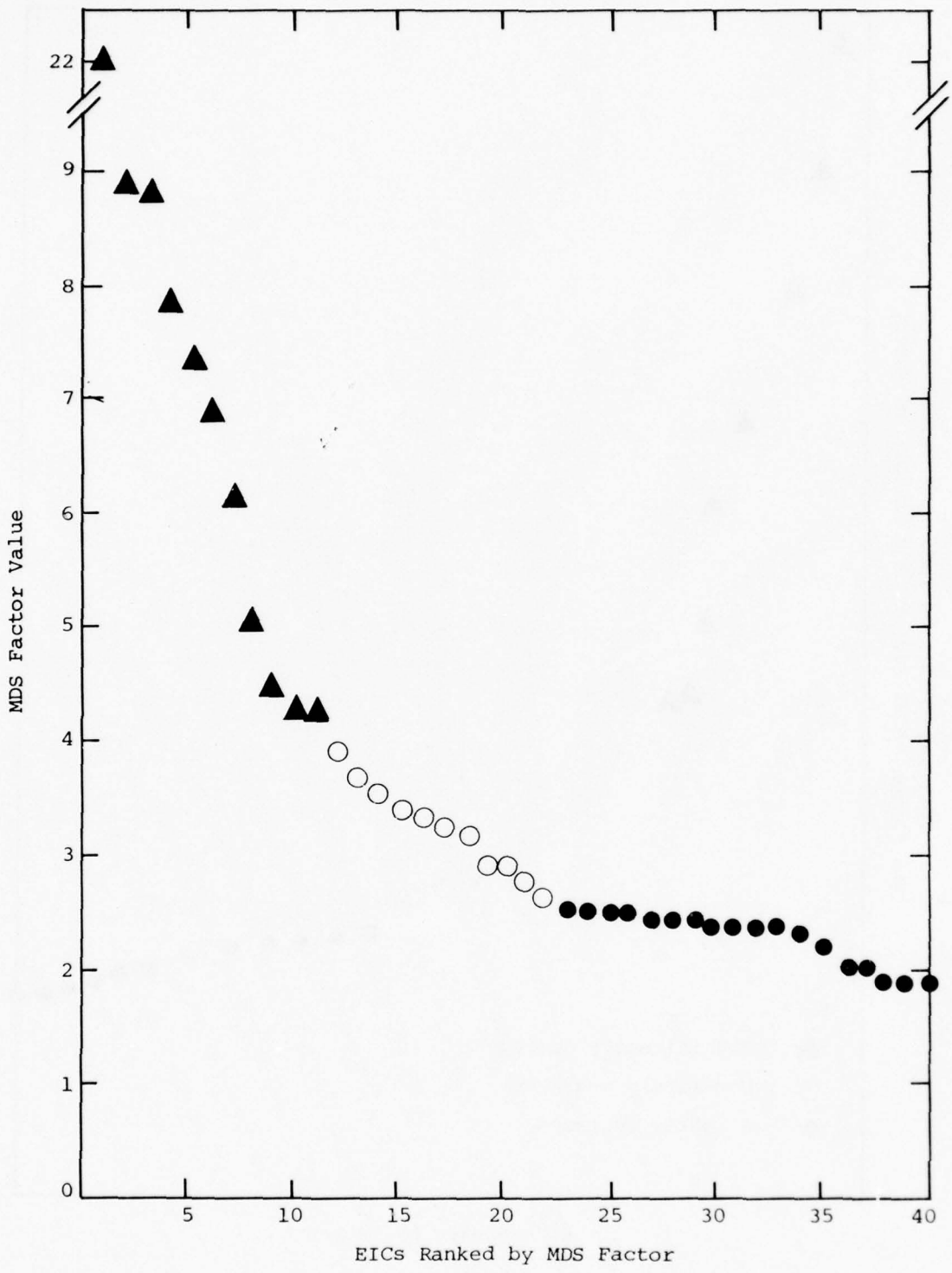


Figure 5-5. LST-1179 CLASS MDS FACTORS

Report, Report Symbol SUP 4400.28-C-1. When the EICs are ranked and plotted by MCRI value (see Figure 5-6), it is evident that significant degradation in material condition was experienced by the first 6 EICs and moderate degradation was experienced by the next 14 EICs; by comparison, only slight degradation was experienced by the remaining EICs.

The third indicator of material condition was next analyzed -- the amount of depot level maintenance, by EIC, during the ROH at the end of the operating cycle. SARPs for LST-1190, 1195, and 1198, as well as the LST-1194 Baseline SARP (representing 17 ships of the class) were analyzed by determining the average maintenance man-days (MMD) required to restore the systems and equipment of each EIC. The EICs were then listed in descending MMD order, and plotted. Figure 5-7 clearly indicates that, from the standpoint of depot level maintenance, significant degradation is evident for the first 6 EICs and moderate degradation is evident for the next 12 EICs. Appendix A contains supporting data from which Figures 5-5, 5-6, and 5-7 were developed. Table 5-4 identifies the EICs showing significant and moderate degradation in material condition. It also shows agreement and consistency in the results obtained from the different indicators.

LST-1179 Class material condition was evaluated from a review of the material-condition indicators summarized in Table 5-4, INSURV results and comments, the Class Corrective Action Plan, and consideration of the age of the ships. The high consistency in the results of the material-condition indicators provides increased confidence in conclusions based on their use.

The very small values, variation, and slope change were recorded for the large majority of the more than 3500 EICs for this class. These EICs all indicated only slightly degraded material condition. The maintenance-critical EICs ranked in Table 5-5 identified all major material condition problems for the class except INSURV report findings of unsatisfactory on a number of JP-5 fueling systems (EIC T605).

Analysis of the MDS data for the class showed approximately 8 percent of the EICs exceeded one or more significance thresholds. Although all of these EICs experienced a maintenance burden of some significance, the greatest concentration of material condition degradation occurs for those few EICs identified as significantly or moderately degraded. While the overall class material condition appears satisfactory from a review of this recorded data, these significantly and moderately degraded EICs significantly affect the mission-performance ability of these ships and show a need for attention and corrective action. A review of the class modernization plans indicates that a number of alterations have been developed to solve some of the major maintenance problems. However, none of the critical EIC equipments is scheduled for replacement or for major configuration change.

5.3.3 LPD-4 Class Material Condition

The LPD-4 Class MDS data were analyzed to assess the class material condition resulting from use of the current maintenance strategy. Some 333 EICs were identified as exceeding one or more of the MDS Factor Indicator

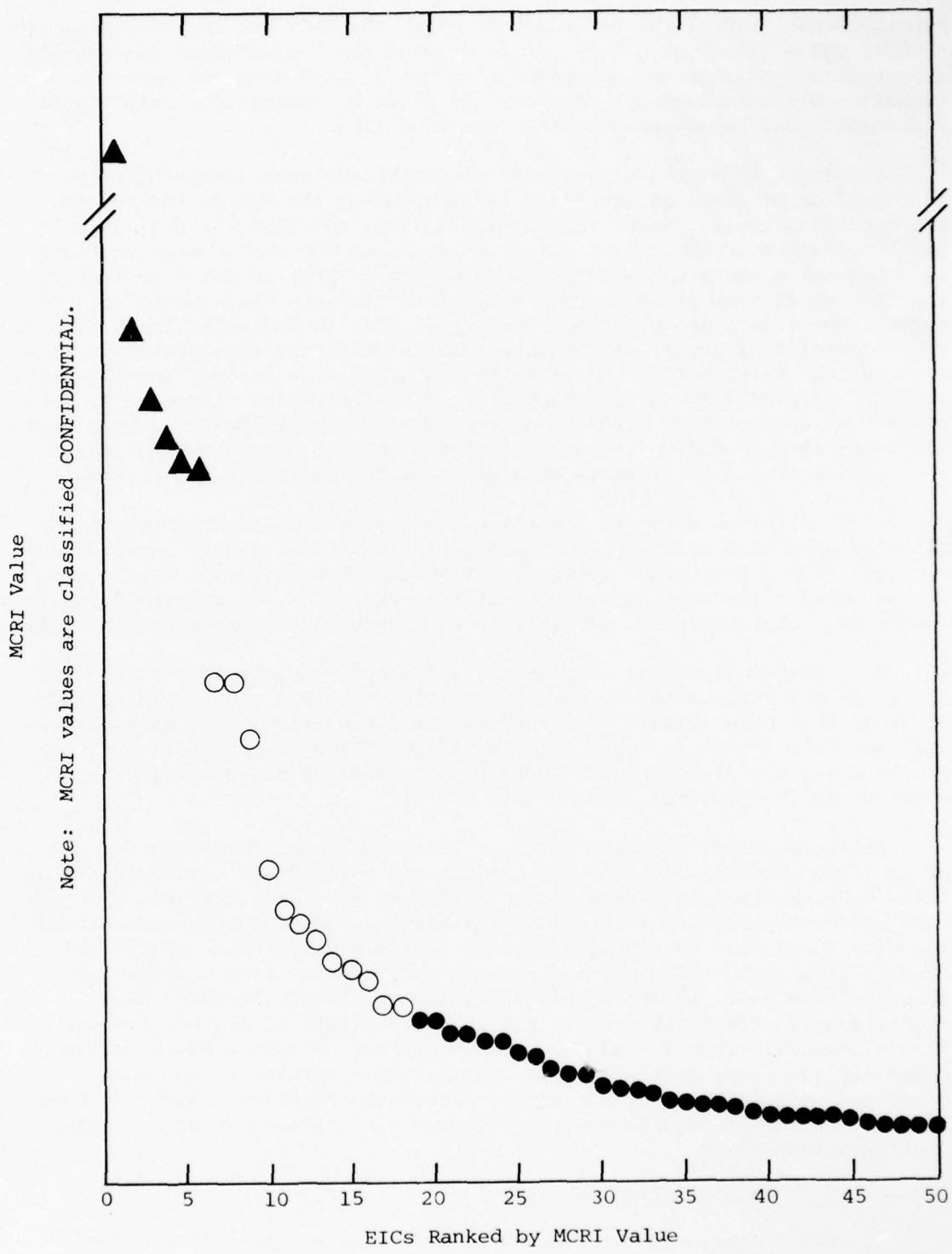


Figure 5-6. LST-1179 CLASS MCRI DATA

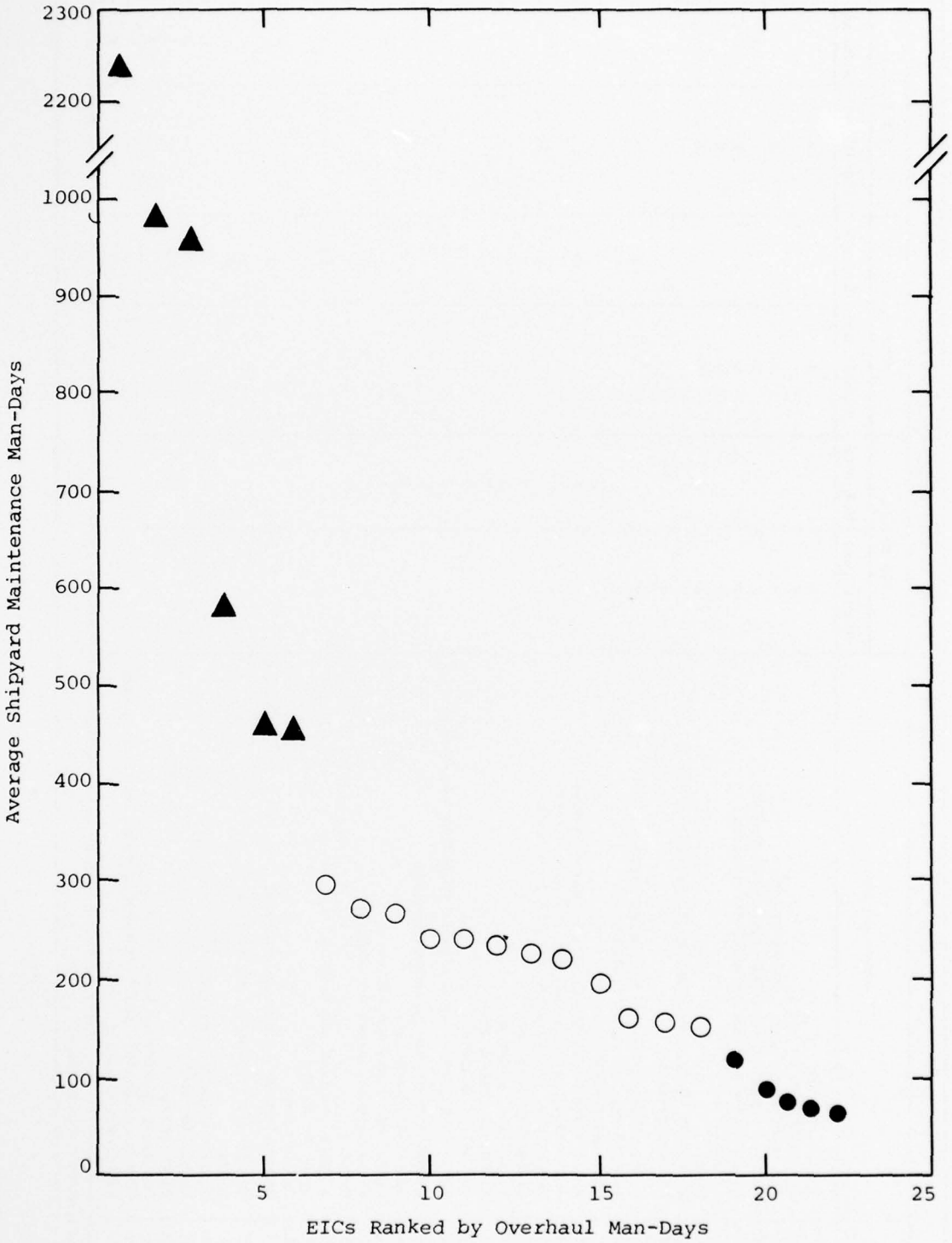


Figure 5-7. LST-1179 CLASS SARP DATA

Table 5-4. IDENTIFICATION OF LST-1179 CLASS MAINTENANCE-CRITICAL EICs

EIC	Nomenclature	MDS Factor		MCRI Factor		ROH Factor	
		Significant	Moderate	Significant	Moderate	Significant	Moderate
B101*	Engine, diesel	X		X		X	
GTBH	Gun sight, Mk 29 Mod 4	X					
3101*	Generator set, 60-Hz, diesel driven	X		X		X	
T104*	Boiler, auxiliary (accessories and controls)	X		X			X
TF03*	Intermediate and low pressure air systems	X		X		X	
T801*	Firemain	X		X		X	
AD04*	Ramps	X		X		X	
GBLE	Mount, 3" 50 Cal. twin RF, Mk 33 Mod 13	X					
1B01	Galley equipment	X					
Y403*	Craft, landing-vehicle personnel (LCVP Mk 7)	X			X		
QB38	R-1051B/URR, receiver, radio	X					
GT2H	Set, radar AN/SPG-50		X				
TM01*	Winches and hoisting equipment, miscellaneous		X		X		
T404	Air conditioning system, chilled water (R-12)		X				X
B408*	Propellers, controllable pitch and controls		X		X	X	
QD4R*	AN/VRC-46, radio set		X		X		
P118*	AN/SPS-10F, radar set		X		X		
QD3R	AN/SRC-20, radio set		X				
T804	Sprinkling systems		X				
TK01	Distilling plant, low pressure, submerged tube/basket		X				
4505	Lighting fixtures, permanent mounted		X				
QD3S	AN/SRC-21, radio set		X				
B301	Gear, reduction, anti-friction				X		X
TL01	Steering gear, electro-hydraulic				X		X
AD05	Hatches				X		
TM06	Winches, snaking and warping				X		
LB31	Gyro, Mk 23 Mod C3				X		
YC04	Davits, boat				X		
TN03	Cargo elevator, load and personnel				X		
QE1N	AN/URT-23(V) transmitting set, radio				X		
AD01	Doors				X		
TA03	Bilge and ballast systems						X
TK05	Distilling unit						X
AD03	Stern gates						X
T806	Sea water service system						X
B305	Clutch, propeller, shaft synchronization, positive engage						X
T503	Refrigeration plant						X

*Maintenance-Critical EICs.

Table 5-5 RANKING OF LST-1179 CLASS MAINTENANCE-CRITICAL EICs

EIC	Nomenclature	MDS Rank	MCRI Rank	MBF
B101	Engine, diesel	1	1	2
3101	Generator set, 60-Hz, diesel driven	3	5	8
AD04	Ramps	7	2	9
T104	Boiler, auxiliary (accessories and controls)	4	7	11
TF03	Intermediate and low pressure air systems	5	6	11
T801	Firemain	6	8	14
B408	Propellers, controllable pitch and controls	15	3	18
TM01	Winches and hoisting equipment, miscellaneous	13	10	23
Y403	Craft, landing - vehicle personnel (LCVP Mk 7)	10	18	28
QD4A	AN/VRC-46, radio set	16	17	33
P118	AN/SPS-10F, radar set	17	16	33

Significant Thresholds and therefore requiring further analysis. MDS Factor values were then computer, a list was prepared ranking EICs by MDS Factor in descending order, and the results were plotted. Figure 5-8 indicates that significant degradation in material condition was experienced by 10 EICs and moderate degradation was experienced by the next 3 EICs.

In a similar manner, the MCRI Factors for the various EICs were analyzed. The listing of EICs ranked by MCRI Factor in descending order is documented in the 30 November 1977 Consolidated CASREP Reporting System Report, Report Symbol SUP 4400.28-C-1. When the MCRI Factors are ranked and plotted by EIC (see Figure 5-9), it is evident that significant degradation in material condition was experienced by the first 7 EICs; moderate degradation was experienced by the next 14 EICs.

The third indicator of material condition was next analyzed -- the amount of depot-level maintenance, by EIC, during the ROH. SARPs for LPD-4, 7, 8, 9, and 13 were analyzed by determining the average maintenance man-days required to restore the systems and equipment of each EIC. The EICs were then listed in descending MMD order and plotted. Figure 5-10 clearly indicates that, from the standpoint of depot level maintenance, significant degradation is evident for the first 10 EICs and moderate degradation is evident for the next 12. Appendix A contains supporting data from which Figures 5-8, 5-9, and 5-10 were developed. Table 5-6 identifies the EICs showing significant and moderate degradation in material condition.

LPD-4 Class material condition was evaluated in the same manner as was that of the LST-1179 Class. Material condition indicator results, summarized in Table 5-6, showed good consistency and recorded only slightly degraded material condition for the great majority of the more than 4100 class EICs. The maintenance-critical EICs ranked in Table 5-7 identified all major material condition problems for the class except INSURV report findings of unsatisfactory on a number of Aqueous Film Forming Foam Systems (EIC T903).

Analysis of the MDS data for the LPD-4 Class, like that for the LST-1179 Class, showed that approximately 8 percent of the EICs exceeded one or more significance thresholds. Although all of these EICs experienced a maintenance burden of some significance, the greatest concentration of material condition degradation occurs for those few EICs identified as significantly or moderately degraded. While the overall class material condition appears satisfactory from a review of these recorded data, these significantly and moderately degraded EICs significantly affect the ability of these ships to perform their missions and show a need for attention and corrective action. A review of the class modernization plans indicates that a number of alterations have been developed to solve some of the major maintenance problems. However, none of the critical EIC equipments is scheduled for replacement or for major configuration change.

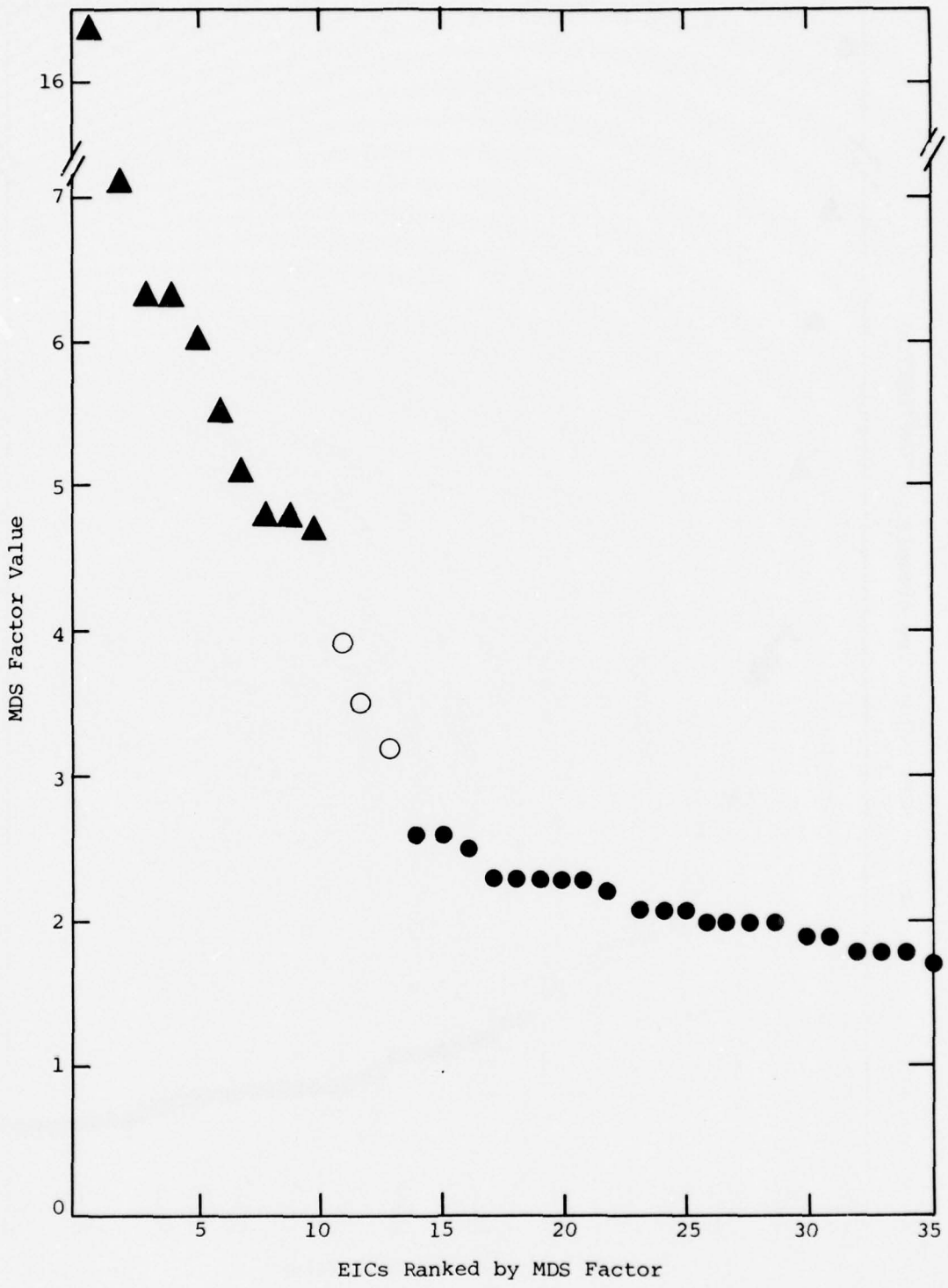


Figure 5-8. LPD-4 MDS FACTORS

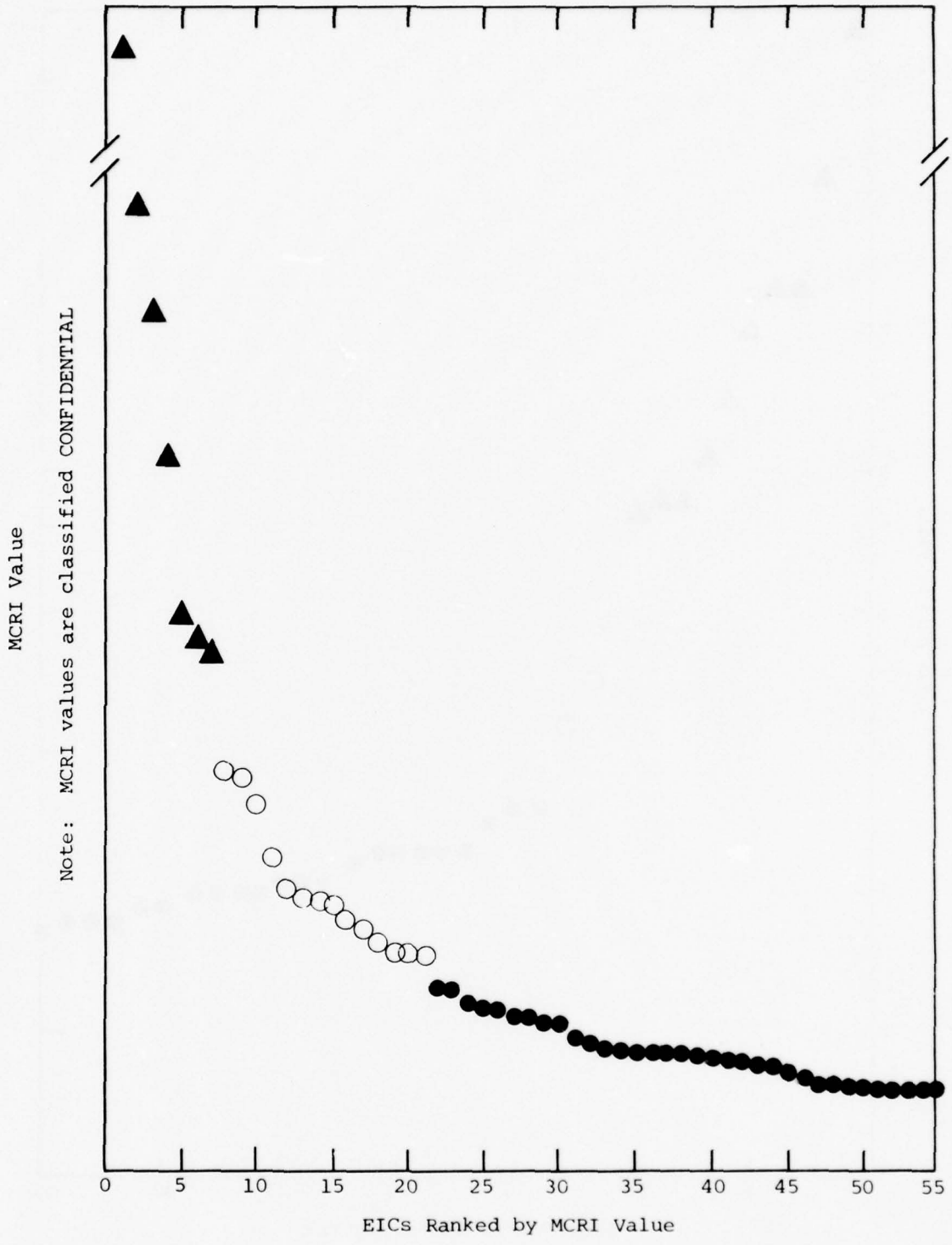


Figure 5-9. LPD-4 CLASS MCRI FACTORS

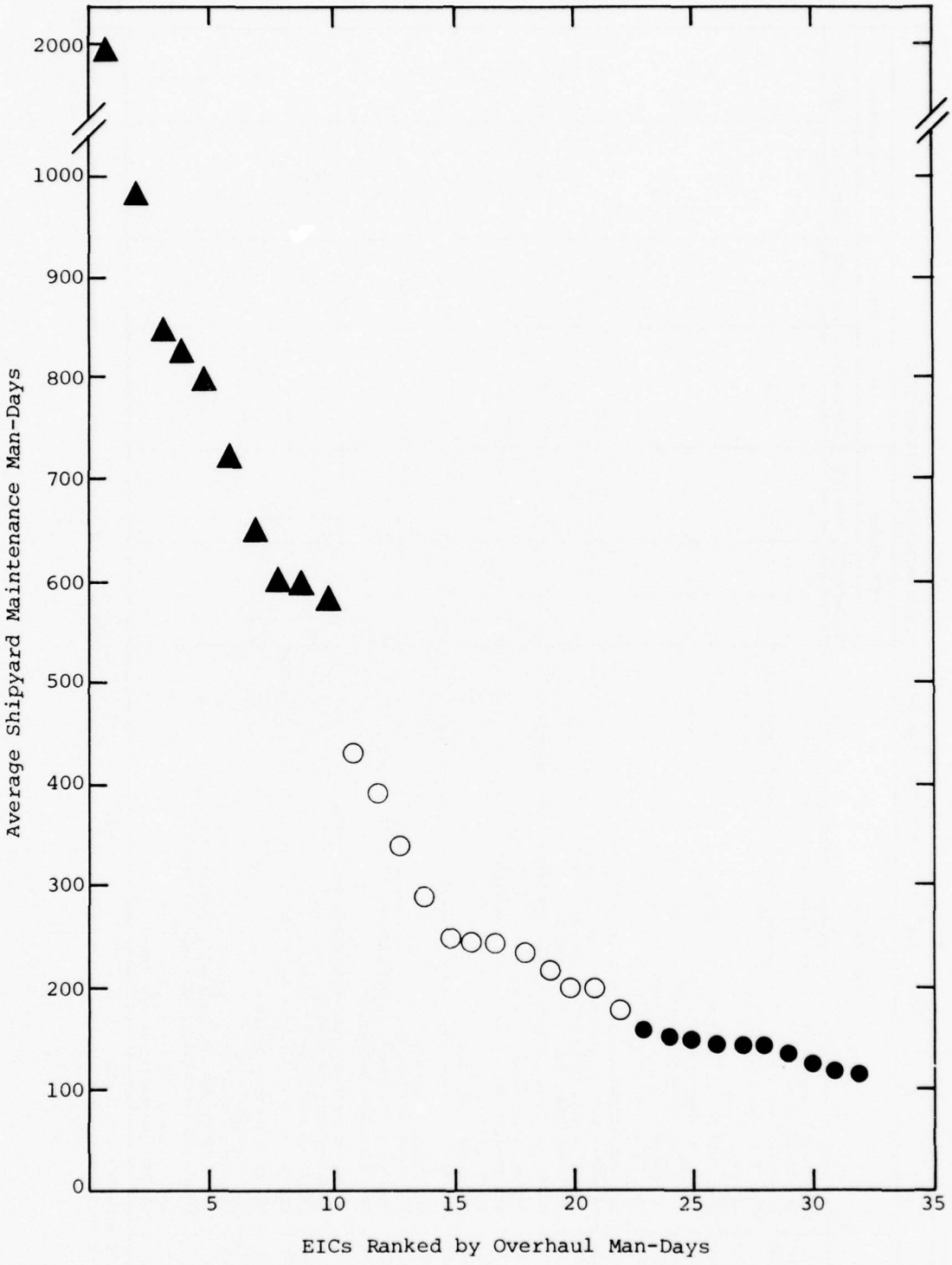


Figure 5-10. LPD-4 CLASS SARP DATA

Table 5-6. IDENTIFICATION OF LPD-4 CLASS MAINTENANCE-CRITICAL EICs

EIC	Nomenclature	MDS Factor		MCRI Factor		ROH Factor	
		Significant	Moderate	Significant	Moderate	Significant	Moderate
F101*	Boiler, D/express/header type, propulsion system	X		X		X	
QD3R*	AN/SRC-20, radio set	X			X		
F303*	Pump unit, centrifugal (multistage, turbine-driven), main feed	X		X		X	
P30T	AN/SPS-40 radar set	X					
T801*	Firemain	X		X		X	
GBL2*	Mount, 3" 50 cal. twin RF Mk 33 Mod 0	X			X		X
1B01	Galley equipment	X					
TK03*	Distilling plant, low pressure, flash type	X		X		X	
QB3A	R-1051B/URR, receiver, radio	X					
F703	Main steam valves	X					
T404*	Air conditioning system, chilled water (R-12)		X		X	X	
QE1W	AN/WRT-2, transmitting set, radio		X		X		
310C*	Generator set, 60-Hz, steam turbine driven		X	X		X	
TN03	Cargo elevator, load and personnel			X			X
F401*	Blower group, air supply system, combustion, main propulsion			X		X	
TN04	Cranes, boat, ammo and stores				X		X
TF03	Intermediate and low pressure air systems				X		X
AD03	Stern gates				X		X
QD3R	AN/SRC-20, radio set				X		
QE1N	AN/URT-23(V), transmitting set, radio				X		
P31V	AN/SPS-40C, radar set				X		
F507	Piping and accessories, main fuel oil service				X		
3101	Generator set, 60-Hz, diesel driven				X		
T903	Foam generating equipment				X		
NC0B	AN/ULQ-6B repeater, countermeasures, ECM, pulse				X		
FE03*	Shafting, main propulsion				X	X	
TH03*	Auxiliary steam supply system					X	
T605*	Fueling service, transfer and blending system, aviation JP-5/HEAF					X	
T806	Sea water service system						X
FA01	Main condenser unit						X
FB03	Main circulating water pump unit, turbine driven						X
F501	Main fuel oil service pump unit, turbine driven						X
FD07	Piping and accessories, main lube oil service						X
TH04	Drain systems, high and low pressure						X
QE1W	AN/WRT-2, transmitting set, radio						X

*Maintenance-Critical EICs.

Table 5-7. RANKING OF LPD-4 CLASS MAINTENANCE-CRITICAL EICs

EIC	Nomenclature	MDS Rank	MCRI Rank	MBF
F101	Boiler, D/express/header-type, propulsion system	1	1	2
F303	Pump unit, centrifugal (multistage, turbine-driven) main feed	3	2	5
T801	Firemain	5	3	8
TK03	Distilling plant, low pressure, flash type	8	6	14
QD3R	AN/SRC-20, Radio set	2	12	14
GBL2	Mount, 3" 50 cal. twin RF Mk 33 Mod 0	6	11	17
310C	Generator set, 60-Hz, steam turbine driven	13	5	18
F401	Blower group, air supply system, combustion, main propulsion	17	7	24
T404	Air conditioning system, chilled water (R-12)	11	15	26
FE03	Shaft, main propulsion	57	25	84
T605	Fueling service, transfer and blending system, aviation JP-5/HEAF	27	58	85
TH03	Auxiliary steam supply system	50	142	192

5.3.4 LHA-1 Class Material Condition

The LHA-1 Class, with a limited amount of historical data available and a good quantity of design data, presented an opportunity to compare and update design values with empirical data. The design data were documented in the shipbuilder's Plans For Maintenance. The PFMs identify the amount of corrective maintenance that can be anticipated for each specific system on the basis of an analysis of the probable equipment failures, their frequency, and Mean Time to Repair (MTTR), as identified in the Maintenance Engineering Analyses (MEAs) that make up each PFM. A PFM usually contains information on more than one EIC and, similarly, several PFMs may apply to each EIC. In order to assure that each EIC applied to only one system, the PFMs were regrouped as shown in Table 4-5 and assigned system numbers as indicated. The MDS and MCRI Factors were calculated for each redefined system (group of EICs) for the LHA-1 Class. MDS Factor values were then listed for the 37 redefined systems ranking each by MDS Factor in descending order, then plotting the results. Figure 5-11 indicates that 3 systems demonstrate significant degradation in material condition while 8 indicate a moderate degradation and still others, by comparison, show only slight degradation. MDS Factor values for the LHA-1 Class are considerably higher than those for the LST-1179 and LPD-4 Classes because the LHA MDS Factors are calculated for PFMs (which represent a group of EICs). The LST and LPD MDS Factors are calculated for individual EICs.

In a similar manner, the MCRI Factors for the various redefined systems were analyzed. The listing of systems by MCRI Factor in descending order was determined by summing those for the individual EIC MCRIs as documented in the 30 November 1977 consolidated CASREP Reporting System Report, Rept. Symbol SUP 4400.2B-C-1. When the MCRI Factors are plotted by systems (see Figure 5-12), it is evident that significant degradation in material condition was experienced by the first 5 systems and moderate degradation was experienced by the next 12.

The usual third indicator of material condition, ROH information, could not be analyzed for the LHA-1 Class because no LHA ship has yet been overhauled. Instead, a different indicator, the Negative Man-Hour Differential (defined as that number of man-hours expended on a system in excess of the PFM projections) was analyzed. In order to make such an assessment it was necessary to define an historical data base of experience equivalent to that contained in the PFMs.

An analysis of the total class data base of 58,897 records spanning the period from 1974 through 8 December 1977 revealed that a single year of LHA-1 operational data existed that closely approximated the operational tempo planned for by the shipbuilder in the PFMs.

For LHA-1 this 365-day period from 1 June 1976 through 31 May 1977 extended from shortly after delivery up to and including the final contract trial. LHA-1 had been under way over 40 percent (of the days) of this

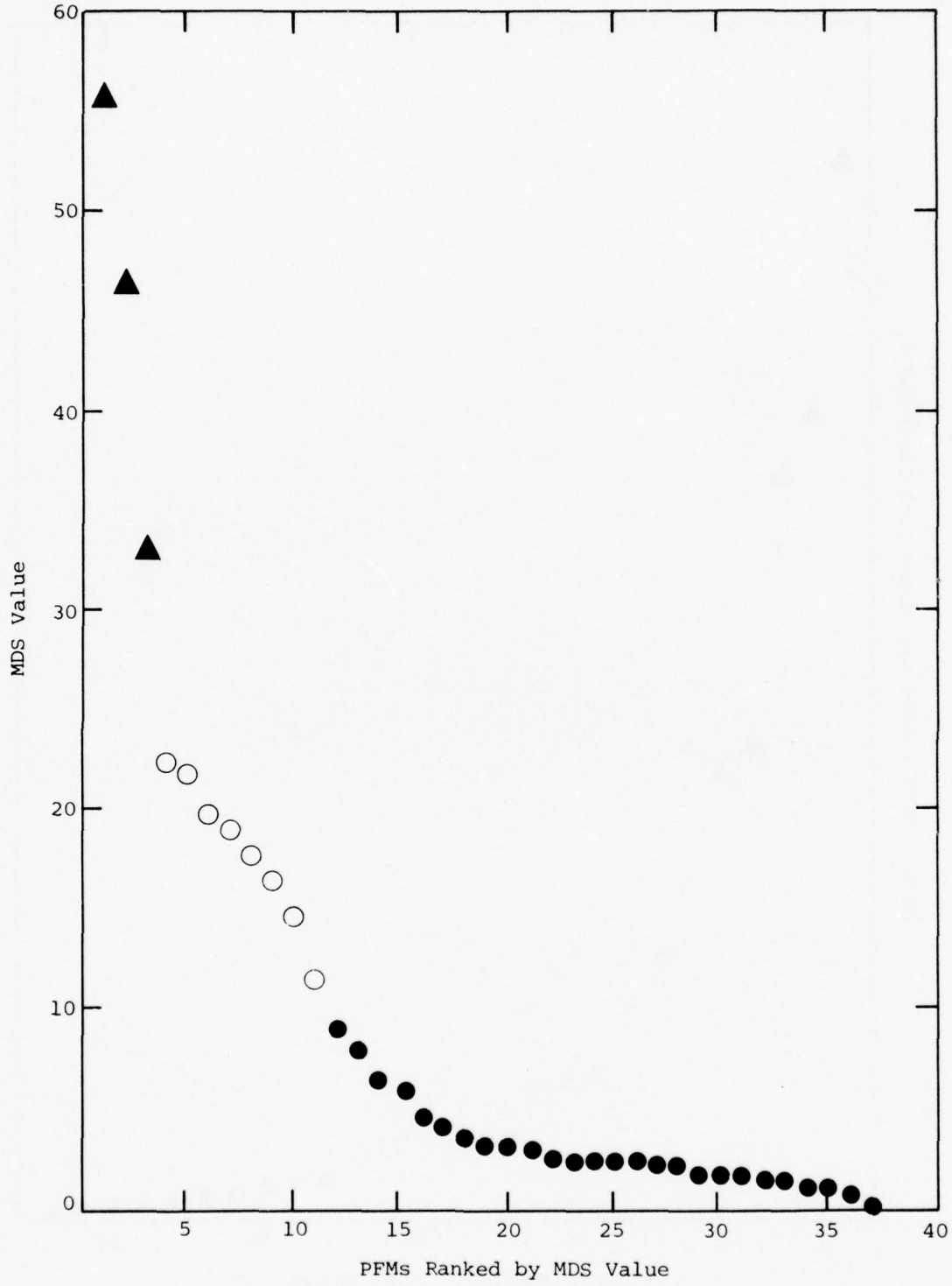


Figure 5-11. LHA-1 CLASS MDS DATA

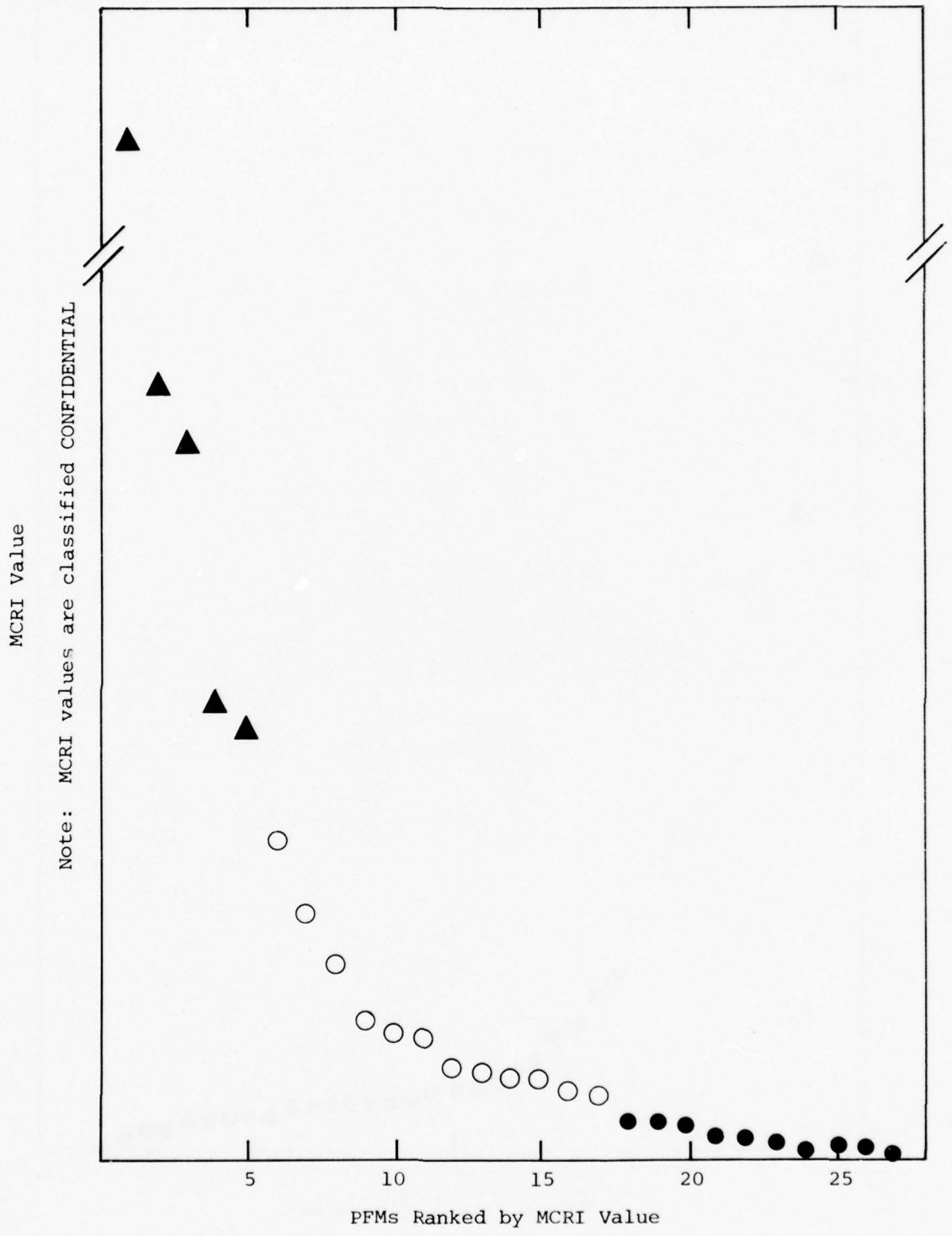


Figure 5-12. LHA-1 CLASS MCRI DATA

period. During that time all systems and equipments were exercised. Specifically, the schedule for LAH-1 was:

1 March 1976	- Acceptance trial
5 May 1976	- Delivery
1 - 27 March 1977	- Operational Evaluation (OPEVAL)*
14 August 1977	- Commenced Post Shakedown Availability (PSA/RAV)

This 365-day data base accounted for 76 percent of total Ship's Force corrective maintenance man-hours and 91 percent of total IMA man-hours reported by the class.

The selected periods of MDS data were sorted, summarized by EIC, grouped by PFM, and related to the PFM summaries shown in Table 5-8. From these data, an NMHD value for each system was established. All Ships' Force man-hour expenditures which exceeded a system's PFM projections were quantified as negative and added to that system's total IMA expenditures. All IMA expenditures were considered negative in that the PFMs defined ashore projections to be depot level. This NHMD value indicates the additional maintenance man-hours (over design data) that were indicated from historical experience. When those values are plotted (Figure 5-13) they are also indicative of material condition. Figure 5-13 clearly shows that, from an NMHD standpoint, significant degradation was experienced by the first 3 systems and moderate degradation was experienced by the next 9 systems. Appendix A contains supporting data from which Figures 5-11, 5-12, and 5-13 were developed. Tables 5-9, and 5-10 identify and rank the EICs showing significant and moderate degradation in material condition.

The limited available historical data were considered insufficient to support a valid determination of overall class material condition. The identified maintenance-critical EICs all have a direct effect on the ship's ability to perform its mission. Preliminary indications are that there is serious degradation in these systems; however, maintenance data did not indicate serious problems in the main propulsion and auxiliary systems which have historically experienced large maintenance burdens on other ship classes. Therefore, comparisons should be made with additional data from other ships of the class before a final determination of class material condition is made. This approach will not only improve the data sample size, but will also provide a truer class representation with less predominance of the data by lead ship experience.

A review of the class modernization plans indicates that a number of alterations have been developed and others are being contemplated to solve some of the major maintenance problems. None of the critical EIC equipments scheduled for replacement; however, several major configuration changes are being contemplated that could affect the critical-EIC analyses.

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*COMNAVSURFPAC commented that during the OPEVAL LHA-1 had conducted 6 months of operations in 30 days.

Table 5-8. SUMMARY OF ANNUAL MAN-HOUR PROJECTIONS FROM THE AUGUST 1976 BUILDERS PLANS FOR MAINTENANCE

PFM No.	Title	Ship's Force Corrective Maintenance	Ashore Corrective Maintenance	Total Corrective Maintenance
A01	Boilers	338.4	0.1	338.5
A02	Propulsion	2,207.4	188.4	2,395.8
A03	Main steam	68.7	0.0	68.7
A04	Feed and condensate	678.6	12.8	691.4
A05	Main circulating water	42.9	8.4	51.3
A06	Fuel oil	561.7	0.0	561.7
A07	Lube oil	151.4	4.0	155.4
A08	Combustion air	95.1	5.1	100.2
B12	Ship's service and emergency power generation	382.4	93.3	475.7
B13	60-Hz distribution	412.2	0.0	412.2
B14	Dc systems	199.9	41.4	241.3
B15	400-Hz distribution	313.1	43.0	356.1
C19	Damage control monitoring	474.2	0.0	474.2
C22	Intercommunications systems	556.4	30.5	586.9
C27	Navigation systems	321.8	752.0	1,073.8
D29	Auxiliary steam and drains systems	1,328.6	6.4	1,335.0
D30	Gasoline systems	578.0	0.2	578.2
D33	Ballast systems	309.6	27.8	337.4
D34	Ship control and steering	58.8	4.6	63.4
D35	Fresh water systems	968.4	3.1	971.5
D37	Compressed air and gases	513.5	0.0	513.5
D40	Communications and control cooling	174.7	0.0	174.7
D45	Ventilation	2,359.5	0.0	2,359.5
D46	Air conditioning	964.7	26.0	990.7
E48	Salt water systems	1,549.8	5.6	1,555.4
E52	Damage control	49.3	0.0	49.3
F10	Deck equipment	446.3	12.6	458.9
F69	Hull and hull fittings	203.4	0.0	203.4
G43	Waste disposal	500.3	0.0	500.3
G54	Supply department systems	1,141.5	0.0	1,141.5
G56	Medical and dental equipment	2.5	0.0	2.5
H36	Printed circuit board repair	818.9	0.0	818.9
H59	Aircraft handling	315.1	0.0	315.1
H61	Assault systems	2,978.6	0.0	2,978.6
J64	Ordnance	2,751.3	72.8	2,824.1
J76	Ship shops	202.2	13.0	215.2
J87	Qualifications standards lab	468.7	35.9	504.6
K57	Aviation shops	115.6	0.0	115.6
LA1	Waveguides	16.6	21.4	38.0
LLA-C & CS	Communications and control support	10,271.0	0.0	10,271.0
LLA 401	Interior voice communications	5,768.6	154.8	5,923.4
LLA 402	Gunfire control	39.3	32.8	72.1
LLA 404	Electronic countermeasures	469.5	161.6	631.1
LLA 405	Guided missile fire control	14.7	35.2	49.9
LLA 408	Surveillance systems	1,621.9	240.6	1,862.5
LLA 409	Radio communications systems	13,255.3	3,239.0	16,494.3
LLA 410	Electronic navigation system	281.3	116.0	397.3
LLA 413	Integrated tactical amphibious warfare data system	4,414.2	416.8	4,831.0
LLA 610	Support equipment	1,465.0	190.4	1,655.4
	Total	95,032.7	6,704.4	101,737.1

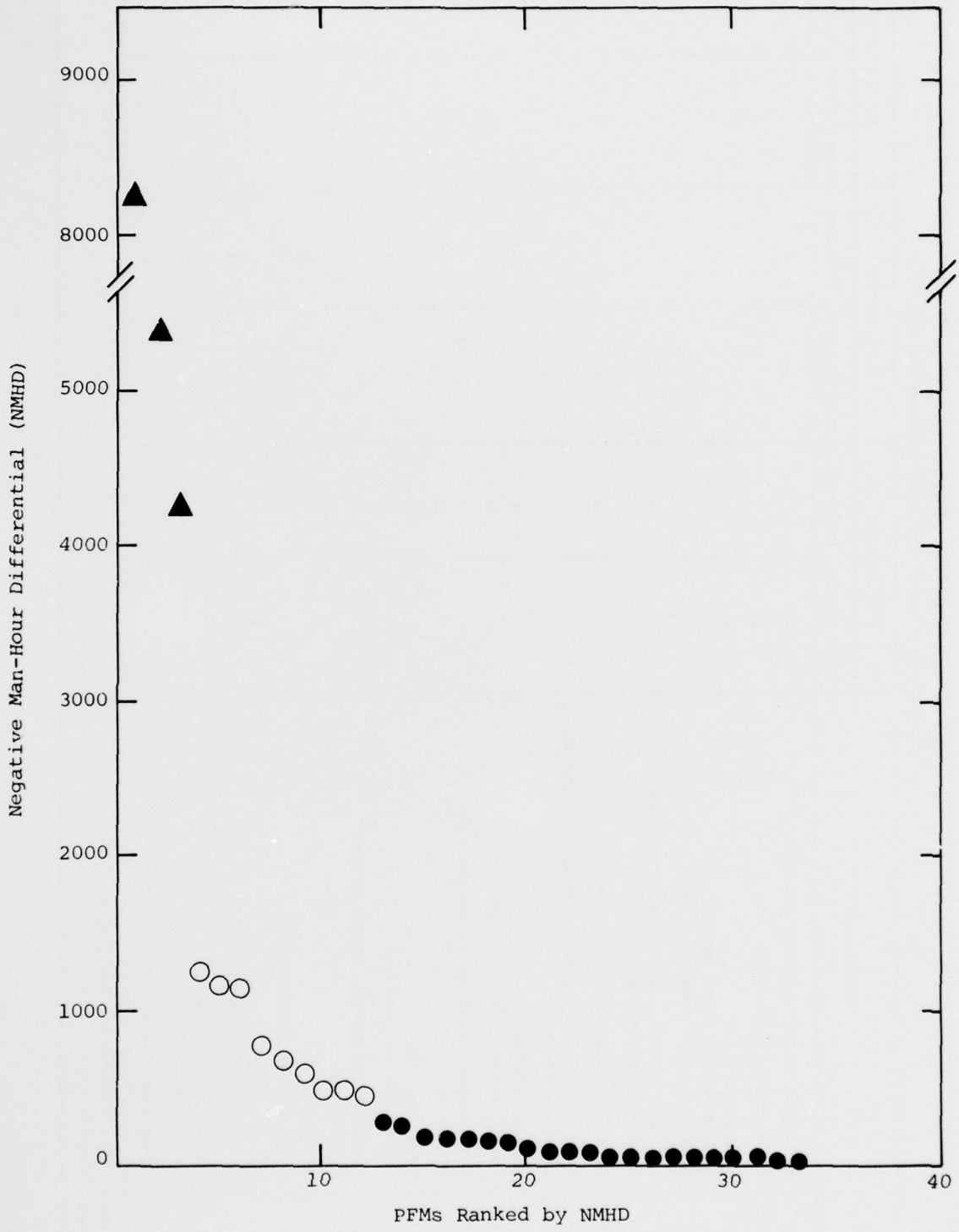


Figure 5-13. LHA-1 CLASS NMHD DATA

Table 5-9. IDENTIFICATION OF LHA-1 CLASS MAINTENANCE-CRITICAL PFMs

PFM*	Nomenclature	MDS Factor		MCRI Factor		NMHD Factor	
		Significant	Moderate	Significant	Moderate	Significant	Moderate
36**	Radio communications and ITAWDS	X		X			
24**	Hull and hull fittings	X				X	
13**	DC monitoring Intercommunications systems Interior voice communications	X				X	
28**	Aircraft handling and assault systems		X	X			X
26	Supply department systems						X
17**	Ballast and salt water systems		X	X		X	
31	Electronics support and standards laboratory		X				X
16	Gasoline systems			X			X
32**	Gunfire control		X		X		X
34**	Guided missile fire control		X		X		X
35**	Surveillance systems and waveguides		X	X			X
29	Ordnance		X				
23**	Deck equipment		X		X		X
20**	Compressed air and gas		X		X		
15	Auxiliary steam and drain systems		X				
2	Propulsion				X		
1	Boilers				X		
18	Ship control and steering				X		
25	Waste disposal				X		
11	Dc electrical systems				X		
37	Electronic navigation				X		
12	400-Hz power distribution				X		
10	60-Hz power distribution and lighting				X		

*PFM System Numbers as assigned in Table 4-5.
**Maintenance-Critical PFMs

Table 5-10. RANKING OF LHA-1 CLASS MAINTENANCE-CRITICAL PFMs

PFM*	Nomenclature	MDS Rank	MCRI Rank	MBF
36	Radio communications and ITAWDS	1	1	2
28	Aircraft handling and assault systems	4	2	6
17	Ballast and salt water systems	6	3	9
35	Surveillance systems and waveguides	11	4	15
32	Gunfire control	9	6	15
34	Guided missile fire control	10	11	21
23	Deck equipment	13	9	22
20	Compressed air and gas	14	10	24
13	DC monitoring Intercommunications systems Interior voice communications	3	23	26
24	Hull and hull fittings	2	100**	102

*PFM System Numbers as assigned in Table 4-5.
**Hull and Hull Fittings reported no CASREPs.

5.4 MAINTENANCE-CRITICAL SYSTEMS

The previous analyses have identified the individual ship class-material condition and have identified the amount of degradation of EICs as viewed from each of several aspects - amount of Ship's Force and IMA maintenance as reported in MDS, importance of EIC or system to ship operations as reported in CASREPs, and amount of additional maintenance as reported in SARPs or calculated by the NMHD method. It would be highly advantageous to develop a list of maintenance-critical systems that would reflect the combined effect and importance of all of these aspects.

The maintenance-critical systems list consists of those EICs that experienced significant or moderate material-condition degradation. These EICs were identified in Tables 5-4, 5-6, and 5-9. Specifically, all EICs identified as significantly or moderately degraded by the MDS Factor *and* significantly or moderately degraded by the MCRI Factor were identified as primary maintenance-critical EICs. To properly consider the additional maintenance factors, those additional EICs, not otherwise designated as primary maintenance-critical, but identified as significantly degraded by the ROH Factor or NMHD, were added to the list of maintenance-critical EICs.

The list of maintenance-critical EICs were then ranked, with equal weighting applied to MDS Factor and MCRI Factor rankings. Factors were ranked from highest to lowest value for each indicator, and each EIC was assigned a relative standing in both categories.

A final ranking was made, using the ranking in each of the two individual indicators. The relative standings of the EICs from each of the two indicators were summed. The resultant sum was the Maintenance Burden Factor (MBF) for the EIC. The MBR was calculated for each class as follows:

For LST-1179 and LPD-4 Classes:

$$MBF_{EIC} = RMDS_{EIC} + RC_{EIC}$$

where

MBF_{EIC} = Maintenance Burden Factor for a specific EIC
$RMDS_{EIC}$ = Rank by MDS factor for that EIC
RC_{EIC} = Rank by CASREP MCRI for that EIC

For LHA-1 Class:

$$MBF_{PFM} = RMDS_{PFM} + RC_{PFM}$$

where

MBF_{PFM} = Maintenance Burden Factor for a specific PFM
MDS_{PFM} = Rank by MDS Factor for that PFM
MCI_{PFM} = Rank by CASREP MCRI for that PFM

Since the system with the lowest Maintenance Burden Factor represented the highest maintenance burden, the Maintenance-Critical Equipments were ranked by ascending Maintenance Burden Factors. These are listed in Tables 5-7, 5-9, and 5-10 for the three ship classes, LST-1179, LPD-4, and LHA-1 respectively. The EICs identified as primary maintenance-critical offer the greatest potential benefit from a revised maintenance strategy and should be the focal point for revisions. As resources permit, those EICs identified as possibly maintenance-critical should be reviewed for added potential benefit from a revised maintenance strategy.

CHAPTER SIX

DEFINITION OF PRELIMINARY PEOC PROGRAM MAINTENANCE STRATEGY

6.1 INTRODUCTION

Significant maintenance burden (corrective and restorative) EICs and PFMs were identified in the preceeding chapter. They indicate problems in current maintenance strategy and also identify equipments offering the potential for the greatest improvement by a revised (PEOC) strategy. This chapter describes the investigation of these maintenance-critical EICs and PFMs, the consideration of maintenance strategy elements, the approach used, and the alternative maintenance strategy selected for each class.

The data (described in Chapter Four) related to identified critical EICs and PFMs were reviewed in detail to evaluate the effects of revising the various elements (LOR, MOR, TOR, and Operating Cycle) of maintenance strategy.

6.2 APPROACH

6.2.1 Level of Repair

Levels of repair were not revised for the PEOC Program classes because data for all classes showed that the majority of maintenance during the operating cycle is currently performed at the organizational level, no significant excess of organizational maintenance capacity was identified, and transfer of maintenance responsibility to a higher level of maintenance conflicts with the Navy's general policy as noted in the previous chapter. While detailed investigation of maintenance-critical EICs during the Development Phase might suggest LOR revisions, no indications of required LOR revisions were identified during the Initiation Phase. Organizational maintenance capability was found to be satisfactory for the large majority of EICs.

6.2.2 Method of Repair

A change from the current piece-part replacement method of repair to modular/subassembly replacement was neither indicated for any of the most significant maintenance-critical EICs or PFMs, nor did it appear feasible for other than the few electronic oriented, maintenance-critical EICs. For the LHA-1 Class, labor and parts cost expenditures indicate modular/subassembly replacement is, in fact, currently practiced in part for the

Guided Missile Systems, the Gunfire Control System, and the Radio Communications and Data Systems. Together, these systems have accounted for 7 percent of reported Ship's Force man-hours and 64 percent of reported parts costs. The high maintenance criticality associated with these systems, from Table 5-9, suggests that modular replacement, where used, has not proven highly effective, and greater use of piece-part replacement should be investigated for these systems. Certainly, modular/subassembly replacement, considering the current configuration of amphibious ships, does not appear to offer a generally satisfactory solution for the maintenance-critical systems and equipment identified in Chapter Five.

Rotable pool replacement is a method that clearly supports the material condition and availability objectives of the program, but no clear need for this method was seen from analyses so far conducted. This method can be used for both electronic and non-electronic major assemblies. The obvious disadvantages of this method are the significant cost of establishing the initial supply of ready spare equipment (the rotable pool), the greater cost of performing the restorative maintenance at a higher level of repair, and the attendant reduction of IMA/Depot capacity resulting from this workload shift. In view of the significant front-end or start-up costs associated with this method and the absence of any clearly indicated need, specific rotable pool recommendations should await the results of the detailed engineering analysis performed in the next (development) phase of the program.

While detailed engineering analysis during the Development Phase may properly identify items for on-condition or condition-dependent maintenance timing, no such conclusions were supportable from the analyses conducted during this phase. The run-to-failure policy was considered totally inappropriate for the identified maintenance-critical systems because of their indicated mission essentiality. These systems do exhibit indications of additional maintenance requirements and so lend themselves to periodic maintenance timing, thus obviating the need for consideration of the run-to-failure policy.

6.2.3 Timing of Repair/Operating Cycle

The identified maintenance-critical systems were further analyzed to determine if they demonstrated an adverse relationship between age (time after overhaul) and material condition. This information permitted better identification of maintenance timing limitiations affecting the development of preliminary PEOC maintenance strategies for the LST-1179 and LPD-4 classes. Although insufficient LHA-1 Class historical information existed to develop these trends, maintenance manpower limitations and their effects on availability identified actions for incorporation into a preliminary PEOC maintenance strategy for that class.

Maintenance information for LST-1179 and LPD-4 Class maintenance-critical EICs was graphed and analyzed to identify those EICs whose material condition degraded with increased time after overhaul. The MDS indicators used in this process included failures, ship man-hours,

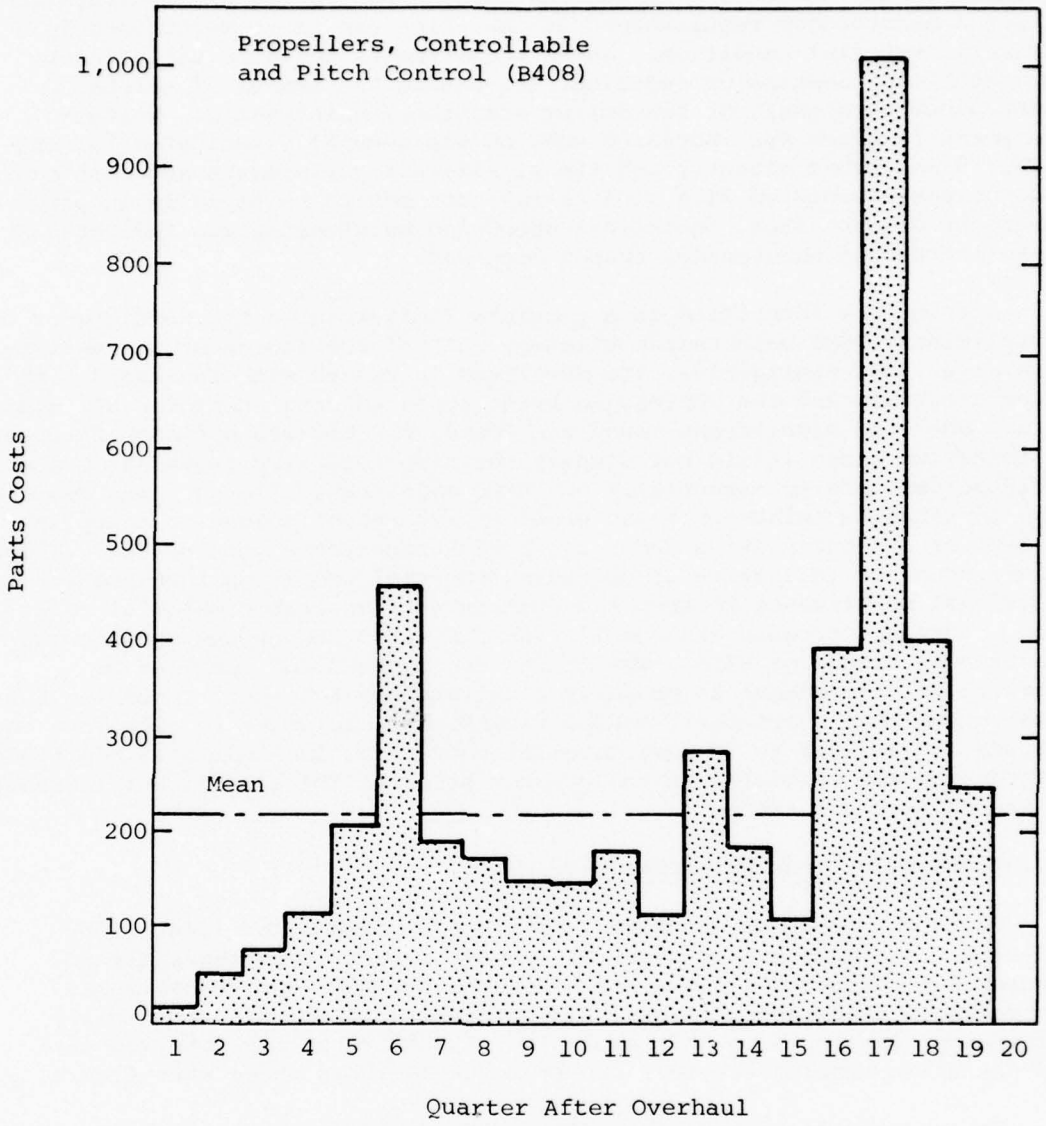
deferrals, outside man-hours, outside deferrals, and parts costs. Trends in these indicators toward increasing maintenance for an EIC indicate additional maintenance requirements if the ships are to be maintained in a desirable material condition. These requirements could be satisfied by equipment modification or redesign, increasing the number of shipboard maintenance personnel, or scheduling additional maintenance. Neither equipment redesign nor increased manning was generally indicated for the LST-1179 and LPD-4 classes, and the significant performance and cost considerations associated with such changes are not to be casually incurred. For these classes then, additional scheduled maintenance was indicated where increasing maintenance trends occurred.

A trend was identified as a possible limitation to the development of a preliminary PEOC maintenance strategy only if the indicator was measurable (i.e., not negligible), its magnitude increased with increased time after overhaul, and the increasing trend appeared consistent for all class data. Where no significant trend was found, the EIC was not considered as a limitation since it did not display the time-sensitive degradation and could accommodate to essentially any PEOC maintenance timing. The decision when to schedule maintenance was based on records of abrupt or sharp increases or discontinuities above the normal experience for the EIC. These occurrences are indicative of degrading material condition that requires additional maintenance to keep the systems at a desirable material condition. Abrupt increases are readily identified on the graphs showing the maintenance trends of EICs. The graphs are plotted and numbered by quarters-after-overhaul to properly highlight the long-term trends in the data rather than short-term, random variations. In order to alleviate the degradation as well as improve material condition, the indicated additional maintenance was scheduled in the quarter prior to the significant increase in the maintenance trend.

6.2.4 LST-1179 Class Maintenance Trends

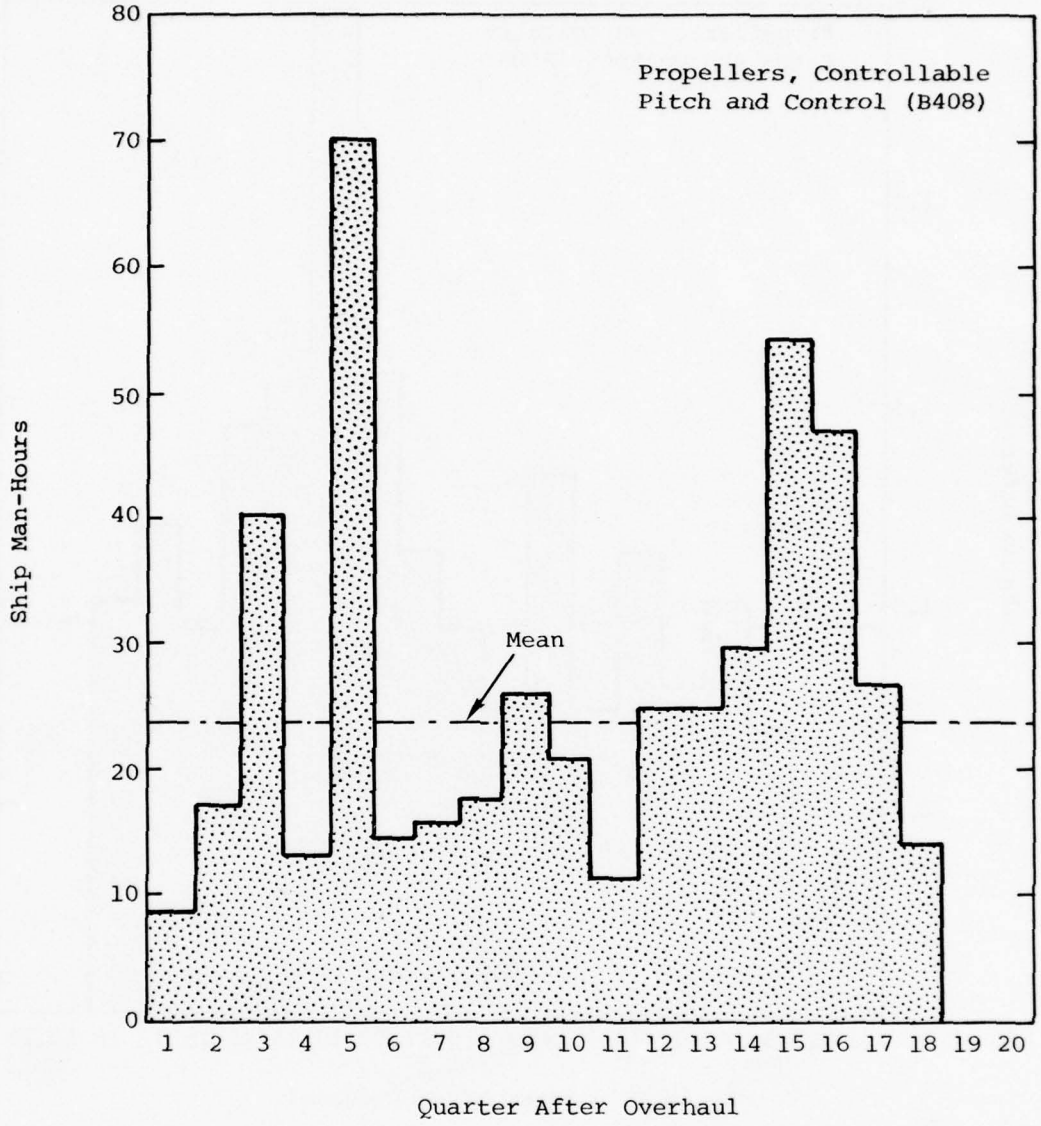
Using the approach described, maintenance trends for identified LST-1179 Class maintenance-critical systems were graphed and analyzed. Figures 6-1 through 6-4 are a set of graphs for EIC B408, Propellers, controllable pitch and controls. These figures illustrate graphically information developed in this analysis. A summary of the observed data and tentative conclusions that can be drawn is shown under each figure.

The quarter for scheduling additional maintenance was selected after reviewing the same criteria discussed for identification of increasing maintenance trends. The absolute value and relative or percent of change associated with an indicator provides a rough measure of the benefit to be derived from performing the indicated maintenance. On occasion, indications of degraded material condition for an EIC could also be observed to progress from one MDS indicator to another, as from an abrupt increase in failures to one in Ship's Force man-hours, to yet another in parts costs or outside deferrals. Relationships such as these and cyclical maintenance demands can be identified from these graphic data displays. An indication of a need for additional maintenance in the first year after overhaul clearly suggest increased attention during the overhaul period as an alternative



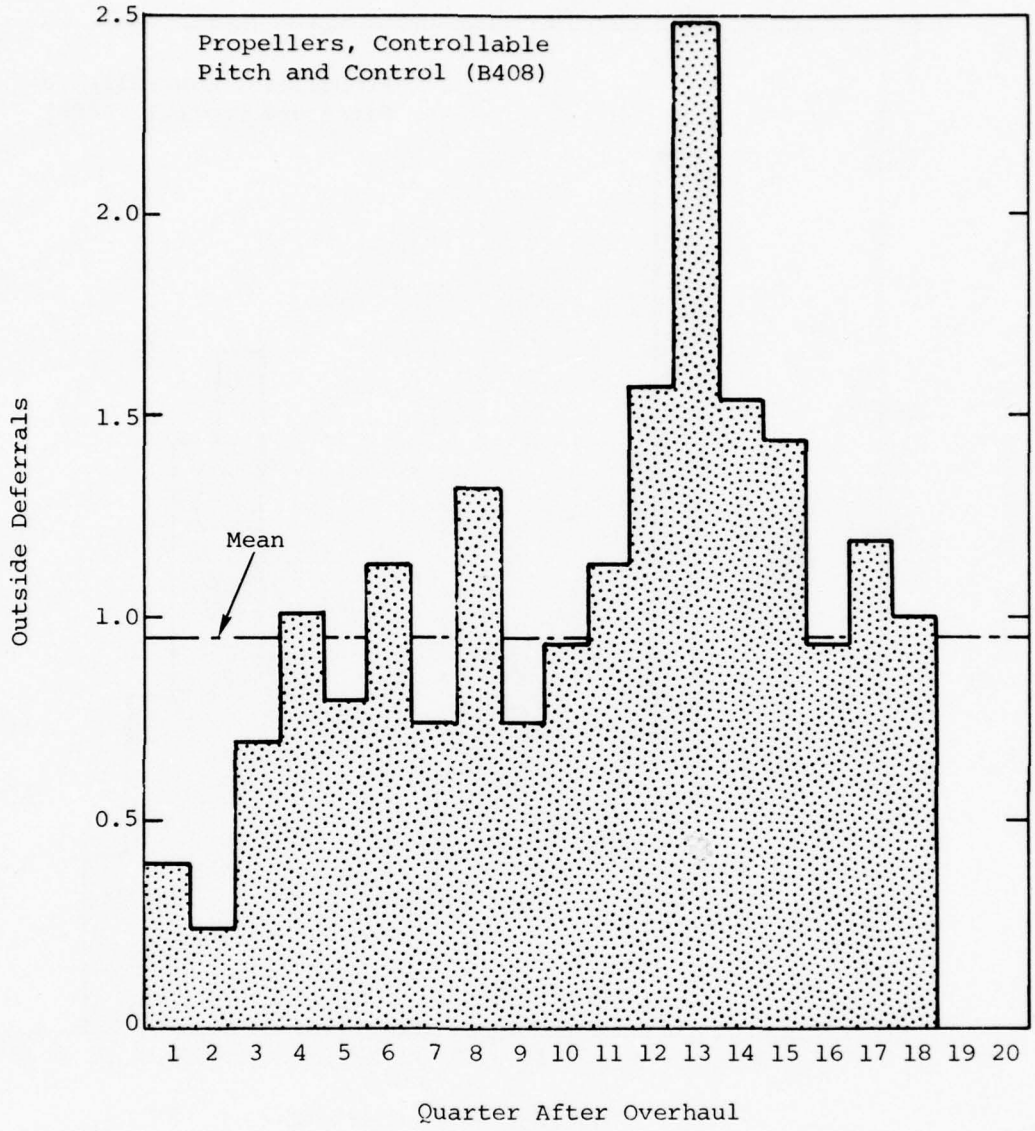
Note: The propellers, controllable pitch and control (EIC B408) exhibit two distinct areas above the mean that are representative of the class and require additional maintenance. The identified areas are the sixth, and the sixteenth through the eighteenth quarters after overhaul. Maintenance should be scheduled during the quarter before the significant increases in parts costs to return the systems to a desirable material condition. Additional maintenance is indicated during the fifth and fifteenth quarters after overhaul.

Figure 6-1. PARTS COSTS VS. QUARTER AFTER OVERHAUL FOR THE LST-1179 PROPELLER, CONTROLLABLE PITCH AND CONTROLS



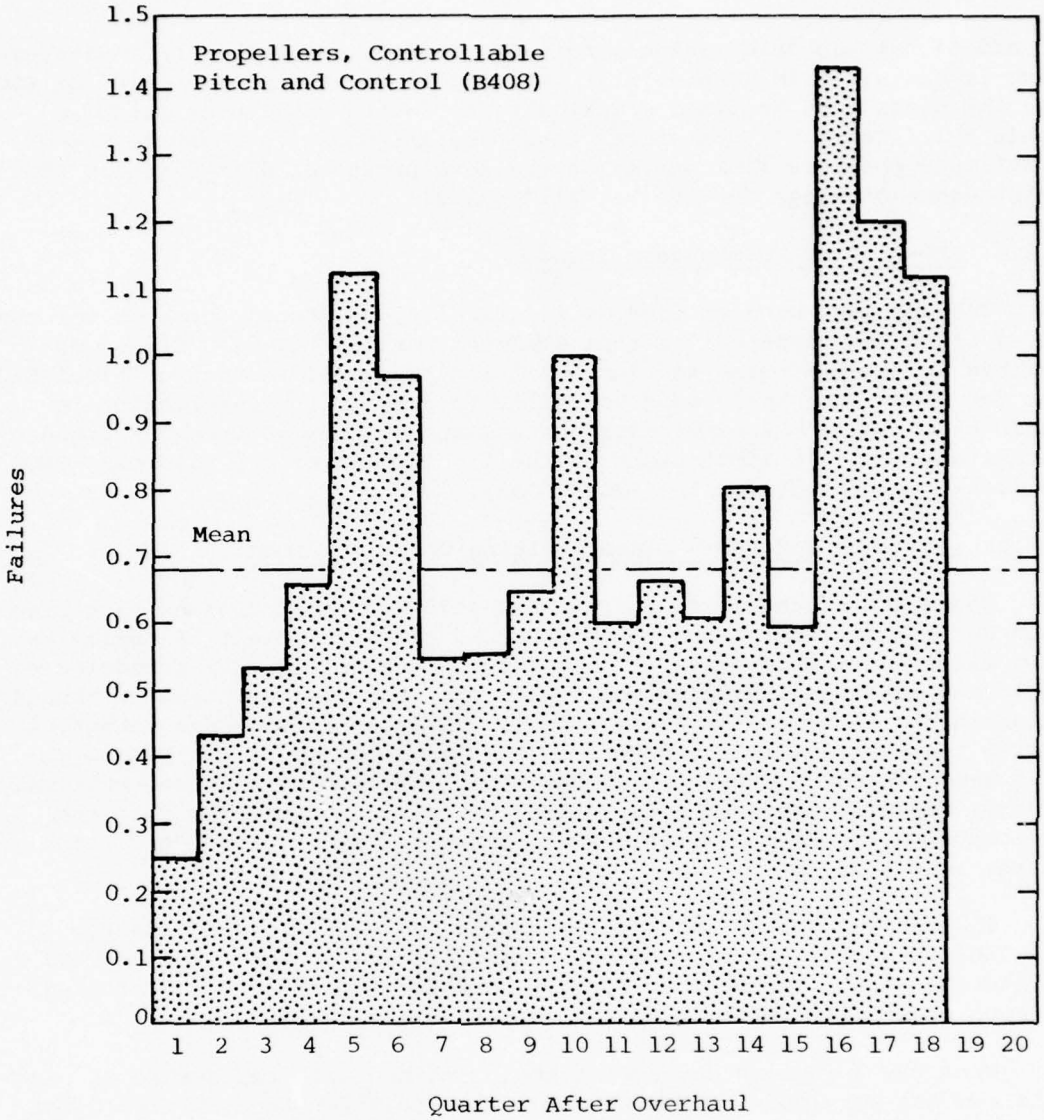
Note: The propellers, controllable pitch and control (EIC B408) exhibit three distinct areas above the mean that are representative of the class and require additional maintenance. The identified areas are the third, fourth, and the fourteenth through the sixteenth quarters after overhaul. Maintenance should be scheduled the quarter prior to the significant increases in ship man-hours to return the systems to a desirable material condition. Additional maintenance is indicated during the ROH and thirteenth quarters after overhaul.

Figure 6-2. SHIP MAN-HOURS VS. QUARTER AFTER OVERHAUL FOR THE LST-1179 PROPELLERS, CONTROLLABLE PITCH AND CONTROLS



Note: The propellers, controllable pitch and control (EIC B408) exhibit one distinct area above the mean that is representative of the class and requires additional maintenance. The identified area is the eleventh through the fifteenth quarters after overhaul. Maintenance should be scheduled the quarter prior to the significant increases in outside deferrals to return the system to a desirable material condition. Additional maintenance is indicated during the tenth quarter after overhaul.

Figure 6-3. OUTSIDE DEFERRALS VS. QUARTER AFTER OVERHAUL FOR THE LST-1179 PROPELLERS, CONTROLLABLE PITCH AND CONTROLS



Note: The failure data for the propellers, controllable pitch and control (EIC B408) were not considered time-sensitive due to the negligible increase of only 0.076 failure during the 20 quarters after overhaul. The maximum relative magnitude of 1.4 failures in the sixteenth quarter after overhaul and an average of 0.686 failures per quarter after overhaul are also insignificant. The failure data for the propellers, controllable pitch and control (EIC B408) do not appear to limit the development of a PEOC maintenance strategy.

Figure 6-4. FAILURES VS. QUARTER AFTER OVERHAUL FOR THE LST-1179 PROPELLERS, CONTROLLABLE PITCH AND CONTROLS

to additional scheduled maintenance. Further discussion of this alternative is contained in Section 6.3. All indicated maintenance-critical EICs for the class were analyzed graphically to develop the information in Table 6-1. Table 6-1 summarizes those systems whose maintenance trends constitute possible limitations on the development of a preliminary PEOC maintenance strategy for the LST-1179 Class.

6.2.5 LPD-4 Class Maintenance Trends

The approach used to develop and identify maintenance trends for the LPD-4 Class was identical to that employed for the LST-1179 Class, described in the preceding section. All indicated maintenance-critical EICs for the class were analyzed graphically to develop the information in Table 6-2. Table 6-2 summarizes those systems whose maintenance trends constitute possible limitations on the development of a preliminary PEOC maintenance strategy for the LPD-4 Class.

6.2.6 LST-1179 and LPD-4 Class Limiting Considerations

The maintenance trends for the LST-1179 and LPD-4 Classes have been seen to present limitations to consider in the development of preliminary PEOC maintenance strategies. Table 6-1 and 6-2 contain the schedules of indicated additional maintenance. When the indicated maintenance should occur in the first year after overhaul, increased maintenance attention during the overhaul is preferable to additional scheduled maintenance. This same increased attention to the other limiting maintenance-critical systems may well improve their initial material condition so that the indicated maintenance limitations are either eliminated or occur later in the ship's cycle.

To best support an Extended Operating Cycle, a Selected Restricted Availability (SRA) may provide the most effective action for indicated maintenance later in the ship's cycle to restore desired material condition without substantially reducing the ship's availability.

From the foregoing considerations, combined with the desire to plan balanced SRA workloads, Table 6-1 indicates that for the LST-1179 Class one SRA should be scheduled during the seventh or eighth quarter after overhaul and one SRA scheduled during the twelfth or thirteenth quarter. Similarly, for the LPD-4 Class, Table 6-2 indicates that one SRA should be scheduled during the seventh quarter and another during the thirteenth or fourteenth quarter.

System Maintenance Analyses (described in Appendix C) during the development Phase of the PEOC Program will focus on specific actions required by these limiting systems and identifying steps recommended to be taken during the SRAs as well as during pre-EOC overhauls. These analyses will provide proper corrections for the systems and will serve to refine the PEOC maintenance strategy where that is advantageous.

Table 6-1. LIMITING SYSTEMS BY QUARTER AFTER OVERHAUL REQUIRING ADDITIONAL MAINTENANCE FOR THE LST-1179 CLASS

Quarter After Overhaul

1	2	3	4	5	6	7	8
	(B408) Propellers, controllable pitch and control (S)		(TN01) Winches (S)	(B408) Propellers, controllable pitch and control (P)	(3101) 60-Hz ac generator (P)	(B101) Diesel engine (P)	(B101) Diesel engine (S) (T801) Firemains (O, F, S)

Quarter After Overhaul

9	10	11	12	13	14	15	16
(AD04) Ramps (P) (B101) Diesel engine (F, O) (QD4R) AN/VRC-46 radio set (S, P) (3101) 60-Hz ac generator (S)	(T104) Auxiliary Boiler (O) (Y403) Landing craft (S, O) (B408) Propellers, controllable pitch and control (O)	(TM01) Winches (S) (TF03) Intermediate and low pressure air systems (P) (3101) 60-Hz ac generator (O)	(3101) 60-Hz ac generator (P) (Y403) Landing craft (P) (AD04) Ramps (O)	(QD4R) AN/VRC-46 radio set (P) (B408) Propellers, controllable pitch and control (S)		(B408) Propellers, controllable pitch and control (P) (TM01) Winches (S)	(TF03) Intermediate and low pressure air systems (O) (T801) Firemains (S)

Legend:
F = Failures
D = Deferrals
S = Ship Man-hours
M = Outside Man-hours
O = Outside Deferrals
P = Parts Costs

Table 6-2. LIMITING SYSTEMS BY QUARTER AFTER OVERHAUL REQUIRING ADDITIONAL MAINTENANCE FOR THE LPD-4 CLASS

Quarter After Overhaul							
1	2	3	4	5	6	7	8
	(T404) Air condition- ing system (S)		(QD3R) External radio communications (F) (TK03) Distilling plant (S) (T801) Firemain (F)			(F303) Feed pumps (S, P)	

Quarter After Overhaul							
9	10	11	12	13	14	15	16
(TK03) Distilling plant (S, F)		(T801) Firemains (F)	(QD3R) External radio communications (F)	(F401) Combustion air system (P) (T404) Air condition- ing system	(T801) Firemain (S) (310C) Ac generator system (O) (F303) Feed pumps (F, S, O) (T404) Air condition- ing system (D)	(F401) Combustion air system (D) (F101) Boilers (D)	(QD3R) External radio communications (F)

Legend:
F = Failures
D = Deferrals
S = Ship man-hours
M = Outside Man-hours
O = Outside Deferrals
P = Parts Costs

6.2.7 LHA-1 Class Assessment

The availability of historical maintenance data encompassing a number of complete overhaul cycles for both the LST-1179 and LPD-4 classes permitted use of the maintenance trend approach for these classes. This same method obviously cannot apply to the LHA-1 Class as no overhaul dates exist for the class, and total data experience represents only a small portion of a complete overhaul cycle for any ship. The available data do, however, provide a good assessment of total maintenance manning requirements for the class and PFM Systems (as defined in Table 4-5). The Negative Man-Hour Differential (NMHD) concept, introduced in Section 5.3.4, provides the tool for this assessment. This indicator quantifies maintenance man-hours expended on a system in excess of PFM projections. An NMHD summary of the PFM Systems described in Table 4-5 is tabulated in Table A-9 of Appendix A.

An assessment of the NMHD for each PFM indicates that of the 31,029 total man-hours only 15,000 affect the formulation of a preliminary PEOC maintenance strategy. This assessment is derived from an analysis of MDS data narratives for each PFM, considering the following factors:

- Construction phase data - That portion of the MDS data directly associated with investigation and correction of design deficiencies and not affecting the workload over the longer range of the class life.
- Manning changes - Those increases in allocated manpower that provide added capability required to perform the projected maintenance for a given PFM.

The three maintenance-critical PFMs with the largest individual NMHD values show a combined total of 17,908 man-hours. This total was reduced to a potential offship maintenance requirement of 8,730 man-hours by an analysis that is summarized as follows:

- Interior Communications (PFM 13)* - Manpower changes (8 additional billets) permit the routine accomplishment of 3,200 man-hours more than had been projected for the design manpower complement in this skill area. NMHD requirements were thus reduced from 8,278 hours to approximately 5,080 hours.
- Salt Water and Ballast Systems (PFM 17) - Construction phase data, particularly in regard to replacement of firemain isolation butterfly valves, reduced the NMHD by approximately 3,000 man-hours with increased manning accounting for the reduction of an additional 1,200 man-hours. NMHD requirements were thus reduced from 5,359 hours to approximately 1,160 hours.
- Hull and Hull Fittings (PFM 24) - Construction phase data accounted for approximately 3,700 man-hours, primarily in the area of furnishings and arrangements, reducing NMHD projected requirements from 4,271 man-hours to approximately 570 man-hours.

*PFM Systems as defined in Table 4-5.

- All Other PFMs - The combined total NMHD of all other systems was reduced from 11,962 hours to approximately 7,000 hours through a similar analysis.

Table 6-3 provides a summary of LHA-1 Class enlisted manpower distribution and reflects authorized changes in manpower relative to the Preliminary Ship Manning Document (PSMD). An assessment of these changes indicates that authorized manning has increased by 22.9 percent whereas the PFMs reflect a projected corrective maintenance burden 29.6 percent greater than had been provided for by the PSMD. This indication of additional class manning requirements is also supported by the foregoing analysis of individual system NMHDs citing a shortfall in the range of 15,730 man-hours with the largest single shortfall of 5,080 man-hours attributable to the Interior Communications Systems.

Table 6-3. LHA-1 CLASS ENLISTED MANPOWER DISTRIBUTION

Department	Preliminary Ship Manning Document	Draft Ship Manning Document
Executive	32	27
Navigation	10	10
Medical	16	15
Dental	3	3
Operations	61	86
Communications	45	42
Air	93	107
AIMD	25	49
Deck	55	70
Combat Systems	75	85
Supply	131	152
Engineering	135	191
Total	681	837

This total shortfall is within the capability of an IMA to accomplish within six calendar weeks. TYCOMs currently project the LHA-1 workload to be in the range of 2000-2500 man-hours per week of IMA availability. Thus;

15,000 manhours ÷ 2,500 = 6 weeks

Relative to the interior communications systems:

5,080 man-hours ÷ 6 weeks = 847 man-hours per week, or
847 ÷ 5 days per week = 169 man-hours per day, or
169 ÷ 8 hours per day = 21 maintenance personnel

All IMAs are projected to have adequate resources to dedicate a 21-man work force* to accomplish work on the interior communications systems. All other system projections are small enough to be accomplished within the same 6-week time period.

This assessment concludes that the shipbuilder's designed maintenance strategy requires the scheduling of an additional 6-week IMA/RAV period annually. The following section will consider cycle lengths that will properly incorporate operational as well as maintenance considerations into the preliminary PEOC Program maintenance strategies.

6.3 DEVELOPMENT OF CYCLE LENGTH ALTERNATIVES FOR MAXIMUM DEPLOYMENT POTENTIAL

For a PEOC maintenance strategy to achieve the identified program objectives, it must be developed from engineering, cost, and availability considerations. Chapter Five has identified significant material condition (engineering) considerations for each class. This section will focus on the proper development of availability considerations in the definition of preliminary PEOC maintenance strategies.

Satisfaction of the program objectives requires that class availability be at least maintained with improvements highly desirable. The preliminary PEOC maintenance strategy must, therefore, be defined with full consideration of associated operational requirements and their effects.

LST-1179 and LPD-4 Classes have a life expectancy of 30 years; the designed life of the LHA-1 Class is 20 years. On the basis of commissioning dates, each class has at least a 20-year life expectancy remaining. Therefore, a 20-year operational period was used for measurement of both current and preliminary PEOC maintenance strategies for purposes of this study.

Current operational and overhaul schedules provide a reference framework to use in considering possible scheduling revisions within the PEOC maintenance strategies. Considerable planning has been done and scheduling relationships are defined within TYCOM scheduling templates. The conventional two-deployment cycles from TYCOM scheduling documents** are displayed in Table 6-4, showing average values for both TYCOMs with ROH durations from OPNAV Instruction 4700.7E. This table identifies the principal segments or "building blocks" of a ship's schedule. The values shown (except ROH duration) were obtained by calculating a mean of SURFLANT and

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*Manpower Authorization (OPNAV 1000/2) modified by Transaction Number 90313 of March 1978.

**Quarterly Schedule SURFLANT STAFF 3120/5 forms, COMSURFPAC OPORD 201. TAB A to Appendix 15 to Annex C.

Table 6-4. CONVENTIONAL TWO-DEPLOYMENT OVERHAUL CYCLES (IN MONTHS)

Ship Class	Post Overhaul	Deploy	Training/ Upkeep Operations	Deploy	Pre-Overhaul	ROH
LST-1179	7.46	5.05	14.70	5.13	3.93	4.00
LPD-4	7.46	5.05	14.70	5.13	3.93	4.50
LHA-1	7.46	5.05	14.70	5.13	3.93	6.00

SURFPAC data. As stated in Chapter Five, comparability between current and alternative maintenance strategies is improved by imposing a standard ROH duration throughout this study. While recent ROH durations have exceeded the standard shceduled lengths, consistent use of either ROH duration value produces essentially similar results. Use of a longer overhaul length, which would be difficult to extrapolate, would, when comparing current and alternative maintenance strategies, slightly favor (about 5 percent) the PEOC maintenance strategies because of their greater intervals between overhauls.

A review of scheduled ship activities during the Pre-Overhaul, ROH, and Post-Overhaul segments of the cycle clearly indicates that these components provide very little operational availability. They constitute a principal limitation to improving the operational availability of these classes. Accordingly, any revised maintenance strategy to improve material condition should not increase that portion of a ship's time devoted to those activities. Furthermore, the relationships in current scheduling templates represent a considerable operational experience base and should be modified only for clear and abiding reasons. When viewed together, these limitations point up the desirability of using existing scheduling templates while maintaining or reducing ships' time devoted to pre-overhaul, ROH, and post-overhaul activities.

An optimum method of achieving both of these aims is to consider a formulation of cycles containing increased numbers of deployments. Such a revision would add one or more periods of deployment as well as a similar number of training, upkeep and operations periods. Use of this building block process provides a variety of cycle length alternatives, with each alternative offering a different multiple of deployments. The modular segments used to construct these alternatives are multiples of training, upkeep, and operations periods, with deployment periods inserted between the current second deployment and the start of the pre-overhaul segment. The additional deployment periods were estimated to equal the average of the two existing deployment periods (5.09 months), while existing training, upkeep, and operations periods were kept at their present value.

This approach provides the deployment and cycle length alternatives shown in Table 6-5. The cycle length for the current two-deployment operating cycle is included for reference. The number of months associated with each component activity are totaled for each alternative. This modular development results in cycle lengths from sixty to over one hundred months when considering three to five deployments. In practice, selection of preliminary PEOC maintenance strategies is limited by two additional items: the FMP and the available data base.

Table 6-5. DEPLOYMENT AND CYCLE LENGTH ALTERNATIVES (IN MONTHS)

Number of Deployments	Post Overhaul	Deploy	Training/ Upkeep Operations	Pre-Overhaul	ROH	Total
LST-1179						
2	7.46	10.18	14.70	3.93	4.00	40.27
3	7.46	15.27	29.40	3.93	4.00	60.06
4	7.46	20.36	44.10	3.93	4.00	79.85
5	7.46	25.45	58.80	3.93	4.00	99.64
LPD-4						
2	7.46	10.18	14.70	3.93	4.50	40.77
3	7.46	15.27	29.40	3.93	4.50	60.56
4	7.46	20.36	44.10	3.93	4.50	80.35
5	7.46	25.45	58.80	3.93	4.50	100.14
LHA-1						
2	7.46	10.18	14.70	3.93	6.00	42.27
3	7.46	15.27	29.40	3.93	6.00	62.06
4	7.46	20.36	44.10	3.93	6.00	81.85
5	7.46	25.45	58.80	3.93	6.00	101.64

A five-deployment cycle appears unrealistic in view of FMP requirements, because it would impose a backlog or deferral of modernization items items for periods of up to eight years. Such a period is well in excess of the normal development time (four to five years) for FMP items and would unnecessarily deprive the ships of improvements provided by the FMP. The four-deployment cycle would similarly impose a backlog of deferral of these items for periods greater than 6 1/2 years, also in excess of the normal development time for FMP items.

Review of the available data base gives added insight into the selection process. Although no data exist to support the validity of a 6 1/2 or 8-year cycle and extrapolation for cycles that long is highly questionable, three LPD-4 Class ships and five ships of the LST-1179 Class have experienced cycle lengths greater than those that would result from a three-deployment cycle. This experience has generated enough data to support the feasibility of three-deployment cycles; their validity for the longer cycles is uncertain. Although the longer cycles would obviously increease availability, the added uncertainty associated with their effects on the ships' material condition make them a riskier alternative. To avoid this added risk to a primary objective of the program, three-deployment cycles were selected for further evaluation as preliminary PEOC maintenance strategies. An added consideration in this selection based on the extensive costs associated with an ROH period was that proving the three-deployment cycle to be cost-feasible would also demonstrate the cost-feasibility of longer cycles. Demonstrating the cost feasibility of a longer cycle, however, would not provide assurance that a three-deployment cycle was cost-feasible.

The rationale for the choice of the times for the Selected Restricted Availabilities (SRAs) in the proposed PEOC operating cycles was driven by several factors. The main influence was the need for maintenance as indicated by the EICs shown in Table 6-1. These EICs have all shown an increasing maintenance burden as a function of time after overhaul or have indicated a peak in their maintenance burden, also as a function of time after overhaul. The other primary influencing factor was the availability of maintenance windows in the proposed PEOC operating cycle. Deployment periods were ruled out for the accomplishment of scheduled maintenance actions and attention was given to the lengthy periods (6 weeks or more), either Intermediate Maintenance Activity Availability (IMAV) or Planned Restricted Availability (PRAV), that exist in the TYCOM scheduling templates.

Analysis of the identified EICs for the type of burden showing an increase or peak and for the time after overhaul when the unsatisfactory burden accrued suggested an acceptable range of time when maintenance should be performed to alleviate these burdens. A very early indication of a need for maintenance assistance (within fourteen months after overhaul) may identify systems or equipments that did not receive attention during the previous overhaul or whose need for maintenance was accelerated by the ship's deployment. In either case, it is not feasible to schedule maintenance periods for these EICs as early in the operating cycle as seems to be called for. These systems should receive special attention through the POT&I, Pre-EOC Overhaul, SARPs, and Test and Certification Procedures to ensure that they are capable of satisfactory operation through at least the first deployment. Other systems needing maintenance more than 14 months but less than 36 months after overhaul were reviewed to determine whether they would require work before the second deployment (about 26 months after overhaul), or if the burden could be postponed.

A number of the systems, particularly on the LST-1179 Class, showed deferrals for outside assistance as burden indications in the period beyond 36 months after overhaul. It is suspected that a number of these deferrals were triggered by the need to have the Current Ship's Maintenance Project (CSMP) up to date for the ROH. If so, maintenance on these systems might be postponed until later when the maintenance would also better serve to support the third deployment in the proposed cycle.

Preliminary indications from the system review and the compatibility of the required maintenance with the proposed operating cycle are that maintenance periods scheduled approximately 21 months and 42 months into the proposed cycle will be responsive to both the operational and maintenance needs of the amphibious ships. After grouping the systems into the most appropriate maintenance periods, estimates were made of the maintenance likely to be required, the man-hours historically required for the repairs, and the level at which the repair should be accomplished. These estimates are shown in Table 6-6 for the LST-1179 Class and Table 6-7 for the LPD-4 Class and reflect approximately 25 percent of the projected requirement for an SRA. On the basis of experience from the DDEOC Program and the identification of approximately 20 percent of the SRA for accomplishment of alterations an estimated 2,800 to 3,500 man-days will be required for each SRA for the LST-1179 Class, and 3,300 to 4,300 man-days for the LPD-4 Class. By straight man-day loading estimates it would take one month to accomplish this work. However, since the nature of the repairs and alterations are not known and since the SRAs are to be inserted into six-week maintenance periods already in the TYCOM schedule templates, it is recommended that six weeks be allowed for these maintenance periods.

Similarly detailed estimates of SRA requirements should be established for the LHA-1 Class after additional data collection and observation of follow-ship performance. Total requirements for each LHA-1 SRA are initially estimated at 8,000 to 10,000 man-days. This estimate is based on the assessment performed in Section 6.2.4, including a six-month ROH period rather than the four-month period of the shipbuilder's designed maintenance strategy.

Figure 6-5 shows the preliminary PEOC maintenance strategies based on extended overhaul cycles and the resulting three-deployment cycle for each class. It should be noted that the maintenance strategies developed during the Initiation Phase are, as the name implies, just preliminary. While these strategies do represent the best current approximation of the required maintenance strategy revisions for the PEOC ship clases, final definition of PEOC maintenance strategies will occur in the Development Phase after results of detailed engineering analysis have been obtained. The preliminary PEOC maintenance strategies are accurate and in enough detail to permit a valid comparison of the relative effectiveness and resource requirements of the current and preliminary PEOC maintenance strategies.

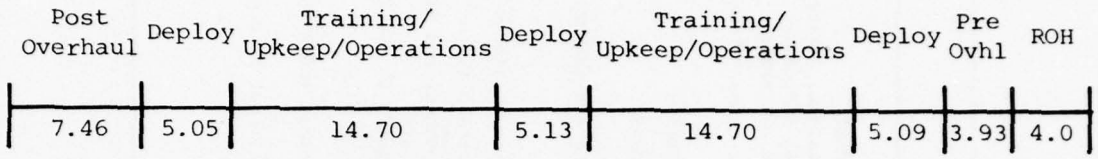
Table 6-6. LST-1179 CLASS OUTSIDE ASSISTANCE INTRACYCLE MAINTENANCE REQUIREMENTS

System (Number of Units)	SWBS	LOR	First Maintenance Period, Man-Hours	Second Maintenance Period, Man Hours	Remarks
Diesel engines (6)	233	SY	1150		Governor air start/injection test/ miscellaneous
Reduction gears and clutch	241	SY	200	460	Class "B" and "C" repairs to lube oil system
Propulsion control (2)	245/252	SY	530	530	Miscellaneous Class "B" and "C" repairs to hydraulic system
60-Hz Ac Generator (3)	311	SY	50	150	Slip rings and brushes/pumps
External radio communications (various)	441	SY	160	160	Repair, align and calibrate
Firemains (1)	511	IMA	160	160	Miscellaneous valve, regulator and line repairs
Auxiliary boilers (2) Feed pumps (2)	517	IMA	430	480	Miscellaneous Class "C" repairs to pump and refractory
Intermediate and low pressure air systems (2 each)	551	SY	500	500	Gauges/rings/valve trips/lap valve seat
Distilling plants (2)	531	IMA	132	132	Class "B" and "C" repairs to pumps and heat exchangers
Cargo and ramp winches (8)	573	SY	200	220	Repair clutch and brakes
Landing craft LCVP (4)	583	SY	300	300	Miscellaneous Class "C" repairs to engine or hull
		IMA	120	120	Minor hull or engine work
Boat davits (2)	583	SY	350	200	Brake/davit/controllers/seals
Stern gate (1)	584	SY	450	450	Brakes/torque coupler brake/switches and controllers
Total		SY	4890	4370	
		IMA	840	890	

Table 6-7 LPD-4 CLASS OUTSIDE ASSISTANCE
INTRACYCLE MAINTENANCE REQUIREMENTS

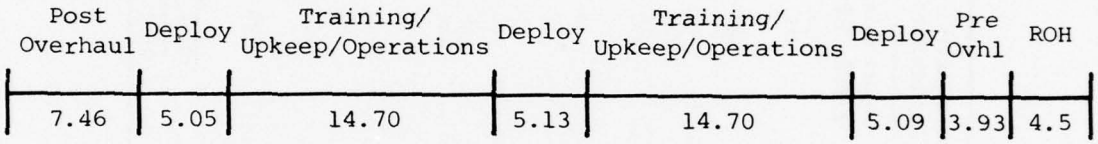
System (Number of Units)	SWBS	LOR	First Maintenance Period, Man-Hours	Second Maintenance Period, Man-Hours	Remarks
Boilers (2)	221	SY	1716	1716	Refractory, valves, piping
		IMA	436	436	water level indicator, repair and calibrate
Main force draft blowers (4)	251	SY	400	400	Miscellaneous Class "C" repairs
Main feed pumps (3)	255	SY	300	300	Class "C" repairs
Ac generator set SSTG (3)	311	SY	400	400	Class "C" repairs
External radio communications (Various)	441	SY	380	380	Repair, align, **and calibrate**
Firemain (1)	511	IMA	260	260	General repairs to valves and pipe
Firepumps (4)	511	SY		600	Class "B" overhaul (2)
		IMA	144	144	Class "C" repairs
Air conditioning system (2)	514	IMA	64		Compressor overhaul and miscellaneous repairs
Distilling plant (2)	531	SY	192	192	Class "C" repairs to shell and tubing
		IMA	48	48	Pump repair and overhaul
Intermediate and low pressure air systems (4)	551	SY	500	1760	Compressor repair and overhaul
Bilge and ballast (2)	551	SY	740	740	Miscellaneous repairs to compressors and control valves
	Total	SY	4630	6490	
		IMA	950	1050	

LST-1179 Class



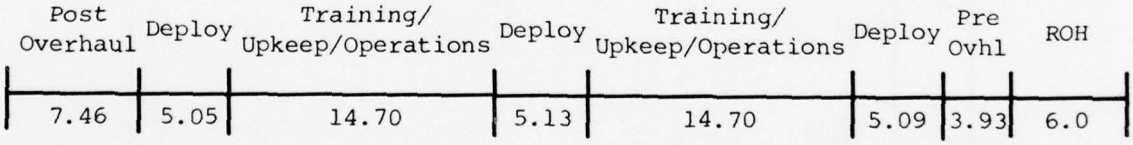
Overhaul cycle length 60.06 months
Operating cycle length 56.06 months

LPD-4 Class



Overhaul cycle length 60.56 months
Operating cycle length 56.06 months

LHA-1 Class



Overhaul cycle length 62.06 months
Operating cycle length 56.06 months

Figure 6-5. PRELIMINARY PEOC CYCLES FOR LST-1179, LPD-4, AND LHA-1 CLASSES (ALL VALUES IN MONTHS)

6.4 SUMMARY OF PEOC MAINTENANCE STRATEGIES

Current maintenance strategy for these classes consists primarily of maintenance performed at the organizational level, using piece-part replacement, much of it at periodic intervals called for in the Planned Maintenance System (PMS). Additionally, the strategy has been to plan for a three-week availability per quarter at an IMA. Industrial requirements are handled on an emergent basis or as they occur during the operating cycle. Regular overhauls for major refurbishment of equipments and structure as well as FMP alterations scheduled approximately every three years for a four- to six-month duration. Recent experience shows that the ROHs for the LST-1179 and LPD-4 Classes have averaged one to two months longer than planned, perhaps driven by the alterations being accomplished as much as the other common problems of Long Lead Time Material (LLTM) and manpower shortages.

In addition to the above maintenance periods, during the past three years COMNAVSURFPAC has been including a six-week PRAV between the two deployments of the operating cycle. This was done is response to the Chief of Naval Operation's establishment of the RED "E" Program and the directive to improve fleet material condition.

The proposed maintenance strategy for the classes of the PEOC Program retains much of the current strategy and is designed to blend with the current notional operating cycles in order to create the least amount of disruption to the Fleet and Type Commander during implementation. The emphasis of the proposed strategy is to provide an organization capable of accomplishing, evaluating, and up-dating the reliability-centered maintenance requirements for each ship class throughout the operating cycle. These requirements will be initially determined by system maintenance analyses (SMAs) performed during the development phase of the PEOC Program. The key elements of the proposed strategy, which is designed to support a three-deployment operating cycle, are:

- Increased use of off-ship maintenance management. A main thrust of the PEOC Program is the engineered approach to identify and meet the maintenance requirements for the LST-1179, LPD-4, and LHA-1 classes. The in-depth detailed engineering analyses conducted during the Development Phase, the System Maintenance Analyses, provide the tool to develop this engineered program of maintenance. This effort adds considerably to the knowledge and understanding of the class maintenance requirements while providing adequate planning and engineering information to permit more cost-effective use of additional off-ship (as well as shipboard) maintenance resources. Significant examples of the PEOC Program's utilization of off-ship maintenance resources include -

  - The development of Class Maintenance and Modernization Plans that will contain reliability-centered maintenance requirements, the frequency of accomplishment, and the level of repair.

These plans describe all the principal aspects of maintenance planning, doctrine, resources, and performance for the class.

- The establishment of a PEOC Program functional organization to provide for the effective planning, coordination, evaluation, updating, and continuity of the PEOC maintenance strategy. This organization will include the following roles, each of which is described in Chapter Ten.
  - PEOC Program Office
  - Dedicated PEOC TYCOM Staff Elements
  - PEOC Central Technical Group
  - PEOC Site Teams
- A pre-EOC overhaul, of approximately 11 months duration, to realize an early improvement in ship material condition, and to facilitate structured planning and accomplishment of class maintenance.
- The use of a Selected Restricted Availability or planned industrial maintenance period of approximately six weeks duration between the ship deployments for the accomplishment of required maintenance on critical systems and limited alterations. These periods are necessary to prevent the maintenance burden on the maintenance-critical systems from building to the point where the material condition and availability of the ships is degraded.

- Modification of current two-deployment operating cycles to three-deployment cycles. The improvements in class material condition resulting from more cost-effective use of shipboard and off-ship maintenance resources enables these ships to include a third deployment within the operating cycle. This step significantly improves class operational availability and permits better relalization of the potential benefits available from increased utilization of off-ship maintenance management.

The combined effect of these elements is improved material condition combined with increased operational availability for the LST-1179, LPD-4, and LHA-1 Classes. Chapters Seven and Eight will evaluate the effectiveness of the current and preliminary PEOC maintenance strategies in order to provide a basis for assessing the feasibility of the preliminary PEOC strategies.

CHAPTER SEVEN

CURRENT MAINTENANCE STRATEGY EFFECTIVENESS AND RESOURCE REQUIREMENTS

7.1 INTRODUCTION

This portion of the Initiation Study evaluates the effectiveness of the current maintenance strategy and estimates the cost of that effectiveness. The effectiveness was measurable in terms of availability, defined as that percentage of time a ship class is either fully or substantially ready to perform its primary mission. States of readiness and the events assumed for each state are described and correspond to the FORSTAT readiness and reporting system. The estimated cost or resource requirements to implement the current strategy for a 20-year period were developed. To provide the greatest degree of standardization and validity in relating cost estimates, the same approach was used for all PEOC classes. In the next chapter the effectiveness and resource requirements for the preliminary PEOC maintenance strategies are estimated, using the same procedures described in this chapter.

7.2 EFFECTIVENESS

Two interrelated measures of availability were used to quantify the effectiveness of current strategies. These two measures are ship availability and Ships Available For Operation (SAFO). Ship availability is that fraction of the overall cycle a ship is either fully or substantially ready to perform its primary mission. SAFO describes the total number of ships of a class that may be expected to be operational at any given time. Mathematically,

SAFO = ship availability $\times$ number of ships in a class

7.2.1 Ship Availability

Ship availability is defined as the fraction of time a ship is either Fully Ready (State 1) or Substantially Ready (State 2) to perform its primary mission. There are two other possible states, Marginally Ready (State 3) and Not Ready (State 4).

Using the approach applied in a recent Navy analysis*, readiness states are assumed for events during a ship's operating cycle. Events and the states assumed for each event are shown in Table 7-1. These associations are used to provide a basis for estimating the effectiveness of the current maintenance strategy. For purposes of this study these associations are both descriptive and valid, recognizing that within events readiness states vary (e.g., ships on deployment are occasionally less than fully ready). Ship availability for the current strategy was computed by applying these readiness definitions to the Fleet's current practice of two deployments per operating cycle. Regular Overhaul durations from OPNAV Instruction 4700.7E of 28 May 1974 are assumed valid for these ships and were used for measuring the effectiveness of the maintenance strategies. Recent experience indicates slightly longer overhaul durations, but the single value was used since it slightly improves the resulting ship availability for the current strategies and provides a uniform basis for measurement. Current cycles for the LST-1179, LPD-4, and LHA-1 classes are shown in Figure 7-1. Table 7-2 provides a separate summary of the time spent in each state, compiled from TYCOM scheduling documents.

From the definition of ship availability, simply adding the fractions of time for State 1 and State 2 from Table 7-2 gives current ship availability values, shown in Table 7-3.

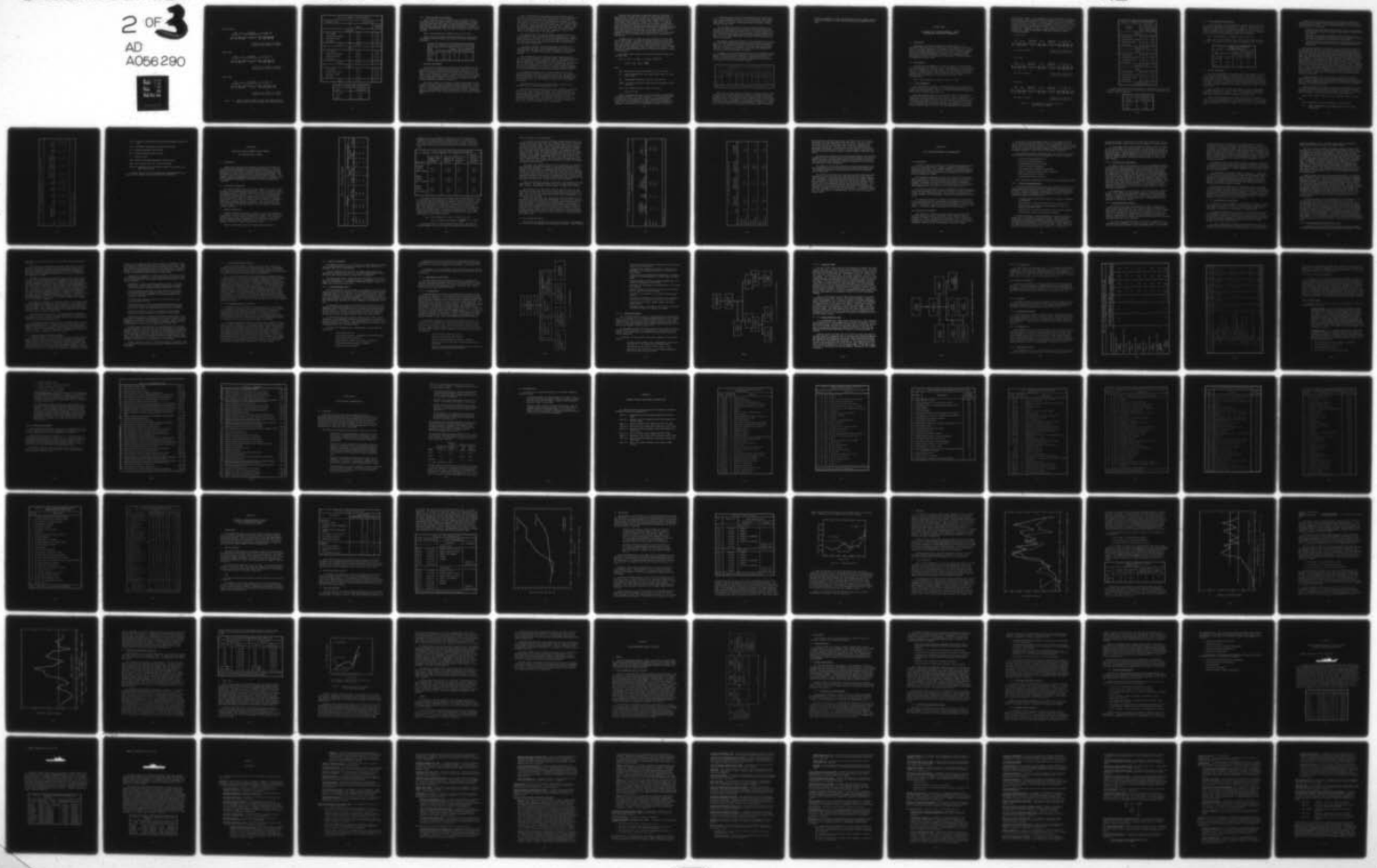
Table 7-1. READINESS STATES AND RELATED EVENTS

Readiness State	Events
1. Fully Ready	Deployed Enroute Fleet Operations
2. Substantially Ready	Technical Availability Prepare for Overseas Movement Leave/Upkeep Operational Propulsion Plant Exam Training (other than refresher training)
3. Marginally Ready	Period after overhaul until completion of refresher training (REFTRA). Includes Ship Qualification Trials, REFTRA, Restricted Availability, Training, Upkeep Restricted Availabilities Intermediate Maintenance Periods
4. Not Ready	Regular or Pre-EOC Overhaul

*SEAMOD - A New Way to Design, Construct, Modernize and Convert U. S. Navy Combatant Ships, by C. Lawson, 14th Annual Technical Symposium (Association of Scientists and Engineers), 1977.

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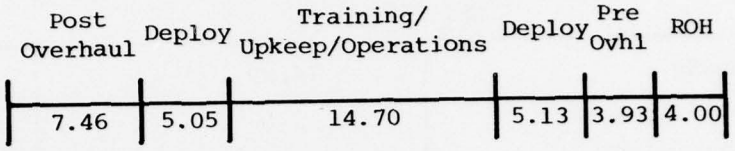
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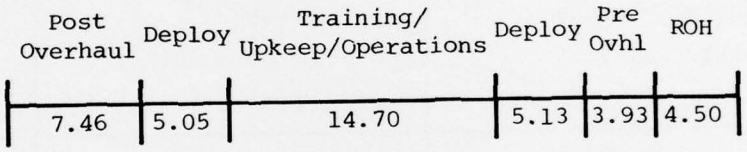
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LST-1179 CLASS



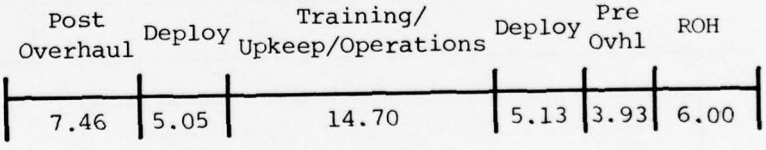
Overhaul Cycle Length 40.27 Months
Operating Cycle Length 36.27 Months

LPD-4 CLASS



Overhaul Cycle Length 40.77 Months
Operating Cycle Length 36.27 Months

LHA-1 CLASS



Overhaul Cycle Length 42.27 Months
Operating Cycle Length 36.27 Months

Figure 7-1. CURRENT OPERATING/OVERHAUL CYCLES (TWO-DEPLOYMENT) FOR LST-1179, LPD-4 and LHA-1 CLASSES (ALL VALUES IN MONTHS)

Table 7-2. SUMMARY OF CLASS READINESS		
Readiness State	Current Cycle	
	Months	Fraction of Time
LST-1179		
1. Fully Ready	16.29	0.405
2. Substantially Ready	9.90	0.246
3. Marginally Ready	10.08	0.250
4. Not Ready	4.00	0.099
Total	40.27	-----
LPD-4		
1. Fully Ready	14.90	0.366
2. Substantially Ready	10.48	0.257
3. Marginally Ready	10.89	0.267
4. Not Ready	4.50	0.110
Total	40.77	-----
LHA-1		
1. Fully Ready	15.01	0.389
2. Substantially Ready	9.67	0.228
3. Marginally Ready	11.59	0.241
4. Not Ready	6.00	0.142
Total	42.27	-----

Table 7-3. CURRENT SHIP AVAILABILITY	
Class	Availability
LST-1179	0.651
LPD-4	0.623
LHA-1	0.584

7.2.2 Ships Available For Operations

Ship availability can be translated into operational terms by multiplying it by the number of ships to which it applies. Assuming that the beginning of ship cycles are uniformly distributed in time throughout the class, the product of ship availability and number of ships yields the expected number of ships available for operations at any time. Mathematically, ships available for operation (SAFO) can be expressed:

SAFO = ship availability x number of ships in the class

Table 7-4 shows the number of ships available for operation for the LST-1179, LPD-4 and LHA-1 classes under the current maintenance strategies.

Table 7-4. NUMBER OF SHIPS AVAILABLE FOR OPERATION

Ship Class	Availability	Number of Ships	Ships Available For Operations
LST-1179	0.651	20	13.0
LPD-4	0.623	12	7.5
LHA-1	0.584	5	2.9

7.3 RESOURCE REQUIREMENTS

This analysis considers the industrial and intermediate level repair costs plus the organizational level repair parts costs that are presently incurred by the proposed PEOC classes LST-1179, LPD-4, and LHA-1. The primary objective of the analysis was to develop the projected 20-year maintenance resource requirements for each of the PEOC classes under current maintenance strategy. This analysis provides the basis for subsequent comparison with a similar analysis of the PEOC strategy maintenance resource requirements.

The initial effort of the analysis involved determination of the maintenance repair categories from which resource requirements would be costed. The average ship's maintenance resource requirements cost for each class was determined from data in the following four repair categories: Restricted and Technical Availabilities (RA/TA), Intermediate Maintenance Activity (IMA), Organizational Repairs, and Regular Overhaul costs.

Before explaining the composition of the cost of each repair category, it must be stated that all maintenance resource requirements costs are direct costs rather than indirect costs. Definitions of these terms are taken from the Navy Program Factors Manual, 31 August 1977 revision. It states, "The classification of data as either direct or indirect hinges on our ability to relate costs to the Navy's ships and aircraft. Examples include fuel and repair costs. Indirect costs are those incurred for the Navy as a whole, but not readily identifiable to individual ships or aircraft. Examples of these are the cost to train manpower and to move supplies".

The indirect costs were excluded from the analysis because the primary objective was to identify maintenance strategy costs. Direct costs satisfy this objective, do not involve apportioning the numerous factors incurred by the Navy as a whole, are readily identifiable to individual ship classes, and provide a valid basis for comparison between alternative strategies.

As previously stated, the direct maintenance costs for the 20-year maintenance strategy resource requirements were totaled in the organizational, IMA, RA/TA, and ROH repair categories. The following paragraphs give a synopsis of the factors included in each repair category.

The organizational repair category includes organizational repair parts costs chargeable to the ship's force. The direct maintenance cost of repair parts is well documented within the Maintenance and Material Management (3M) System and is easily accessible. By including only the repair parts costs of Ship's Force corrective maintenance, the costs of a significant portion of the current strategy's organizational level maintenance can be identified without addressing manpower costs (including indirect costs needed to support the ship's crew).

The IMA costs analyzed were the average annual cost of intermediate maintenance activity for a ship of the class. The figure is primarily related to the direct material support costs expended during the IMA availabilities. This analysis does not require accounting for IMA personnel costs, nor for IMA facility costs, either operational or overhead.

The RA/TA costs were the average annual costs of this type of availability for a ship of the particular class.

The ROH costs were the average annual costs expended to perform an overhaul on a single ship of that class. This cost, referred to as unit overhaul cost, included the average cost of labor, material, and overhead required to accomplish the general repairs part of the overhaul, excluding alterations. Alterations are funded by the Fleet Modernization Program and are not considered part of the cost to operate a ship. Therefore, alteration costs have not been considered as part of the ship's maintenance costs in this analysis.

Given the four categories of maintenance and the definition of those elements of repair to be costed, a standard data source for measuring each category was then selected. All maintenance costs included were based on the Navy Resource Model (NARM) taken from the Navy Program Factors Manual, 31 August 1977 revision. The NARM was initially investigated because of the wide acceptance this process receives throughout the Navy for producing accurately programmed costs. Additional supportive information was obtained by comparing NARM FY 1979 dollar figures and historical costs. This analysis, conducted on the four repair categories for the LST-1179 and LPD-4 classes (see Appendix B) showed the NARM FY 1979 dollar figures to be a valid representation of the current maintenance strategy costs incurred by the PEOC classes.

The NARM allows for uniform and easy extraction of costing data for all PEOC classes. The data are divided into direct and indirect costs. The specific composition of organizational repair parts costs, IMA, RA/TA, and unit ROH costs are found in the NARM. The average costs used in this analysis result from combining each fleet's average cost per ship and developing a class average for each category. These costs were subsequently projected over a twenty-year period in constant FY 1979 dollars.

The formula used to develop the 20-year maintenance resource requirements was:

$$MC_{20} = 20\ (RC) + 20\ (IMA) + 20\ (RA/TA) + \frac{20}{X}\ (UROH)$$

$$= 20\ \left[RC + IMA + RA/TA + \frac{UROH}{X}\right]$$

where:

MC_{20} = maintenance resource requirements cost for 20 years

RC = annual organizational level repair parts costs for a ship of the class

IMA = intermediate maintenance activity costs per year

RA/TA = restricted availability and technical availability costs per year

UROH = unit overhaul cost for a ship of the class

X = years per cycle

Several considerations went into the development and application of specific figures to the costing formula. The 20-year maintenance costs for the current maintenance strategy were calculated using FY 1979 dollars as presented in the Navy Program Factors Manual of August 1977. These predicted 1979 maintenance costs were modeled by the NARM, using the most recent information available to the Navy.

No inflation factors have been introduced into the analysis process. This preserves the integrity of the costing data, while permitting subsequent application of any desired inflation rate or method. Additionally, this ensures consistency between conventional strategy and PEOC strategy costs.

All the categories used in the 20-year current maintenance strategy resource requirements formula except cycle length have been explained in previous portions of this section. The cycles calculated in this analysis were also taken from the planning factors computed by the NARM. The NARM cycle durations were in direct agreement with the CNO Goals set out in OPNAV Instruction 4700.7E and so were considered valid for this analysis.

The results of applying the NARM FY 1979 cost predictions to the 20 year maintenance resource requirements costing formula are displayed in Table 7-5. The organizational level repair parts costs and IMA costs represent a relatively small percent of the total 20-year maintenance costs for each class, but constitute a valid basis for comparison of conventional and PEOC maintenance strategies.

In summary, the FY 1979 NARM figures were selected because the NARM data compilation and modeling represent the most current data on these classes. The data have been validated by comparative analysis and found to be compatible with the spending trends observed from the historical data on all four maintenance categories.

Table 7-5. CURRENT MAINTENANCE STRATEGY RESOURCE REQUIREMENTS COSTS FOR CANDIDATE PEOC CLASSES (FY 1979 NARM ESTIMATES, IN THOUSANDS OF DOLLARS)

Class	Organizational Repair Parts (Annual)	RA/TA (Annual)	IMA (Annual)	Unit ROH (Cycle)	Cycle Length (Years)	20-Year Total
LST-1179	251.5	432.5	124.0	8,300.0	4.00	57,660.0
LPD-4	396.5	490.5	39.5	13,250.0	3.75	89,196.7
LHA-1	1,163.0	1,860.5	72.5	21,100.0	3.83	172,007.0

All costs are per ship and exclude organizational and IMA labor costs.

These 20-year totals include no changes or revisions to the current strategy and the associated maintenance-critical systems identified in in Chapter Five. Thse systems have a significant effect on the mission capability of these ships and have shown a need for timely attention and corrective action. Perpetuation of the current strategy will do nothing to alleviate existing problems of degraded material condition and readiness, but will continue to concentrate maintenance burden and material

condition degradation in these few maintenance-critical systems and postpone the development of a more effective maintenance program for these ships.

CHAPTER EIGHT

PRELIMINARY PEOC PROGRAM MAINTENANCE STRATEGY EFFECTIVENESS AND RESOURCE REQUIREMENTS

8.1 INTRODUCTION

This portion of the study evaluates the effectiveness of the preliminary PEOC maintenance strategy (discussed in Chapter Six) and estimates the resource requirements to implement these strategies for a 20-year period. The same procedures are used in this chapter to develop estimates for the preliminary PEOC maintenance strategies as were used in Chapter Seven for the current maintenance strategies. This standardization of methodology facilitates and validates the comparison of the two strategies in Chapter Nine of this study.

8.2 EFFECTIVENESS

Two measures of availability were used to quantify the effectiveness of the preliminary PEOC strategies. These two measures are ship availability and Ships Available for Operation (SAFO). Ship availability is that fraction of the overhaul cycle a ship is either fully or substantially ready to perform its primary mission. SAFO describes the total number of ships of a class that may be expected to be operational at any given time. Mathematically,

SAFO = ship availability × number of ships in a class

8.2.1 Ship Availability

Ship availability is defined in Chapter Seven as the fraction of time a ship is either Fully Ready (State 1) or Substantially Ready (State 2) to perform its primary mission. There are two other possible states, Marginally Ready (State 3) and Not Ready (State 4).

Using the approach applied in a recent Navy analysis (see Chapter 7), readiness states are assumed for events during a ship's operating cycle. (States and the events assumed for each state are shown in Table 7-1.) These associations are used to provide a basis for estimating the effectiveness of the preliminary PEOC maintenance strategy. For purposes of this study these associations are both descriptive and valid, recognizing that within events readiness states vary (e.g., ships on deployment are occasionally

less than fully ready). Ship availability for the preliminary strategies was computed by applying these readiness definitions to the three deployment cycles identified in Chapter Six. Regular Overhaul durations from OPNAV Instruction 4700.7E of 28 May 1974 are reasonable objectives for these ships and were utilized for measuring the effectiveness of both strategies. Preliminary PEOC cycles for the LST-1179, LPD-4, and LHA-1 classes are shown in Figure 8-1. Table 8-1 provides a separate summary of the time spent in each state, compiled from events in previously referenced TYCOM scheduling documents.

LST-1179 CLASS

Post Ovhl	Deploy	Training/ Upkeep/Ops	Deploy	Training/ Upkeep/Ops	Deploy	Pre Ovhl	ROH
7.46	5.05	14.70	5.13	14.70	5.09	3.93	4.0

(All values in months)

Overhaul Cycle Length 60.06
Operating Cycle Length 56.06

LPD-4 CLASS

Post Ovhl	Deploy	Training/ Upkeep/Ops	Deploy	Training/ Upkeep/Ops	Deploy	Pre Ovhl	ROH
7.46	5.05	14.70	5.13	14.70	5.09	3.93	4.5

(All values in months)

Overhaul Cycle Length 60.56
Operating Cycle Length 56.06

LHA-1 CLASS

Post Ovhl	Deploy	Training/ Upkeep/Ops	Deploy	Training/ Upkeep/Ops	Deploy	Pre Ovhl	ROH
7.46	5.05	14.70	5.13	14.70	5.09	3.93	6.0

(All values in months)

Overhaul Cycle Length 62.06
Operating Cycle Length 56.06

Figure 8-1. PRELIMINARY PEOC CYCLES FOR LST-1179, LPD-4 and LHA-1 CLASSES

Table 8-1. SUMMARY OF CLASS READINESS		
Readiness State	PEOC Cycle	
	Months	Fraction of Time
LST-1179		
1. Fully Ready	27.02	0.450
2. Substantially Ready	14.73	0.245
3. Marginally Ready	14.31	0.238
4. Not Ready	4.00	0.067
Total	60.06	--
LPD-4		
1. Fully Ready	24.25	0.401
2. Substantially Ready	16.24	0.268
3. Marginally Ready	15.57	0.257
4. Not Ready	4.50	0.074
Total	60.56	--
LHA-1		
1. Fully Ready	24.47	0.394
2. Substantially Ready	14.85	0.239
3. Marginally Ready	16.74	0.270
4. Not Ready	6.00	0.097
Total	62.06	--

From the definition of ship availability, simply adding the fractions of time for State 1 and State 2 from Table 8-1 give ship availability values. These are shown in Table 8-2.

Table 8-2. SHIP AVAILABILITY	
Class	Availability
LST-1179	0.695
LPD-4	0.669
LHA-1	0.633

8.2.2 Ships Available for Operations

Ship availability can be translated into operational terms by multiplying it by the number of ships to which it applies. Assuming that the beginning of ship cycles are uniformly distributed in time throughout the class, the product of ship availability and number of ships yields the expected number of ships available for operations at any time. Mathematically, ships available for operation (SAFO) can be expressed:

SAFO = ship availability × number of ships in the class

Table 8-3 shows the number of ships available for operation for the LST-1179, LPD-4, and LHA-1 classes under the preliminary PEOC strategies.

Table 8-3. NUMBER OF SHIPS AVAILABLE FOR OPERATION (PEOC)

Ship Class	Availability	Number of Ships	Ships Available for Operations (SAFO)
LST-1179	0.695	20	13.9
LPD-4	0.669	12	8.0
LHA-1	0.633	5	3.2

8.3 RESOURCE REQUIREMENTS

This analysis considers the industrial and intermediate level repair costs plus the organizational level repair parts costs incurred by the proposed PEOC classes: LST-1179, LPD-4, and LHA-1. The primary objective of the analysis was to develop the projected 20-year maintenance resource requirements for each of the PEOC classes under preliminary PEOC maintenance strategy. This analysis provides the basis for subsequent comparison with the similar analysis conducted of the current strategy maintenance resource requirements.

Costs for each level of repair were based on projected requirements developed in Chapter Six. Current cycle planning includes one Planned Restricted Availability (PRAV) per cycle, to be funded from the general restricted availability-technical availability (RA/TA) budget.

Annual costs for Organizational Repair Parts, RA/TA, and IMA were taken from FY 1978 NARM data since no significant change to current experience is indicated for these cost areas. SRA costs are based on the maximum man-day requirements estimated in Chapter Six, with a $210 average man-day rate.

Overhauls for these ships within the PEOC Program were estimated to increase in cost by 5 percent for the LPD-4 Class and 10 percent for the LST-1179 and LHA-1 classes. These increased percentages were selected after consideration of the following:

- Reliability and maintainability alterations during these overhauls will be reduced by proper scheduling of SRA periods to perform these improvements.
- The number and severity of maintenance-critical systems on the LPD-4 Class represented a smaller percent of the total ship overhaul costs than was indicated for the other two ship classes.
- Increased emphasis on system testing and certification will tend to increase costs, particularly for the more complex equipments of the LHA-1 Class.

The Pre-EOC Overhauls are projected to cost 25 percent more than the FY 1979 NARM Unit ROH Costs, in order to accomplish the required work to ensure that these ships are able to maintain a satisfactory material condition and to facilitate structured class maintenance planning and accomplishment. This increase equals the largest percent increase projected for any DDEOC ship class (the FF-1052 Class) and was selected to provide a conservative estimate of costs required for these overhauls. The added expense of these overhauls is primarily due to three areas of emphasis. First is the authorization of more all-inclusive system work for the industrial facility rather than splitting the job into three levels of repair. This is important to ensure the responsibility for proper and satisfactory test and certification. Second is increased emphasis on the test and certification of systems, with the subsequent repair of components not necessarily worked on by the repair facility. Third is the accomplishment of the reliability and maintainability alterations needed to ensure satisfactory operation through a longer operating cycle.

Program development costs were obtained by summing the estimated organizational support and engineering requirements (discussed in Chapter Ten). Program operating costs were obtained by multiplying estimated steady-state (FY 1984) organizational support costs by 20 to provide for support throughout the projected 20 years.

Table 8-4 presents the 20-year total resource requirements for a ship under the preliminary PEOC maintenance strategy for the LST-1179, LPD-4, and LHA-1 classes. All costs are in constant FY 1979 dollars. The formula used to develop the 20-year maintenance resource requirements was:

$$MC_{20} = 20(RC + RA/TA + IMA + PDC + POC) + \frac{20}{X}(SRA + UROH) + \text{Pre-EOC}$$

where:

MC_{20} = maintenance resource requirements cost for 20 years

RC = annual organizational level repair parts costs for a ship of the class

Table 8-4. 20-YEAR SUPPORT COSTS FOR A SHIP UNDER PEOC MAINTENANCE STRATEGIES (COSTS IN THOUSANDS OF DOLLARS)*

Class	Organizational Repair Parts (Annual)	RA/TA (Annual)	IMA (Annual)	Two SRAs (Cycle)	Unit ROH (Cycle)	Additional Cost of Pre-EOC** (One-Time)	Amortized Program Development (Annual)	Amortized Program Operating (Annual)	Cycle Length (Years)	20-Year Total Cost
LST-1179	251.5	432.5	124.0	1,470.0	9,130.0	2,075.0	16.3	47.4	5.01	61,867.0
LPD-4	396.5	490.5	39.5	1,806.0	13,910.0	3,310.0	16.3	47.4	5.05	85,397.0
LhA-1	1,163.0	1,860.5	72.5	4,200.0	24,265.0	5,275.0	16.3	47.4	5.17	178,549.0

* Excluding organizational and IMA labor costs.

**Additional to Basic ROH cost in Table 7-5.

RA/TA = restricted availability and tecnhical availability costs per year

IMA = intermediate maintenance activity costs per year

PDC = program development costs per year

POX = program operationg costs per year

X = years per cycle

SRA = selected restricted availability costs per cycle

UROH = unit overhaul costs for a ship of the class

Pre-EOC = additional cost of a pre-EOC overhaul over current, regular overhaul costs

In Chapter Nine the current and preliminary PEOC maintenance strategies will be compared using this 20-year cost information.

CHAPTER NINE

COMPARITIVE ANALYSIS BETWEEN CURRENT STRATEGY AND PRELIMINARY PEOC STRATEGY

9.1 INTRODUCTION

Chapter Seven developed and presented two measures of availability for quantifying the effectiveness of maintenance strategies. These two measures are ship availability and Ships Available For Operation (SAFO). Calculations of these measures for both the current and preliminary PEOC maintenance strategies were presented in Chapters Seven and Eight. Additionally, resource requirements were calculated for both strategies. This chapter compares the measured effectiveness and resource requirements for the strategies and determines the feasibility of the preliminary PEOC strategies.

9.2 EFFECTIVENESS COMPARISON

This section compares the measured effectiveness for current and preliminary PEOC Program maintenance strategies. Table 9-1 presents a summary comparison of the measured effectiveness for both strategies from the information provided in Chapters 7 and 8. This table compares availability and SAFO resulting from the current and projected PEOC Program and shows the percent of increases predicted for the projected PEOC Program. For purposes of this study, the 20-year period of comparison commences on completion of overhaul (regular or pre-EOC). Table 9-1 indicates that both availability and SAFO will increase in effectiveness by more than 7 percent overall, with the LHA-1 Class showing the greatest improvement in both categories.

9.3 RESOURCE COMPARISONS

Results presented in the previous chapter show that ship availability increases under the PEOC Program with an attendant slight increase in support cost. In this sections, a comparison is made of the current and the PEOC Program resource requirements. The comparison is made on the basis of two measures that combine availability and cost. The first measure is the cost to support a SAFO over 20 years.

Table 9-2 shows that under the preliminary PEOC maintenance

Table 9-1 EFFECTIVENESS COMPARISON

Availability				Ships Available for Operations			
Class	Current	Projected PEOC Program	Percent Increase	Number of ships in Class	Current	Projected PEOC Program	Percent Increase
LST-1179	0.651	0.695	6.8	20	13.0	13.9	6.9
LPD-4	0.623	0.669	7.4	12	7.5	8.0	6.7
LHA-1	0.584	0.633	8.4	5	2.9	3.2	10.3

strategies, the cost to support a SAFO over 20 years is essentially unchanged for the LST-1179 Class, and decreases by 10.2 percent for the LPD-4 Class, and 6.0 percent for the LHA-1 Class. For the same period, total cost increased by 7.3 percent for the LST-1179 Class, 3.8 percent for the LHA-1 Class, and actually decreased by 4.3 percent for the LPD-4 Class.

Table 9-2. COST TO SUPPORT A SHIP AVAILABLE FOR OPERATION

Ship Class	Unit 20-year Support Cost (Millions of Dollars)	Class 20-year Support Cost (Millions of Dollars)	Ships Available For Operation (SAFO)	20-Year Support Cost Per SAFO (Millions of Dollars)
LST-1179				
Current	57.7	1,153.2	13.0	88.7
PEOC Program	61.8	1,237.3	13.9	89.0
LPD-4				
Current	89.2	1,070.4	7.5	142.7
PEOC Program	85.4	1,024.8	8.0	128.1
LHA-1				
Current	172.0	860.0	2.9	296.6
PEOC Program	178.5	892.7	3.2	279.0

The second measure, which also combines cost and availability, is the cost to obtain an equivalent SAFO as projected for the PEOC Program. Using the LST-1179 Class as an example, the number of new ships needed to obtain an equivalent SAFO will be calculated. For the LST-1179 Class, the current cycle will provide 13.0 SAFO and the PEOC cycle will provide 13.9 SAFO. This increase of 0.9 SAFO is achieved at a total cost increase of $83.6 million over 20 years. To obtain an increase of 0.9 SAFO under the current cycle would require the construction and operation of 1.4 additional LST-1170 Class ships. This result is based on the current cycle availability of 0.651 and the formula:

$$\text{SAFO} = \text{ship availability} \times \text{number of ships in a class}$$

$$\text{where the added ships required} = \frac{0.9 \text{ SAFO}}{0.651} \quad \text{or 1.4 ships.}$$

A fractional part of a ship including these values, represent the calculated number of new ships needed for equivalency and are useful and

valid for purposes of cost estimation.

On the basis of the 31 August 1977 Navy Program Factors Manual, the average annual direct operating costs (excluding fuel costs) is $5.4 million for the LST-1179 Class, $9.1 million for the LPD-4 Class, and $16.7 million for the LHA-1 Class. This is the annual added direct operating costs that would be spent to deliver equivalent SAFO with new or added ships under the current maintenance strategy. No incremental cost for fuel is included because the equivalent SAFO values would require equal amounts of fuel. Table 9-3 shows the additional costs, under the current strategy, of delivering an equivalent SAFO to that calculated for the projected PEOC program. NARM FY 1979 values were used to obtain 20-year direct operating costs per ship, and the histroical average acquisition cost for each class was inflated to FY 1979 dollars to obtain the assumed construction costs per ship.

The direct cost comparison between the two strategies for obtaining and supporting equivalent SAFO values is calculated by combining the results of Tables 9-2 and 9-3. Continuing with the LST-1179 Class as an example, the preliminary PEOC maintenance strategy delivers 13.9 SAFO for 20 years at a total cost of $1,237.3 million. Under the current strategy, the 20-year total cost would be $1,380.1 million, which is the sum of the currently projected class costs plus the additional cost of delivering an equivalent SAFO value. The savings of employing the PEOC Program for this class total $142.8 million, or more than $7.1 million annually.

Table 9-4 presents the results of this direct cost comparison for all three classes. The combined savings shown for the PEOC Program amount to $818.9 million, representing an annual savings of nearly $41.0 million.

Note that the LPD-4 Class total costs for operation under the PEOC Program are actually less than that for continuation of the current strategy. This is due to the shorter cycle length and greater proportion of total costs that UROH costs represent for this class in comparison to the LST-1179 and LHA-1 Classes.

Recall, too, that these cost savings under the PEOC Program are accompanied by specific and general improvements in class material condition resulting from pre-EOC Overhauls and increased engineered maintenance of class requirements. The identification and planning of maintenance to reduce and prevent degraded material condition will produce a higher material readiness condition for these classes than is currently being experienced. More frequent access to depot level repair facilities under the PEOC Program not only permits closer scheduling of class maintenance requirements, but also permits more rapid correction of significant emergent repair needs.

9.4 PEOC PROGRAM FEASIBILITY

This chapter has compared the effectiveness and resource requirements of the current and preliminary PEOC maintenance strategies. The preliminary

Table 9-3 COST OF OBTAINING ADDITIONAL SHIPS AVAILABLE FOR OPERATIONS (SAFO) UNDER CURRENT STRATEGY

Class	Additional Ships Available For Operations Under PEOC Program	(a) New Ships Needed	(b) 20-Year Direct Operating Cost/Ship* (Millions of Dollars)	(c) Assumed Construction Cost/Ship (Millions of Dollars)	TOTAL = (a) (b + c) (Millions of Dollars)
LST-1179	0.9	1.4	108.0	54.1	226.9
LPD-4	0.5	0.8	182.0	86.8	215.0
LHA-1	0.3	0.5	334.0	562.4	448.2

*Excluding fuel costs.

Table 9-4 TOTAL COSTS TO OBTAIN AND PROVIDE EQUIVALENT SAFO

Ship Class	SAFO (Total)	Basic 20-Year Support Cost (Millions of Dollars)	Added Costs for Equivalent SAFO (Millions of Dollars)	Total Cost for Equivalent SAFO (Millions of Dollars)	PEOC Program Savings (Millions of Dollars)
LST-1179					
Current	13.9	1,153.2	226.9	1,380.1	----
PEOC Program	13.9	1,237.3	----	1,237.3	142.8
LPD-4					
Current	8.0	1,070.4	215.0	1,285.4	----
PEOC Program	8.0	1,024.8	----	1,024.8	260.6
LHA-1					
Current	3.2	860.0	448.2	1,308.2	----
PEOC Program	3.2	892.7	----	892.7	415.5

PEOC maintenance strategies were shown to provide better than 7 percent improvement in overall availability and SAFO values. The cost to obtain and support equivalent SAFO values under the current strategy totals $818.9 million more than comparable costs using the preliminary PEOC maintenance strategies. All these gains are achieved from 3-deployment preliminary PEOC strategies and would, of course, improve even more should detailed engineering analysis support a greater number of deployments per cycle.

The engineered maintenance of the PEOC Program produces this increased availability over a 20-year period with an improved material condition resulting initially from the pre-EOC Overhauls, and throughout this period from data analysis and engineering analysis to improve the identification and scheduling of class requirements.

The additional cost of $70.6 million above current maintenance strategy requirements over the 20-year period will produce appreciable gains in availability and material condition which result over the remaining life of these ships.

The results of this study have shown the preliminary PEOC maintenance strategies to be more effective and economical than the current maintenance strategies. These preliminary PEOC strategies will effect required early improvements in material condition during pre-EOC overhauls, maintain the ships in a combat ready status at cost savings indicated in this chapter, and deliver measurably improved operational availability. From these results, the selected preliminary PEOC maintenance strategies are concluded to be both feasible and highly beneficial. The planning and engineering requirements to conduct the PEOC Program are contained in Chapter Ten. The conclusions and recommendations of this study are presented in Chapter Eleven.

CHAPTER TEN

PEOC PROGRAM DEVELOPMENT AND IMPLEMENTATION

10.1 INTRODUCTION

In order to realize the benefits of the program discussed and justified in the preceding chapter, a number of planning and engineering activities are required. This chapter discusses the principal planning and engineering efforts that should be conducted to develop and implement the PEOC Program, the associated resource requirements, and a Plan of Action and Milestones (POA&M).

The engineering requirements specify the studies and analyses that must be performed to develop and implement the details of an engineered maintenance strategy. This includes the identification of specific equipment maintenance and material condition problems, development of appropriate solutions, measurement of the effectiveness of the solutions, and adjustment of the solutions to increase their effectiveness.

The planning requirements specify the management efforts required to assure that the results of the engineering efforts are properly implemented to meet the PEOC Program objectives. This includes the preparation of guidance documents and establishment of suitable program support organizations.

The resources required to accomplish the planning, the engineering, and the implementation have been estimated and documented in this report to provide the information required for the development of budgetary cycle inputs. In addition, a PEOC program POA&M is presented at the end of the chapter. The POA&M recommends a program schedule and sequence.

10.2 ENGINEERING REQUIREMENTS

Upon approval of the preliminary PEOC maintenance strategy, the necessary engineering studies, maintenance plans, material condition assessment procedures, and evaluation processes required to convert this strategy into a viable program must be determined. These studies and analyses will result in documents that detail the steps for the effective development, implementation, and management of the PEOC program.

At the onset of the Development Phase, the PEOC Program staff will need to expend a significant amount of effort in coordinating and supervising the various activities involved. The Program Manager (and his staff) must be able to take the necessary actions to implement the changes required to make the transition from current procedures to improved engineering approaches leading to a higher state of ship material readiness.

The engineering studies, maintenance plans, and evaluation processes required for the detailed design and management of the PEOC program are:

- Critical Equipments/Systems List
- Projected Class Configuration
- System Maintenance Analyses (SMAs)
- Pre-EOC Overhaul Requirements
- Class Maintenance and Modernization Plans
- Material Condition Assessment (MCA) Procedures
- Post-Overhaul Analysis Program
- Program Effectiveness Procedures

These engineering requirements are discussed in the following sections.

10.2.1 Critical Equipments/Systems

The Critical Equipments/Systems List will be required for each of the three classes to ensure that the PEOC Program's maintenance engineering development efforts concentrate on those equipments or systems that have the most significant maintenance related burden. The list will identify, in priority order, the candidates for engineering attention. These efforts will support the preparation of:

- In-depth engineering maintenance analyses of systems, equipments, and components
- Identification of required Technical Repair Standards (TRSs)
- Identification of candidate systems/equipments for Material Condition Assessment (MCA)
- Identification of repair requirements for the pre-EOC overhauls
- Identification of Test and Certification Manuals

The general approach to the development of a Critical Equipments/System List is to establish criticality criteria, gather maintenance-related data, and analyze and summarize the data. The type of data required is dictated by the PEOC program objectives and constraints and the analyses to be performed. The sources of data, however, depend on the extent of operational history of the ship class. Actual ship class historical data are preferred for this analysis. If, however, the

operational history is insufficient to provide the necessary data, as in the case of the LHA-1 Class, ship design data (MEAs) will also be analyzed.

It is projected that Critical Equipments/Systems Lists will be required for all three classes in the PEOC program. The development of the lists for the LST-1179 Class and LPD-4 Class will require an approach similar to that utilized by the DDEOC Program Office and described by the EOC Program Development Manual. The development of a list for the LHA-1 Class will require a somewhat different approach since the historical data for this class are sparse; however, the product should be similar to that of the other classes.

10.2.2 Projected Class Configuration

In order to ensure that planning is not done for equipments scheduled to be replaced in the near future and that the required planning is accomplished for new systems/equipments to be installed soon, an alteration list needs to be developed for each class to be incorporated into PEOC. To structure the list of applicable alterations, the Fleet Modernization Plan (FMP) must be reviewed to identify alterations and funding authorization by fiscal year. Additionally, alterations not currently authorized in the ship class FMP should be thoroughly investigated to identify those that offer significant increases in reliability and maintainability. The alteration list should identify the recommended Shipalts and OrdAlts, with their associated priorities and schedules. It is anticipated that the majority of alterations identified during the Development Phase will be scheduled for performance either during the Pre-EOC overhaul or during an early PEOC availability.

The comprehensive, prioritized list of required alterations needs to be sent to the TYCOMs, applicable NAVSEA codes, and CNO for review and approval. The alteration requirements forwarded to the TYCOMs, NAVSEA, and CNO for funding and scheduling are a PEOC Program recommenation and should be documented with enough justification to demonstrate that they represent a cost-effective package.

10.2.3 System Maintenance Analyses

EICs identified as areas of maintenance criticality (listed in Chapter Five) form the basis for projecting the number of System Maintenance Analyses required for the three classes of ships in the PEOC Program Using these lists and the experience of the existing EOC Program as a guide, it is estimated that approximately 30 systems per ship class will require in-depth analysis. Before the System Maintenance Analyses are conducted, the initial requirements should be further examined for refinement after the Alteration List is completed.

The Critical Equipments/Systems List needs to be compared with the alteration list to determine the extent of changes to be made to the equipment and systems that represent a high maintenance burden. If the effect

of the alteration on the operation of the system cannot be readily determined, the extent of anticipated configuration change is noted for use during the engineering analyses. When a sufficient number of related equipments are identified as having significant maintenance problems, they are grouped into a system and the system (instead of the individual equipments) is identified for analysis. The criticality of each equipment and system as reconfigured is then re-estimated and the ranking revised accordingly. From the type and form of the available data, specific analytical and engineering techniques are identified for the performance of the engineering analyses.

The SMA for selected ship systems develops a comprehensive definition of known and potential problems that will have an EOC impact, determines an economical and effective maintenance program for solving these problems, and reports these findings in a format compatible with other PEOC program and other Navy documents.

The SMA process is described in detail in Appendix C. Essentially, it consists of specifically defining the system to be analyzed, identifying and classifying problems that will affect the EOC, and selecting appropriate cost-effective maintenance program solutions. This process may result in Integrated Logistic Support (ILS) changes, PMS changes, overhaul requirements, and inputs to other PEOC Program documents (e.g., CMMP and Post-Overhaul Analysis Program).

In determining the analyses to be accomplished, resources required to analyze the most critical systems should be estimated. On the basis of these estimates, available resources will be allocated to those systems that will benefit most from engineering analysis. A schedule of engineering analyses by system must then be prepared by projecting resources and methods. This schedule will be used by the Program Office to manage the engineering analysis phase of the PEOC program.

10.2.4 Pre-EOC Overhaul Requirements

To realize an early improvement in ship material condition, to return PEOC ships to an acceptable material condition, and to establish a baseline condition from which a structured class maintenance plan may be implemented, each ship will be subjected to a pre-EOC overhaul.

The repair requirements for the pre-EOC overhauls must be identified and documented to allow for orderly planning. The identification will provide a basis from which to estimate the resources that will be required to perform the pre-EOC overhauls, including an accurate estimate of labor man-days and material expenditure, long-lead-time materials (LLTM), special tools, skills, and facilities.

The repair requirements include the repair standards and the post-overhaul test and certification requirements common to the entire class and essential for the reliable and sustained operation of a ship during the

Engineered Operating Cycle. Alteration requirements are merged with repair requirements to constitute the overhaul package.

The list of pre-EOC overhaul requirements should be prepared from a combination of the results of system engineering analyses, previous overhaul experience, and engineering judgment. Because of the time required to accomplish the engineering analyses, the list of pre-EOC overhaul requirements may have to be prepared before all System Maintenance Analyses are completed. Until those analyses are completed, the list of pre-EOC overhaul requirements must depend on the best available data and information. As analyses of systems or equipments are completed, the overhaul repair requirements should be refined to reflect the results of the analyses. All system engineering analyses should be completed before development of the pre-EOC overhaul requirements or initiation of the first pre-EOC overhaul. The Plan of Action and Milestones (Section 10.5) shows these analyses as being completed just before the start of the pre-EOC overhauls, recognizing that this is an ideal situation that may not be wholly feasible.

Another element of the pre-EOC overhaul development is the Technical Repair Standard for use by the overhauling activity to ensure a standard type and level of repair. TRSs were originally developed in the submarine maintenance community as a prerequisite to achieving a level of material condition from which an engineered maintenance program could be expected to successfully operate throughout the operating cycle. The use of TRSs has also been incorporated into the DDEOC and 1200 PSI Improvement Programs. As a separate effort or as a supporting part of the PEOC Program, it is recommended that NAVSEA 941 have TRSs developed for those major-burden equipments most frequently overhauled during maintenance periods. This is especially important for the amphibious ships because of the use of various civilian repair activities where the repairs are less apt to be standardized.

A follow-up program to the TRS development is the development of test and certification procedures designed to demonstrate satisfactory accomplishment of the repairs and to highlight other repair requirements not previously identified. The use of test and certification procedures was also developed in the submarine maintenance and the 1200 PSI Improvement Programs. The use and development of Test and Certification Manuals for Weapons Systems as well as Engineering Systems is a part of the DDEOC Program. To achieve and maintain a higher state of material condition of the ships of the PEOC Program, it is recommended that NAVSEA 941 begin development of Test and Certification Manuals for the primary systems of these classes. It is possible that some of the procedures already developed for destroyers may be directly applicable to some systems of the amphibious ships.

10.2.5 Class Maintenance and Modernization Plans

The purpose of the Class Maintenance and Modernization Plan (CMMP) is to integrate the PEOC maintenance and modernization requirements of a typ-

ical ship of a class and to project the associated resource requirements over time.

The CMMP specifies predictable maintenance tasks and their probable frequency, modernization tasks and their schedule, and provide a summary of the associated resources necessary to maintain and modernize a ship class throughout its Engineered Operating Cycle. Maintenance requirements that are documented elsewhere, as in the PMS, are generally not included in the CMMP.

The CMMP is a synthesis of information from various sources, including the vendor technical communities in addition to Navy organizations. In order to assure the completeness of information, the major ship systems and equipments are listed, various sources of repair requirements are researched, and the requirements compiled against the system/equipment list. The sources include SMAs, repair profiles, SARPs, departure reports, etc. The repair list is then compared to the Critical Equipments/Systems List to identify any unexplained omissions of repair requirements for previously identified high-burden systems or equipments. In addition, the repair list is reviewed for omissions on the basis of experience of the technical community. Estimates or reservations should be substituted for unexplained omissions, relying on the best available data or experience of the technical communtiy.

Development of the CMMP is an iterative process. In its early stages it may be considered tentative, primarily because the engineering analyses will probably not be complete. Upon completion of each iteration, it may be desirable for the Type Commander and interested technical codes to review the CMMP. Their comments should be used to improve task selection and description and resource requirements.

It is important that the sources for CMMP maintenance requirements and changes to them be traceable to permit justifying the repairs and repair selections and to show that the CMMP is based on sound premises and responsive to PEOC Program requirements.

In its final form the CMMP must be able to provide input to individual ship maintenance plans. It must also be in a form in which it can be updated throughout the EOC in response to experience and configuration changes. This requires that careful thought be given to the physical layout of the CMMP. A computerized data base is recommended to facilitate change and to aid in validation after each change.

10.2.6 Material Condition Assessment Methods

An essential element of an EOC program structured to improve material condition and operational availability is the development of effective means to assess the performance and material condition of selected ship systems or their components. The objectives of these assessments, which will be referred to as Material Condition Assessments (MCAs), are to determine existing material condition and operational performance levels and to provide data to aid in predicting the approach of unacceptable material

condition or performance levels, thereby precluding catastrophic failure and allowing for scheduling corrective or restorative maintenance. When the suitability of MCA procedures has been determined by the SMA or other means, the assessment parameters and values are established. Assessment procedures and assessment data analysis techniques must be developed to provide the optimum cost/benefit solution to the problem.

The purpose of developing the Material Condition Assessment methods is to determine and document, in a specified format, the following information and procedures for the system or components identified by the SMA or other analyses:

- Operational or material condition parameters, which, if assessed periodically, would provide information required for the prevention of the system or component problems identified in the SMA
- For the parameters identified, the value levels that correspond to the best operation or material condition to be expected and the value levels that correspond to the minimum acceptable performance or condition
- If identified as necessary by the SMA or other analyses, post-repair assessment criteria
- Detailed procedures to assess the performance and material condition of the system or its components identified for assessment by the SMA using the assessment parameters previously identified
- Analytical techniques to be used in evaluating the assessment data and monitoring performance and material condition trends.

MCA methods consist of criteria and procedures invoked at the system level or at the component and equipment level. Wherever possible, system performance is measured to indicate material condition. Where system performance does not give a valid indication of material condition, criteria and procedures are applied at the component and equipment level.

The MCA criteria and procedures are established using all existing relevant information. MCA data are collected, parameters are identified, and upper and lower limits are selected. The MCA procedures are developed through a review of existing MCA information and existing procedures verified or modified as necessary. When necessary, new procedures are prepared. When approved, the procedures are recorded on MRC cards for implementation by Ship's Force or an IMA activity. A validation process may be desirable to determine the effectiveness of the MCA methods.

Efforts currently in effect in the DDEOC Program are intended to identify the extent to which existing criteria and procedures may satisfy this requirement.

10.2.7 Post-Overhaul Analysis Program

The Post-Overhaul Analysis Program records the ship configuration changes and material condition on entering the EOC. This is accomplished by identifying the repairs and alterations performed during the overhaul, then comparing them to the pre-EOC overhaul requirements document to identify the repairs and alterations required but not accomplished.

It is anticipated that the Post-Overhaul Analysis Program will be an iterative process. After several post-overhaul analyses have been conducted on individual ships, trend analyses should be performed to evaluate the overall effectiveness of the pre-EOC overhaul requirements development and of the pre-EOC overhauls themselves. Improvements should be identified for subsequent pre-EOC overhauls within the class, i.e., refined work packages, updated schedules, additional work specifications, etc. In addition, the effectiveness of the Post-Overhaul Analysis Program should be reviewed. Specific elements of the program to be considered include analysis effectiveness, adequacy of program procedures, and quality and utility of analyses outputs. By continually evaluating the outputs generated from each overhaul analysis, the Post-Overhaul Analysis Program will remain responsive to the objective of ensuring that ships of the class receive a comprehensive overhaul, where necessary, before EOC entry and enter the EOC in an acceptable material condition.

10.2.8 Program Effectiveness Procedures

The PEOC Program effectiveness must be determined for three reasons: (1) to document the program's value to the subject classes, (2) to identify successful maintenance management methods that should be expanded and unsuccessful ones that should be eliminated or modified, and (3) to demonstrate the cost-effectiveness of PEOC. The program effectiveness can be estimated during the development of the PEOC Program, then validated at some time when the ship classes are well into the Implementation Phase and sufficient EOC historical data are available for analysis.

The program effectiveness technique should progress through four basic steps: (1) define measures of effectiveness (MOE), (2) determine historical values of MOEs (if possible), (3) determine current values of MOEs during the program, and (4) compare historical and current values. Effectiveness of a large Navy maintenance program has never been measured precisely. Large changes in results are necessary to justify strong statements about the difference between old and new maintenance strategies. Resulting effectiveness will dictate the changes to the PEOC Program; if the actual program effectiveness is equal to or greater than the predictions, changes are necessary only for further improvement; however, if the actual program effectiveness is significantly less than the predicted, the cause must be identified and appropriate changes made to the PEOC Program.

10.3 PLANNING REQUIREMENTS

The guidance necessary for the execution of a PEOC Program is provided by the program management and support organizations and documented in a management plan and in a program plan.

The PEOC Management Plan provides the primary program guidance by specifying the program objectives, the responsible organizations, and the process by which the program will develop and be implemented.

The PEOC program office, administers primary guidance in the development and implementation of the program through the management plan. Fleet support and coordination is provided by TYCOM staff elements, field site teams, and a central technical group.

10.3.1 Program Management Plan

The PEOC Management Plan is designed to serve managers and other principals as a guide for the execution of the PEOC Program as well as provide information and serve as a reference tool for those not directly involved in the PEOC Program. This plan must (1) describe the background, objectives, and constraints of program development; (2) delineate the authority and responsibilities of those associated with the PEOC Program; and (3) explain the personnel interfaces of various commands in the program's execution.

The Management Plan should be the document that displays the various segments of the program blended together to constitute a coordinated and integrated effort. By describing the entire effort and displaying how the various elements fit together, it will provide the means for interested parties at all levels to gain an appreciation of the entire program and see how their duties and responsibilities affect the overall effort.

The PEOC Program may require certain actions by the staff of Fleet Commanders or Type Commanders, requiring the cooperation of personnel not under the direction of COMNAVSEA. Upon program approval by the CNO, it is assumed that PEOC actions will be implemented without time-consuming chain-of-command approval for individual actions.

The text of the Management Plan should address, as a minimum, six basic topics:

- PEOC Program Overview
- PEOC Program Functions, Assignments and Responsibilities
- Program Organization Structure
- Program Material Condition Assessment Procedures
- Program Maintenance and Supply Management
- Program Resource Management

Additional topics such as Automated Data Processing (ADP) Systems, Class Maintenance and Modernization Plans, and Work Package Planning may be desirable or necessary, depending on development of the program structure.

Development of the PEOC Management Plan should commence upon approval of this Initiation Study in order that guidance may be promulgated as soon as possible.

10.3.2 Organizational Requirements

The PEOC organizational requirements consist of a Program Office, which provides primary management direction; TYCOM staff elements, which provide coordination between the Fleet and the Program office; Field Site Teams, which gather data and monitor certain conditions; and a Central Technical Group, which analyzes the data.

10.3.2.1 Program Office

A Program Office will need to be established with a Program Officer responsible for managing the PEOC Program under the direction of the PEOC Program Manager (SEA 941). It will serve as the PEOC Program Headquarters with the primary responsibility of establishing the necessary elements and formulating their functions to carry out the PEOC Program objectives. The Program Office will provide technical direction, program management, and fiscal administrative support to these elements. The Program Office should be assigned to the Amphibious and Combat Support Ship Logistic Office (NAVSEA 941) to be able to deal quickly and effectively with the other organizations that must support the PEOC Program efforts. If it is infeasible to establish the PEOC Program Office at NAVSEA Headquarters, an alternate location at PERA(ASC) is recommended. However, that location would make program coordination more difficult and require the Program Officer and key staff members to split their time between PERA(ASC) and NAVSEA 941.

The proposed organization of the PEOC Program Office is shown in Figure 10-1. This organization would be valid through FY 1984. A total of 14 billets (3 officers and 11 civilians) should be projected in the POM for FY 1981 through FY 1984. This is the project level of manning for this program element through the life of the ships in the PEOC Program. The major tasks to be performed or managed by the Program Office include the following:

- Provide overall program supervision
- Conduct program feasibility studies
- Establish equipment material condition standards
- Develop pre-EOC O/H, BOH, ROH, and SRA requirements for PEOC ships
- Develop and update program management plans as required to implement and execute the PEOC Program

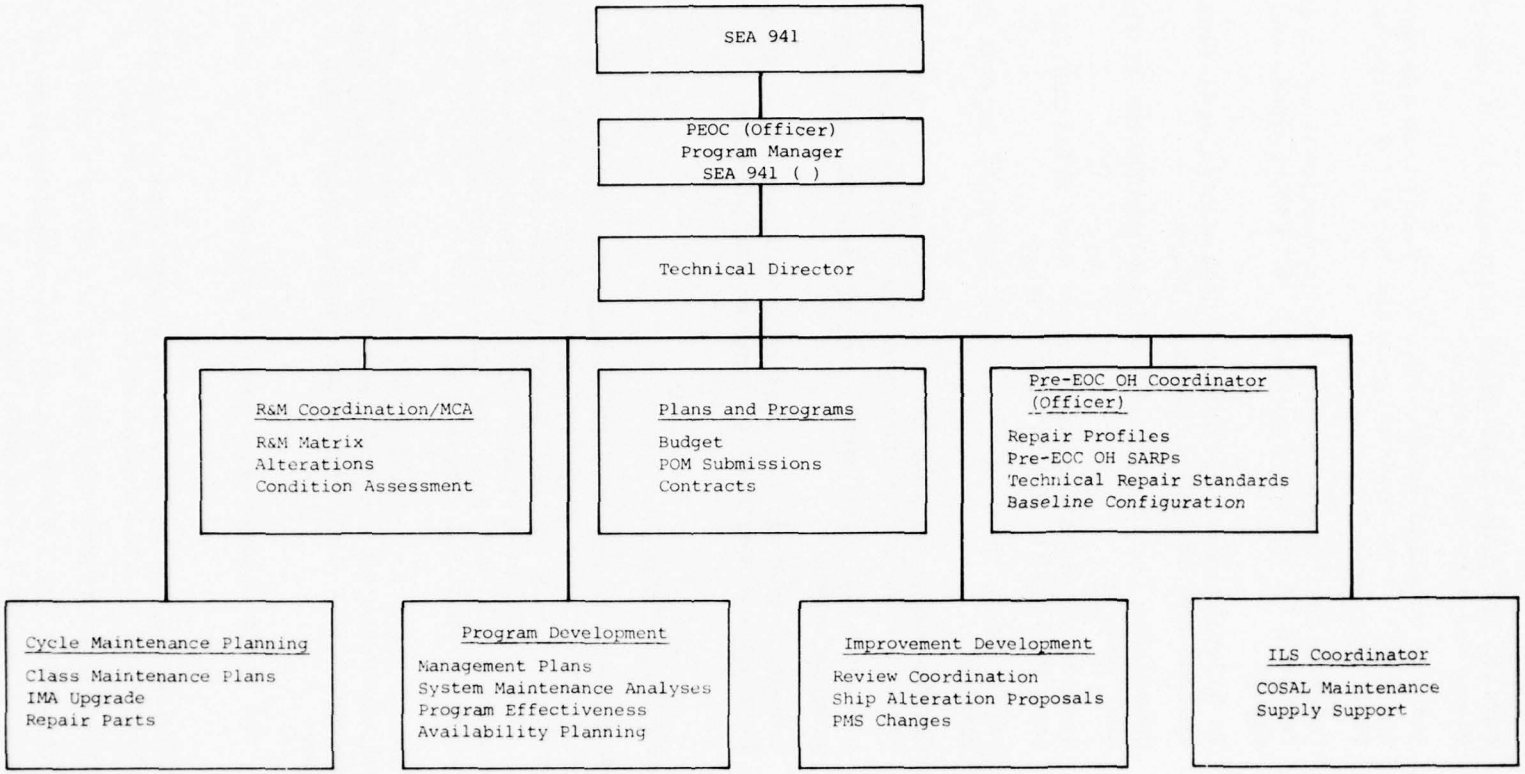


Figure 10-1. PEOC PROGRAM OFFICE

- Develop and promulgate Class Maintenance and Modernization Plans for PEOC ship classes
- Perform detailed engineering analyses of maintenance requirements on a system-by-system basis for ships in the PEOC Program
- Conduct engineering studies and investigations to improve reliability and maintainability of PEOC systems and equipments
- Task development of Technical Repair Standards (TRSs) for systems and equipments on PEOC ships
- Coordinate the development and implementation of the assessment program
- Provide coordination and liaison with SECAS and FMP managers in support of the PEOC Program
- Participate, as required, in all external program budget reviews
- Continuously evaluate the effectiveness of the program so that it will be responsive to the needs of the Fleet
- Periodically brief OPNAV, NAVMAT, NAVSEA, and TYCOMs program status
- Recommend changes to staffing levels, or take other staffing actions required to support the program.

10.3.2.2 TYCOM Staff Elements

The PEOC TYCOM elements assigned to COMNAVSURFLANT AND COMNAVSURFPAC should be incorporated into the Engineering/Maintenance Division. Initial manning would consist of only the PEOC Program Coordinator, a Lieutenant Commander (1110) with Amphibious/Combat Support Ship engineering experience. The functional relationship of the PEOC Program Coordinator in the overall PEOC Program is shown in Figure 10-2.

As the number of ships and classes entering EOCs increase, the staff element should be augmented by the assignment of a Maintenance Planning Officer, a Lieutenant (1110) with Amphibious/Combat Support Ship engineering experience.

In general, the staff element will provide support to the PEOC Program by:

- Providing liaison between shore establishment organizations contributing to the program and the TYCOM's staff
- Coordinating program matters with the TYCOM's staff
- Coordinating the activities of, and providing program guidance to the PEOC Field Site Teams

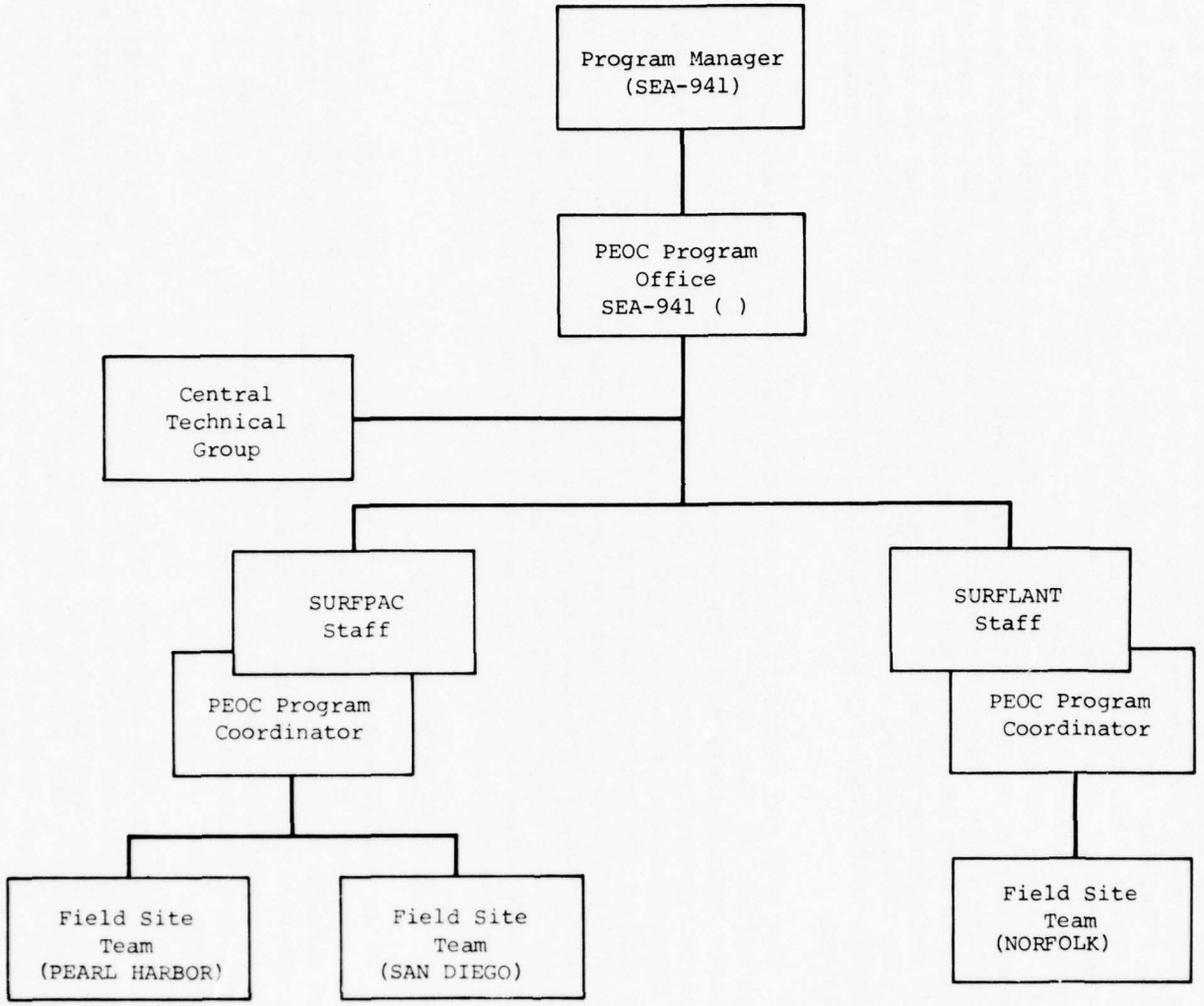


Figure 10-2. PEOC PROGRAM FUNCTIONAL ORGANIZATION

10.3.2.3 Field Site Teams

The use of site teams to monitor key equipments and systems was originated by SMMSO for the submarine maintenance management program. The DDEOC Program has incorporated this concept into the maintenance strategy for the destroyers and has programmed the establishment of four site teams at Norfolk, Virginia; Mayport, Florida; San Diego, California; and Pearl Harbor, Hawaii. The Initiation Phase of the PEOC Program has resulted in the recommendation of a maintenance strategy very similar to that for the DDEOC Program, including the requirement for two Selected Restricted Availabilities (SRAs), one SRA five months before the second deployment, and the second SRA five months before the third deployment of a three-deployment operating cycle. Initial identification of maintenance-critical systems indicates that monitoring and data gathering will also be required for the PEOC maintenance strategy. Therefore, it is recommended that the concept of site teams, located at the centers of Amphibious and Combat Support Ship homeport concentrations, be implemented as part of the PEOC maintenance strategy.

The size and composition of the PEOC Field Site Teams are not fully identifiable at this time. However, for planning purposes, a number of billets approximately 60 to 75 percent the size of the DDEOC requirements appears reasonable in view of the three PEOC ship classes to be monitored in comparison with the five DDEOC ship classes. This estimate results in one officer and ten enlisted men in each of the three teams. The PEOC Field Site Teams will be required at three locations: Norfolk, San Diego, and Pearl Harbor. The exact composition of the teams (rates and qualifications of the members) will be an important task to be analyzed in the Development Phase as the requirements for system and equipment monitoring are more clearly defined.

10.3.2.4 Central Technical Group

It is recommended that a PEOC Central Technical Group (CTG), operating as an extension of the PEOC Program Office and under the direction of the PEOC Program Officer, be established at PERA (ASC) in Portsmouth, Virginia. The CTG will provide technical and engineering support to the PEOC Program by continuously assessing the material condition of PEOC ships and identifying maintenance improvements to assist in achieving program objectives.

Locating the CTG with PERA (ASC) will provide the CTG with access to available technical information and, at the same time, facilitate dealings with the office responsible for overhaul and other availability planning and engineering for Amphibious type ships. Figure 10-3 shows the proposed PEOC Central Technical Group organization. An in-depth review of the functions and responsibilities, as well as the exact composition of this group, should be made early in the Development Phase of the PEOC Program to refine the requirements and develop adequate justification for a POM-81 submission.

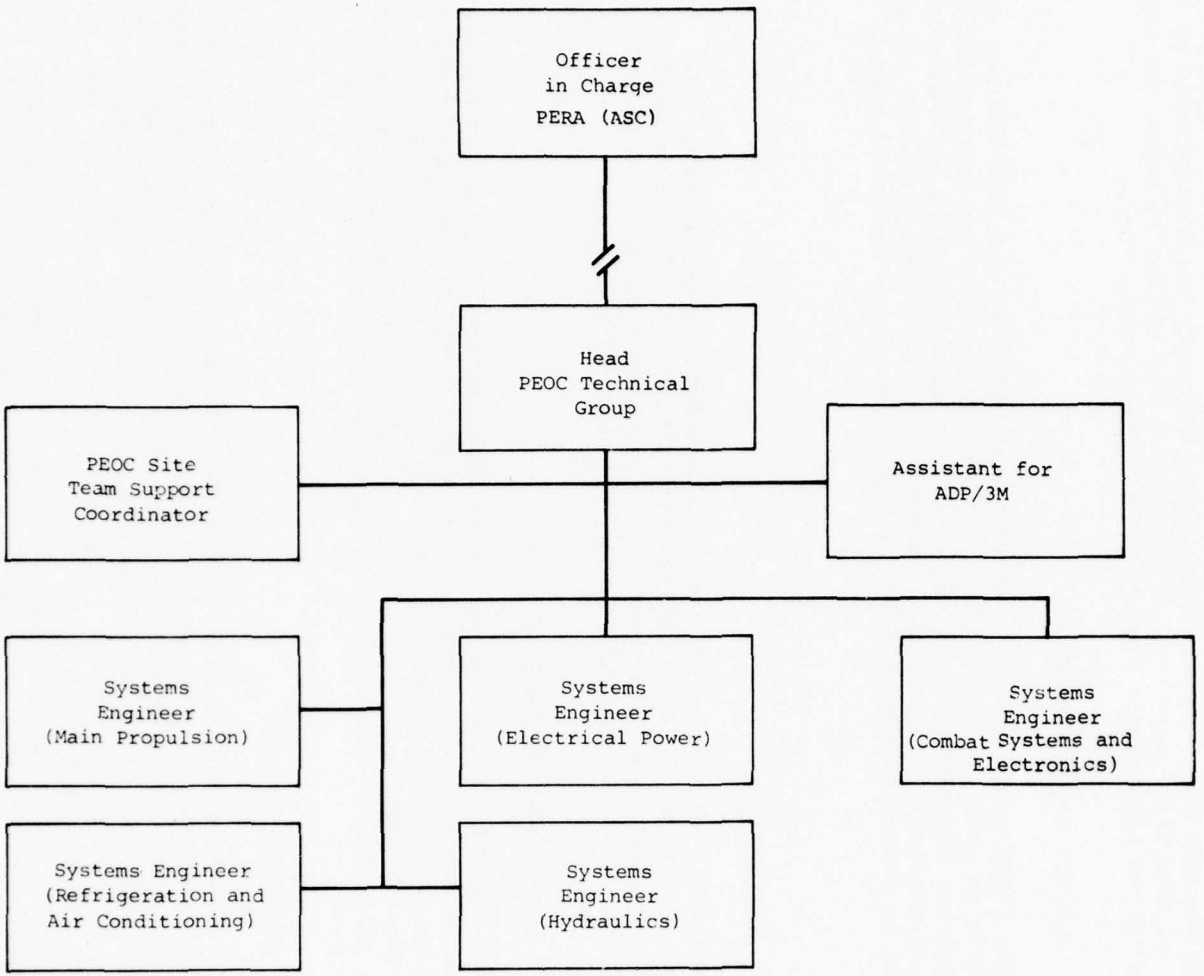


Figure 10-3. PEOC CENTRAL TECHNICAL GROUP OFFICE ORGANIZATION

10.3.3 PEOC Program Plan

The last step of the Development Phase is the preparation of the PEOC Program Plan, which, assembles under one cover the several Development Phase documents to be used during the Implementation Phase. Additionally it should describe the Implementation Phase schedules and requirements as they apply to each ship class. The PEOC Program Plan serves to guide the transition from the Development Phase to the Implementation Phase.

10.4 RESOURCE REQUIREMENTS

The resources required to develop and implement the PEOC Program were estimated in order to provide the information required for preparation of POM inputs. Program personnel requirements were identified and summarized by orgainzation. Organizational support costs were then estimated and summarized to determine the program development and implementation costs.

10.4.1 Personnel

Estimates of program personnel requirements, shown in Table 10-1 were developed considering the organizational structures and responsibilities previously identified in section 10.3. The estimates are time phased to correspond with the program schedule depicted in the POA&M.

10.4.2 Organizational Support

The cost of the PEOC support organizations was estimated on the basis of personnel requirements and the amount of travel, training and other support deemed necessary to perform each organization's assigned functions. The organizational support costs, in constant FY 1979 dollars, are presented in Table 10-2. The costs shown correspond with the POA&M schedule and Table 10-1.

10.4.3 Development Cost

The Development Cost for the PEOC Program is that cost incurred to develop and initiate the program during the period FY 1978 through FY 1984. The Development Cost consists of organizational support group costs plus the increased cost of pre-EOC overhauls above current, regular overhaul costs. Organizational support group cost for FY 1978 through FY 1984 totals $12,053,000 from Table 10-2. The increased cost of pre-EOC overhauls totals $107,595,000 based on the additional costs identified in Table 8-4. Total Development Cost for the PEOC Program is therefore $119,648,000.

10.4.4 Implementation Cost

The Implementation Cost for the PEOC Program is the total cost of continuing an established, mature program. This cost therefore consists of

Table 10-4. PEOC PROGRAM PERSONNEL REQUIREMENTS BY FISCAL YEAR

Organizational Element	Current Year	Budget Year	POM	Out Years			
	FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984
PEOC Program Office							
Officer	1	2	2	2	2	2	2
Civilian	4	7	7	11	11	11	11
PEOC Central Technical Group							
Civilian				8	8	8	8
SURFLANT Staff							
Officer			1	2	2	2	2
Norfolk Site Team							
Officer				1	1	1	1
Enlisted				6	10	10	10
SURFPAC Staff							
Officer			1	2	2	2	2
San Diego Site Team							
Officer				1	1	1	1
Enlisted				6	10	10	10
Pearl Harbor Site Team							
Officer				1	1	1	1
Enlisted				3	6	10	10
Totals							
Officer	1	2	4	9	9	9	9
Enlisted	0	0	0	15	26	30	30
Civilian	4	7	7	19	19	19	19

Table 10-2. PEOC PROGRAM FYDP PLANNING BUDGET (THOUSANDS OF DOLLARS)

Organizational Elements/Budget Line Items	FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984
1. PEOC Program Office							
a. Civilian Salaries	152	266	266	418	418	418	418
b. Engineering Development	211	1,334	1,547	305	140	52	0
c. Engineering Support	-	-	250	272	308	306	158
d. Travel	8	15	16	23	23	23	23
e. Training and Professional Development (PEOC sponsored)	6	11	11	16	16	16	16
f. Test equipment (OPN) Purchase	-	-	4	6	8	8	8
g. Miscellaneous Support (copies, etc.)	-	-	4	4	8	8	8
2. PEOC Central Technical Group							
a. Civilian Salaries	-	-	-	304	304	304	304
b. Travel	-	-	-	14	14	14	14
c. Training and Professional Development (PEOC sponsored)	-	-	-	10	10	10	10
d. Vibration Program (Analysis and Support)	-	-	-	40	50	50	60
e. PEOC R&D Studies (Improved Test Techniques, etc.)	-	-	-	30	40	40	50
f. ADP/Miscellaneous Support	-	-	-	100	60	60	70
3. PEOC TYCOM Staff Elements Travel (Figure includes both TYCOMS)	-	-	2	5	7	7	7
4. PEOC Field Site Teams (Figures includes all three teams)							
a. Travel				36	94	124	132
b. Training				22	35	40	40
c. Test Equipment Calibration/Refurbishment				3	6	12	12
d. Miscellaneous Support				3	6	6	6
5. Milpers							
a. Officer	12	36	72	156	216	216	216
b. Enlisted				90	246	336	360
Totals -	389	1,662	2,172	1,859	2,009	2,050	1,912

the stabilized organizational support group costs after the last ship has entered into an engineered operating cycle. That cost is estimated to be equal to the Table 10-2 FY 1984 cost of $1,912,000 annually. Twenty year Implementation Cost totals are $38,240,000.

10.5 PLAN OF ACTION AND MILESTONES

In support of the CNO objective to improve the material condition of the Fleet, NAVSEA 941 authorized a study to investigate the feasibility and cost-effectiveness of an Engineered Operationg Cycle Program for Amphibious ships. The program has the objectives of achieving an adequate state of material readiness in the three classes of amphibious ships currently designated and to maintain the material condition of the ships through an integrated, engineered, reliability-centered maintenance strategy in a resource-effective and balanced manner. The results of the study support the feasibility and cost-effectiveness of the PEOC Program. The Plan of Action and Milestones displayed in this section present a schedule to develop and implement the Amphibious EOC Program in an orderly fashion.

10.5.1 Plan of Action

The plan of Action to initiate, develop, and implement the PEOC program includes three phases:

- Initiation Phase - This phase consists of developing program POA&M and cost alternatives and performing preliminary engineering studies to establish the requirements of the Development Phase. The Initiation Study has validated, by analysis, the feasibility of achieving the program objectives and has tentatively defined, for the three designated ship classes, maintenance strategy and program planning and engineering requirements. The Initiation Phase will last approximately one year. An Initiation Study has been completed within 8 months, and should be reviewed (and revised as necessary) during months 9 through 12 so that a formal program can be established by the beginning of FY 1979.

- Development Phase - The Development Phase has been compressed to twenty-seven months to permit the results of engineering analyses to contribute to the first ships of each class's pre-EOC overhauls before the ships enter the PEOC Program. In this phase detailed ship system engineering work will produce the following major products:

  - Ship Alteration and Repair Packages (as required)
  - Critical Equipments/Systems Lists
  - System Maintenance Analyses
  - Class Maintenance and Modernization Plans

- Program Management Plan
- Material Condition Assessment Procedures
- Program Effectiveness Procedures
- Post-Overhaul Analysis Program

- Implementation Phase - During this phase, the PEOC Program will be established and implemented in the Fleet as individual ships are introduced into the program. An engineered maintenance management information system will be developed to process the information from all levels of maintenance activity throughout the PEOC overhaul cycle.

  The Implementation Phase includes the pre-EOC overhauls and overhaul analysis programs to establish ship baseline material condition. During this phase, EOC Site Teams will be established at the Type Commander level and the EOC Central Technical Group will be activated at PERA (ASC) to test and assess the material condition of ship's equipment. An ADP-assisted maintenance management system will be implemented to schedule maintenance from inputs of the Class Maintenance and Modernization Plan, individual ship's CSMP, and the PEOC Central Technical Group.

10.5.2 Milestones and Schedule

The milestones for initiating, developing, and implementing the Amphibious Engineered Operating Cycle Program are presented in Table 10-3 with the proposed dates for their commencement or completion.

These milestones contain a phased schedule for developing and implementing the PEOC Program on a class basis. This phasing spreads out the engineering workload for the program and facilitates the completion of detailed engineering analyses prior to Pre-EOC overhauls. The availability of more complete engineering analyses results contributes to more accurate class maintenance and modernization plans.

The specific sequence shown in these milestones was based on an early priority, assigned by class population, and may be modified to reflect different class priorities.

Table 10-3. PEOC Program Milestones

1.	Start program Initiation Phase.	1 Oct 77
2.	Start program initiation study.	1 Oct 77
3.	Complete program initiation study	1 Jun 78
4.	Start NAVSEA/OPNAV review of program initiation study.	1 Jun 78
5.	Start development of critical equipments/systems list for LHA-1 Class.	1 Jun 78
6.	Start development of projected class configuration for LHA-1 Class.	1 Jun 78
7.	Start engineering analysis of critical systems for LHA-1 Class.	1 Jun 78
8.	Start program Development Phase for LHA-1 Class.	1 Jun 78
9.	Start development of critical equipments/systems list for LST-1179 Class.	1 Jun 78
10.	Start development of projected class configuration for LST-1179 Class.	1 Jun 78
11.	Complete development of critical equipments/systems list for LHA-1 Class.	1 Oct 78
12.	Complete development of projected class configuration for LHA-1 Class.	1 Oct 78
13.	Complete development of critical equipments/systems list for LST-1179 Class.	1 Oct 78
14.	Complete development of projected class configuration for LHA-1 Class.	1 Oct 78
15.	Complete program Initiation Phase.	1 Oct 78
16.	Enter resource requirements in Navy POM.	1 Oct 78
17.	Complete initiation study review. Establish Amphibious EOC Program.	1 Oct 78
18.	Start program Development Phase for LST-1179 Class.	1 Oct 78
19.	Start development of BOH SARP for LST-1179 Class.	1 Oct 78
20.	Start engineering analysis of critical systems for LST-1179 Class.	1 Oct 78
21.	Start development of class maintenance plan for LHA-1 Class.	1 Oct 78
22.	Start development of class maintenance plan for LST-1179 Class.	1 Oct 78
23.	Start development of program mangement plan.	1 Oct 78
24.	Start development of critical equipments/systems list for LPD-4 Class.	1 Oct 78
25.	Start development of projected class configuration for LPD-4 Class.	1 Oct 78
26.	Complete development of critical equipments/systems list for LPD-4 Class.	1 Apr 79
27.	Complete development of projected class configuration for LPD-4 Class.	1 Apr 79
28.	Start program Development Phase for LPD-4 Class.	1 Apr 79
29.	Complete preliminary class BOH requirements for LST-1179 Class.	1 Apr 79
30.	Start development of BOH SARP for LPD-4 Class.	1 Apr 79
31.	Start engineering analysis of critical systems for LPD-4 Class.	1 Apr 79
32.	Start development of class maintenance plan for LPD-4 Class.	1 Apr 79
33.	Start development of ship class material condition baseline and material condition monitoring/assessment procedures for LHA-1 Class.	1 Apr 79
34.	Start development of ship class material condition baseline and material condition monitoring/assessment procedures for LST-1179 Class.	1 Apr 79
35.	Start BOH planning (A-18) for LHA-1 Class.	1 Apr 79
36.	Start BOH planning (A-18) for LST-1179 Class.	1 Apr 79
37.	Start development of program effectiveness assessment procedures.	1 Jul 79

Table 10-3. (continued)

38.	Complete preliminary program management plan	1 Aug 79
39.	Complete preliminary class BOH requirements for LPD-4 Class.	1 Oct 79
40.	Complete preliminary class maintenance plan for LHA-1 Class.	1 Oct 79
41.	Complete preliminary class maintenance plan for LST-1179 Class.	1 Oct 79
42.	Start development of Management Information System (MIS).	1 Oct 79
43.	Start development of ship class material condition baseline and material condition monitoring/assessment procedures for LPD-4 Class.	1 Oct 79
44.	Start BOH planning (A-18) for LPD-4 Class.	1 Oct 79
45.	Complete proposed SARP for first ship BOH for LST-1179 Class.	1 Jan 80
46.	Complete preliminary class maintenance plan for LPD-4 Class.	1 Apr 80
47.	Complete proposed SARP for first ship BOH for LPD-4 Class.	1 Jul 80
48.	Complete program management plan.	1 Aug 80
49.	Complete engineering analysis of critical systems for LHA-1 Class.	1 Oct 80
50.	Complete engineering analysis of critical systems for LST-1179 Class.	1 Oct 80
51.	Complete ship class material condition baseline and material condition monitoring/assessment procedures for LHA-1 Class.	1 Oct 80
52.	Complete ship class material condition baseline and material condition monitoring/assessment procedures for LST-1179 Class.	1 Oct 80
53.	Complete program effectiveness assessment procedures.	1 Oct 80
54.	Start implementation of program engineered maintenance management system.	1 Oct 80
55.	Start first LHA-1 Class ROH	1 Oct 80
56.	Start first LST-1179 Class BOH.	1 Oct 80
57.	Complete class maintenance plan for LHA-1 Class.	1 Jan 81
58.	Complete class maintenance plan for LST-1179 Class.	1 Jan 81
59.	Complete program Development Phase for LHA-1 Class.	1 Jan 81
60.	Complete program Development Phase for LST-1179 Class.	1 Jan 81
61.	Start program to translate class plans into individual ship plans.	1 Jan 81
62.	Complete MIS Development	1 Jan 81
63.	Establish Central Technical Group.	1 Jan 81
64.	Establish Site Teams.	1 Jan 81
65.	Complete program Development Phase for LPD-4 Class.	1 Apr 81
66.	Start first LPD-4 Class BOH.	1 Apr 81
67.	Complete engineering analysis of critical systems for LPD-4 Class.	1 Apr 81
68.	Enter CMMP items into MIS.	1 Apr 81
69.	Complete ship class material condition baseline and material condition monitoring/assessment procedures for LPD-4 Class.	1 Apr 81
70.	Complete program to translate class plans into individual ship plans for first ships to enter PEOC.	1 Apr 81
71.	Complete class maintenance plan for LPD-4 Class.	1 Jul 81
72.	Complete first LHA-1 Class ROH; ship enters EOC.	1 Sep 81
73.	Complete first LST-1179 Class BOH; ship enters EOC.	1 Sep 81
74.	Complete first LPD-4 Class BOH; ship enters EOC.	1 Mar 82

CHAPTER ELEVEN

CONCLUSIONS AND RECOMMENDATIONS

11.1 CONCLUSIONS

Conclusions drawn from the analyses conducted during the Amphibious Engineered Operating Cycle Initiation Study were based on maintenance data and other data sources identified in the study. Ample historical data existed (and were used) for the LST-1179 and LPD-4 classes, but design data was used to augment LHA-1 Class historical data because of limited operating experience for this class. The conclusions of this study are based on the average experience of the individual ships of each ship class investigated.

The following conclusions were reached as a result of this study:

- Adoption of a revised maintenance strategy for the proposed classes of amphibious ships will assist in maintaining their combat readiness at an acceptable cost and will maintain or increase their peacetime operational availability.

- Maintenance-critical systems were identified with a high degree of correlation among all the material condition indicators investigated. These identified maintenance-critical systems have underscored the need for revised or alternative long-range class maintenance strategies for the LST-1179, LPD-4, and LHA-1 classes of amphibious ships.

- Analyses of maintenance-critical systems reveal the desirability of revisions to the Timing of Repair and the Operating Cycle elements of maintenance strategy to offer the highest potential for improving maintenance strategy.

- Early improvement in material condition can best be obtained through a pre-EOC overhaul. The pre-EOC overhaul should be considered a prerequisite for a ship's entering an Engineered Operating Cycle.

- Ships in the PEOC Program will maintain an improved level of material condition. Planned actions to provide this improvement include:

  - Continuing identification, analyses and monitoring of maintenance and mission critical equipments in order to plan and correct problems prior to failure or unacceptable degradation.

  - Scheduling of required maintenance, based on class as well as individual ship experience and trends.

  - Shorter intervals between scheduled depot availabilities for ships because SRAs are planned between overhauls. This allows correction of major problems earlier.

  - Strong emphasis on the completion of reliability and maintainability alterations initially during the pre-EOC Overhaul, and as they are identified during the operating cycle.

- The preliminary PEOC Program maintenance strategies for the LST-1179, LPD-4, and LHA-1 classes call for maintenance performed on a periodic (or scheduled) basis. The most effective operational cycle is one with 3-deployments per cycle, with two six-week Selected Restricted Availabilities per cycle.

- The preliminary PEOC maintenance strategies are projected to provide the following benefits over a 20-year period. These benefits are in addition to an appreciable improvement in material condition.

Class	Increase in Availability (%)	Increase in Ships Available For Operation (%)	Increase in Total Cost (%)	Savings For Equivalent SAFO (Millions)
LHA-1	8.4	10.3	3.8	415.5
LPD-4	7.4	6.7	(4.3)*	260.6
LST-1179	6.8	6.9	7.3	142.8

*( ) show a decrease in cost.

- The PEOC program for the LST-1179, LPD-4 and LHA-1 classes of ships is feasible and projected to be both operationally and cost effective. The benefits of the program are greatest for the LHA-1 Class and nearly equivalent for the LPD-4 Class. LST-1179 Class cost benefits are less, however, the material condition improvements are appreciable.

11.2 RECOMMENDATIONS

On the basis of the study conclusions, the following recommendations are offered:

- Develop and implement the PEOC Program for the LHA-1, LPD-4 and LST-1179 classes of Amphibious ships in general accordance with the results of this study. A Plan of Action and Milestones is a part of this study.

- Establish as the initial goal of the PEOC Program, three deployments between shipyard overhauls for all three classes. However, during the Development Phase of the program, an analysis should be conducted to investigate further extension of the cycle to include four deployments.

APPENDIX A

MATERIAL CONDITION INDICATORS, SUPPORTING DATA

This Appendix contains supporting data for the Material Condition Indicators discussed in Chapter Five.

Table A-1 Maintenance Data System Factor Ranking for LST-1179 Class

Table A-2 Material Condition Readiness Index Factor Ranking for LST-1179 Class

Table A-3 Regular Overhaul Factor Ranking for LST-1179 Class

Table A-4 Maintenance Data System Factor Ranking for LPD-4 Class

Table A-5 Material Condition Readiness Index Factor Ranking for LPD-4 Class

Table A-6 Regular Overhaul Factor Ranking for LPD-4 Class

Table A-7 Maintenance Data System Factor Ranking for LHA-1 Class

Table A-8 Material Condition Readiness Index Factor Ranking for LHA-1 Class

Table A-9 LHA-1 Class Negative Man-Hour Differential (NMHD) Ranking

Table A-1. MAINTENANCE DATA SYSTEM FACTOR RANKING FOR LST-1179 CLASS

Rank	EIC	MDS Factor Value	Nomenclature
1	B101	22.0	Engine, diesel
2	GTBH	8.9	Gun sight Mk 29 Mod 4
3	3101	8.8	Generator set, 60-Hz, diesel driven
4	T104	7.9	Boiler, auxiliary (accessories and controls)
5	TF03	7.3	Intermediate and low pressure air systems
6	T801	6.9	Firemain
7	AD04	6.1	Ramps
8	GBLE	5.0	Mount, 3" 50 Cal. twin RF Mk 33 Mod 13
9	1B01	4.4	Galley equipment
10	Y403	4.2	Craft, landing-vehicle personnel (LCVP Mk 7)
11	QB38	4.2	R-1051B/URR, receiver, radio
12	GT2H	3.9	Set, radar AN/SPG-50
13	TM01	3.7	Winches and hoisting equipment, miscellaneous
14	T404	3.6	Air conditioning system, chilled water (R-12)
15	B408	3.4	Propeller, controllable pitch and controls
16	QD4R	3.3	AN/VRC-46 radio set
17	P118	3.2	AN/SPS-10F, radar set
18	QD3R	3.1	AN/SRC-20, radio set
19	T804	2.9	Sprinkling systems
20	TK01	2.9	Distilling plant, low pressure submerged tube/basket
21	4505	2.8	Lighting fixtures, permanent mounted
22	QB3S	2.7	AN/SRC-21, radio set
23	B301	2.6	Gear, reduction, anti-friction
24	YC04	2.6	Davits, boat
25	Y401	2.6	Craft, landing, vehicle personnel (CLVP)
26	QE1P	2.6	AN/URT-24, transmitting set, radio
27	AD03	2.5	Stern gates
28	Y406	2.5	Craft, landing-personnel, light LCP(L) Mk 4
29	1A06	2.5	Miscellaneous items manufactured by tender
30	1A01	2.4	Laundry and tailor shop equipment
31	M403	2.4	Telephone system, sound powered
32	M704	2.4	Projector, motion picture, 16 mm
33	B403	2.4	Shaft, stern tube group
34	1103	2.3	Safety and guard fittings
35	QE1N	2.2	AN/URT-23(V) transmitting set, radio
36	TM06	2.0	Winches, snaking and warping
37	1805	2.0	Lockers, damage control

Table A-2. MATERIAL CONDITION READINESS INDEX FACTOR RANKING FOR LST-1179 CLASS

Rank	EIC	Nomenclature
1	B101	Engine, diesel
2	AD04	Ramps
3	B408	Propeller, controllable pitch and controls
4	B301	Gear, reduction anti-friction
5	3101	Generator set, 60-Hz, diesel driven
6	TF03	Intermediate and low pressure air systems
7	T104	Boiler, auxiliary (accessories and controls)
8	T801	Firemain
9	TL01	Steering gear, electro-hydraulic
10	TM01	Winches, equipment
11	AD05	Hatches
12	TM06	Winches, snaking and warping
13	LB31	Gyro, Mk 23 Mod C3
14	YC04	Davits, boat
15	TN03	Cargo elevator, load and personnel
16	P118	AN/SPS-10F, radar set
17	QD4R	AN/VRC-46, radio set
18	Y403	Craft, landing-vehicle personnel (LCVP Mk 7)
19	QE1N	AN/URT-23(V) transmitting set, radio
20	AD01	Doors
21	R50Z	AN/UQN 4 sounding set, sonar (DEEP)
22	TLOC	Bow thruster
23	T601	Cargo system, gasoline
24	TM04	Anchor windlass
25	T903	Foam generating equipment
26	AD03	Stern gates
27	QE1P	AN/URT-24, transmitting set, radio
28	GTBH	Gun sight Mk 29 Mod 4
29	B403	Shaft, stern tube group
30	TK05	Distilling unit
31	TS03	Masts
32	LDOB	Indicator, dead reckoning analyzer, Mk 9, Mod 4

Note: MCRI values are classified CONFIDENTIAL.

Table A-3. REGULAR OVERHAUL FACTOR RANKING FOR LST-1179 CLASS

Rank	EIC	Nomenclature	Average Man-Days Per Overhaul
1	B101	Engine, diesel	2,255
2	3101	Generator set, 60-Hz, diesel driven	986
3	B408	Propeller, controllable pitch and controls	966
4	AD04	Ramps	578
5	T801	Firemain	462
6	TF03	Intermediate and low pressure air systems	454
7	T104	Boiler, auxiliary (accessories and controls)	292
8	TA03	Bilge and ballast systems	273
9	TK05	Distilling unit	260
10	T404	Air conditioning system, chilled water (R-12)	239
11	AD03	Stern gates	238
12	T806	Sea water service system	235
13	YC04	Davits, boat	225
14	B305	Clutch/brake, friction	216
15	TN03	Cargo elevator, load and personnel	195
16	T503	Refrigeration plant (R-12)	156
17	T101	Steering gear, electro-hydraulic	154
18	B301	Gear, reduction, anti-friction	142
19	B801	Lube oil service group	108
20	T605	Fueling service, transfer and blending system, aviation JP-5/HEAF	92
21	TB03	Potable water	80
22	B807	Lube oil purifiers	74
23	TS03	Masts, kingposts, booms and rigging	62

Table A-4. MAINTENANCE DATA SYSTEM FACTOR RANKING FOR LPD-4 CLASS

Rank	EIC	MDS Factor Value	Nomenclature
1	F101	16.4	Boiler, D/express/header type, propulsion
2	QD3R	7.1	AN/SRC-20, radio set
3	F303	6.3	Pump unit, centrifugal (multistage, turbine-driven) main feed
4	P30T	6.3	AN/SPS-40 radar set
5	T801	6.0	Firemain
6	GBL2	5.5	Mount, 3" 50 Cal. twin RF Mk 33 Mod 0
7	1B01	5.1	Galley equipment
8	TK03	4.8	Distilling plant, low pressure, flash type
9	QB3A	4.7	R-1051B/URR, receiver, radio
10	F703	4.0	Valves, main steam
11	T404	3.9	Air conditioning system, chilled water (R-12)
12	QE1W	3.5	AN/WRT-2, transmitting set, radio
13	310C	3.2	Generator set, 60-Hz, steam turbine driven
14	F507	2.6	Piping and accessories, main fuel oil service
15	1A06	2.6	Miscellaneous items manufactured by tender
16	QD4R	2.5	AN/VRC-46, radio set
17	F401	2.3	Blower group, air supply system, combustion, main propulsion
18	TA03	2.3	Bilge and ballast systems
19	FD07	2.3	Piping and accessories, main lube oil service
20	QB38	2.3	R-1051/URR, receiver, radio
21	Y407	2.3	Craft, landing-personnel light LCP(L) Mk 11
22	L606	2.2	AN/URN-20, radio set
23	M401	2.1	Telephone system, dial
24	QD3S	2.1	AN/SRC-21, radio set
25	F501	2.1	Fuel oil service pump unit
26	T503	2.0	Refrigeration plant (R-12 direct expansion)
27	T605	2.0	Fueling service, transfer and blending system, aviation JP-5/HEAF
28	UG03	2.0	Lagging, miscellaneous
29	4505	2.0	Lighting fixtures, permanent mounted
30	TF03	1.9	Intermediate and low pressure air systems
31	N81P	1.9	AN/WLR-1C, receiving set, countermeasures
32	T903	1.8	Foam generating equipment
33	M704	1.8	Projector, motion picture, 16 mm

Table A-5. MATERIAL CONDITION READINESS INDEX FACTOR RANKING FOR LPD-4 CLASS

Rank	EIC	Nomenclature
1	F101	Boiler, D/express/header type, propulsion system
2	F303	Pump unit, centrifugal (multi-stage turbine-driven), main feed
3	T801	Firemain
4	TN03	Cargo elevator, load and personnel
5	310C	Generator set, 60-Hz, steam turbine driven
6	TK03	Distilling plant, low pressure, flash type
7	F401	Blower group, air supply system, combustion
8	TN04	Cranes, boat, ammo and stores
9	TF03	Intermediate and low pressure air systems
10	AD03	Stern gates
11	GBL2	Mount, 3" 50 Cal. twin RF, Mk 33 Mod 0
12	QD3R	AN/SRC-20, radio set
13	QE1N	AN/URT-23(V), transmitting set, radio
14	P31V	AN/SPS-40C, radar set
15	T404	Air conditioning system, chilled water (R-12)
16	F507	Piping and accessories, main fuel oil service
17	3101	Generator set, 60-Hz, diesel driven
18	QE1W	AN/WRT-2 transmitting set, radio
19	T903	Foam generating equipment
20	L606	AN/URN-20, radio set
21	NC0B	AN/ULQ-6B repeater, countermeasures, ECM, pulse
22	P71F	AN/SPA-66 indicator group
23	QB3A	R-1051B/URR, receiver, radio
24	N81P	AN/WLR-1C, receiving set, countermeasures
25	FE03	Shaft, main propulsion
26	TA03	Bilge and ballast systems
27	T601	Cargo system, gasoline
28	P30T	AN/SPS-40 radar set
29	TM04	Windlass, anchor
30	FD07	Piping and accessories, main lube oil service
31	F301	Pump unit, centrifugal (single-stage, turbine-driven) main feed
32	TL01	Steering group, electro-hydraulic

Note: MCRI values are classified CONFIDENTIAL.

Table A-6. REGULAR OVERHAUL FACTOR RANKING FOR LPD-4 CLASS

Rank	EIC	Nomenclature	Average Man-Days Per Overhaul
1	F101	Boiler, D/express, header type, propulsion system	1922
2	310C	Generator set, 60-Hz, steam turbine driven	986
3	F303	Pump unit, centrifugal (multi-stage turbine-driven) main feed	841
4	T801	Firemain	816
5	FE03	Shafting, main propulsion	799
6	TH03	Auxiliary steam supply system	723
7	TK03	Distilling plant, low pressure, flash type	657
8	F401	Blower group, air supply system, combustion, main propulsion	601
9	T404	Air conditioning system, chilled water (R-12)	597
10	T605	Fueling service, transfer and blending system, aviation JP-5/HEAF	589
11	TN03	Cargo elevator, load and personnel	425
12	T806	Sea water service system	391
13	TF03	Intermediate and low pressure air systems	339
14	TN04	Cranes, boat, ammo and stores	292
15	FA01	Main condenser unit	249
16	FB03	Main circulating water pump unit, axial flow steam turbine driven	246
17	AD03	Stern gate	245
18	F501	Main fuel oil service pump unit, turbine driven	231
19	FD07	Piping and accessories, main lube oil service	209
20	GBL2	Mount, 3" 50 Cal. twin RF, Mk 33 Mod 0	198
21	TH04	Drain systems, high and low pressure	197
22	QE1W	AN/WRT-2, transmitting set, radio	178
23	T903	Foam generating equipment	165
24	FC01	Reduction gears, main propulsion	160
25	F801	Turbine, high pressure, main propulsion	157
26	T30B	Fan unit, type vaneaxial	150
27	LB05	Gyrocompass, Mk 8, Mod 3	150
28	F507	Piping and accessories, main fuel oil service	146
29	T503	Refrigeration plant	136
30	TH01	Auxiliary steam exhaust system	119
31	FB09	Piping and accessories, main salt water cooling	116
32	TB03	Potable water system	114

Table A-7. MAINTENANCE DATA SYSTEM FACTOR RANKING FOR LHA-1 CLASS

Rank	System Description	MDS Factor Value
1	Radio communications and data	55.200
2	Hull and hull fittings	46.200
3	I.C. systems	32.800
4	Assault and aircraft handling	22.000
5	Supply department systems	21.600
6	Salt water and ballast systems	19.600
7	Electronics support and laboratory systems	18.700
8	Gasoline systems	17.500
9	Gunfire control	16.400
10	Guided missile control	14.600
11	Surveillance systems	11.500
12	Ordnance	8.900
13	Deck equipment	7.800
14	Compressed air and gas	6.100
15	Auxiliary steam and drains	5.900
16	Propulsion	4.500
17	Boilers	4.100
18	60-Hz power distribution and lighting	3.400
19	Main steam	3.200
20	SS and emergency power generator	3.100
21	Fresh water systems	3.000
22	Dc electrical systems	2.900
23	Lube oil	2.700
24	400-Hz power distribution	2.600
25	Ventilation systems	2.540
26	Combustion air	2.490
27	Ship shops	2.350
28	Feed and condensate	2.100
29	Waste disposal systems	1.895
30	Air conditioning	1.879
31	Mechanical navigation systems	1.800
32	Electronic countermeasures	1.590
33	Electronic navigation systems	1.490
34	Ship control and steering	1.000
35	Medical and dental systems	0.900
36	Fuel oil systems	0.400
37	Main circulation water systems	0.100

Table A-8. MATERIAL CONDITION READINESS INDEX FACTOR RANKING FOR LHA-1 CLASS

Rank	Nomenclature
1	Radio communications and data systems
2	Assault systems and aircraft handling
3	Salt water and ballast systems
4	Surveillance systems
5	Gasoline systems
6	Gunfire control systems
7	Boilers
8	Ship control and steering systems
9	Deck equipment
10	Compressed air and gases
11	Guided missile fire control systems
12	Waste disposal systems
13	Propulsion
14	Dc electrical systems
15	Electronic navigation systems
16	400-Hz power distribution systems
17	60-Hz power distribution and lighting
18	Ship service and emergency electric power generator
19	Supply department systems
20	Electronic countermeasures
21	Non-electronic navigation systems
22	Ordnance systems
23	Interior communications systems
24	Air conditioning systems
25	Feed and condensate system
26	Main circulating water systems
27	Ship shops

Note: MCRI values are classified CONFIDENTIAL.

Table A-9. LHA1 CLASS NEGATIVE MAN-HOUR DIFFERENTIAL (NMHD) RANKING
(DATA PERIOD: JUNE 1976 THRU MAY 1977 LHA-1 ONLY)

Rank	System Description	Ship Man-Hours		Difference	IMA Experience	NMHD
		Projections	Experience			
1	Interior communications	6799	15074	-8275	3	8278
2	Salt water and ballast systems	1859	7106	-5247	112	5359
3	Hull and hull fittings	203	3375	-3172	1099	4271
4	Assault and aircraft handling systems	3294	4462	-1168	37	1205
5	Gasoline systems	578	1688	-1110	49	1159
6	Surveillance systems	1639	2765	-1125	12	1137
7	Deck equipment	446	1192	-746	18	764
8	Electronics support and lab systems	13073	177	+12896	663	663
9	Supply systems	1142	1143	-1	585	586
10	Electronic countermeasures	470	949	-479	0	479
11	Gunfire control systems	39	472	-433	24	457
12	Guided missile control	15	443	-428	0	428
13	Main circulation water system	43	285	-242	17	259
14	Auxiliary steam and drains	1329	244	+1085	225	225
15	Compressed air and gas	514	689	-175	0	175
16	Ships service and emergency power generation	382	554	-172	2	174
17	Lube oil systems	152	213	-61	90	151
18	Main steam systems	69	87	-18	116	134
19	Combustion air	95	69	+26	108	108
20	400-Hz electric power	313	103	+210	106	106
21	Dc electric power	200	74	+126	94	94
22	Medical and dental systems	3	91	-88	0	88
23	Propulsion systems	2208	409	+1799	81	81
24	Non-electronic navigation	322	398	-76	1	77
25	Ordnance	2751	266	+2485	74	74
26	Feed and condensate systems	679	142	+537	49	49
27	Fresh water systems	1143	306	+837	37	37
28	Boilers	338	279	+59	35	35
29	Ship shops	318	351	-33	1	34
30	Electronic navigation	281	63	+218	21	21
31	Waste disposal	500	353	+147	14	14
32	Radio communications and data systems	17670	3033	+14637	12	12
33	60-Hz power and lighting	32224	372	+31852	8	8
34	Ventilation	2360	491	+1869	5	5
35	Fuel oil	562	16	+546	1	1
36	Ship control and steering	59	41	+18	0	0
37	Air conditioning	965	151	+814	0	0
	Miscellaneous:					
	Undefined auxiliaries	0	1100	-1100	121	1221
	Outfitting and furnishings	0	979	-979	757	1736
	Other - tests, service, utilities, etc.		1323	-1323	1	1324
	Total	95037	51328	+43709	4578	31029

APPENDIX B

ANALYSIS OF CURRENT MAINTENANCE STRATEGY RESOURCE REQUIREMENTS FOR LST-1179, LPD-4 AND LHA-1 SHIP CLASSES

1. INTRODUCTION

This appendix describes the process utilized to develop projected 20-year resource requirements for the PEOC classes, using their current maintenance strategies. This 20-year period is a very good approximation of the remaining ship life projected for the LST-1179 and LPD-4 classes, and is also the design value of the LHA-1 Class ship life. A baseline for determining costs was established by comparing historical costs with the Navy Resource Model (NARM) FY 1979 cost projections.

2. ANALYSIS APPROACH

The following paragraphs with accompanying tables and graphs address the comparative analysis applied to each of the PEOC classes. The purposes of the analyses were twofold: first to develop the manner in which the maintenance resource requirement data compiled for each class were utilized for costing purposes and second, to provide a source of historical data from which a comparative analysis could be made with the NARM FY 1979 cost projections.

The analysis was segmented into two sections: (1) LST-1179 and LPD-4 classes and (2) LHA-1 Class. The reason for segmenting the PEOC classes into two analysis sections was the distinctive differences in availability of maintenance resource requirement costing data.

3. DATA

The data utilized for this analysis are taken from the sources listed in Table B-1.

For purposes of distinguishing data, the sources were considered to be either historical data (actual transactions with corresponding dollar costs) or planning data (estimated or modeled ROH, IMA, RA/TA, or organizational repair parts dollars). The historical costs and spending data were compared with the planning data.

Table B-1. SOURCES OF DATA BY TYPE

Data Source	Data Category			
	Organization	IMA	RA/TA	ROH
Historical				
Departure Report				X
SURFLANT Financial Management Records			X	X
SURFPAC Financial Management Records			X	X
MDS Records (1/1/70-9/30/77)	X	X		
IMA Scheduling Records		X		
COMNAVLOGPAC Records		X		
Planning				
Navy Resource Model	X	X	X	X
Class Program Managers, PERA(ASC)				X
IMA Scheduling Records		X		

Where multiple data records from any source existed, the data were averaged so all information depicted would be representative of class averages. This was done because the data are meant to reflect the average experienced by or expected for the entire class, rather than indicate the specific past or future performance of any single ship of the class.

4. LST-1179 AND LPD-4 CLASSES

The analysis that follows will explain the comparative analysis conducted with NARM data and historical and planning data related to the LST-1179 and LPD-4 Classes. As the analysis is developed the logic for selecting the NARM estimates for LST-1179 and LPD-4 Classes will be brought forth. This extensive analysis has been conducted to support the use of NARM maintenance cost dollars as the maintenance strategy costing data for the LST-1179 and LPD-4 classes.

4.1 Unit Overhaul Costs

The unit overhaul costs shown by NARM calculations for FY 1979 dolars are acceptable projections of the recorded growth experienced in prior unit overhaul costs for these two classes. The costs tabulated in Table B-2 are

the average unit ROH costs for the specified fiscal year. It is more important in this analysis to track the growth of an "average" ROH's cost rather than to indicate the total dollar amounts spent during any given year by the entire class, because unit ROH costs are used in formulating the 20-year maintenance resource requirements costs for a single ship of the class. Additionally, the fact that ships of the class are overhauled as operational availability and shipyard capacity permit leads to some years having greater numbers of a class being overhauled with resultant greater class totals of ROH money expended. Table B-2 and Figure B-1 point out the increasing costs incurred by both classes for unit ROH. Although the graph does not show a smooth linear cost growth, the trend is one of overall cost increases. The NARM dollars fall within a reasonable tolerance of the trend established by prior ROH unit costs.

Table B-2. UNIT OVERHAUL COSTS

FY	Unit OH Cost*	Data Category/Source	
		Historical	Planning
LST-1179 Class			
1974	$ 4,327,402	SURFPAC Departure Report	
1975	5,206,792	SURFPAC Departure Report	
1976	5,288,813	SURFPAC and SURFLANT	
197T	5,924,000	SURFPAC	
1977	5,647,063	SURFLANT	
1978	6,500,000		PERA(ASC)
1979	8,300,000		NARM FY 1977
LPD-4 Class			
1973	$ 5,158,746	Departure Report	
1974	4,752,440	SURFPAC Departure Report	
1975	4,423,446	SURFPAC Departure Report	
1976	8,487,379	SURFPAC and SURFLANT	
197T	10,062,015	SURFPAC	
1977	11,003,549	SURFLANT	
1978	11,000,000		PERA(ASC)
1979	13,250,000		NARM FY 1979

*Costs are stated in corresponding fiscal-year dollars.

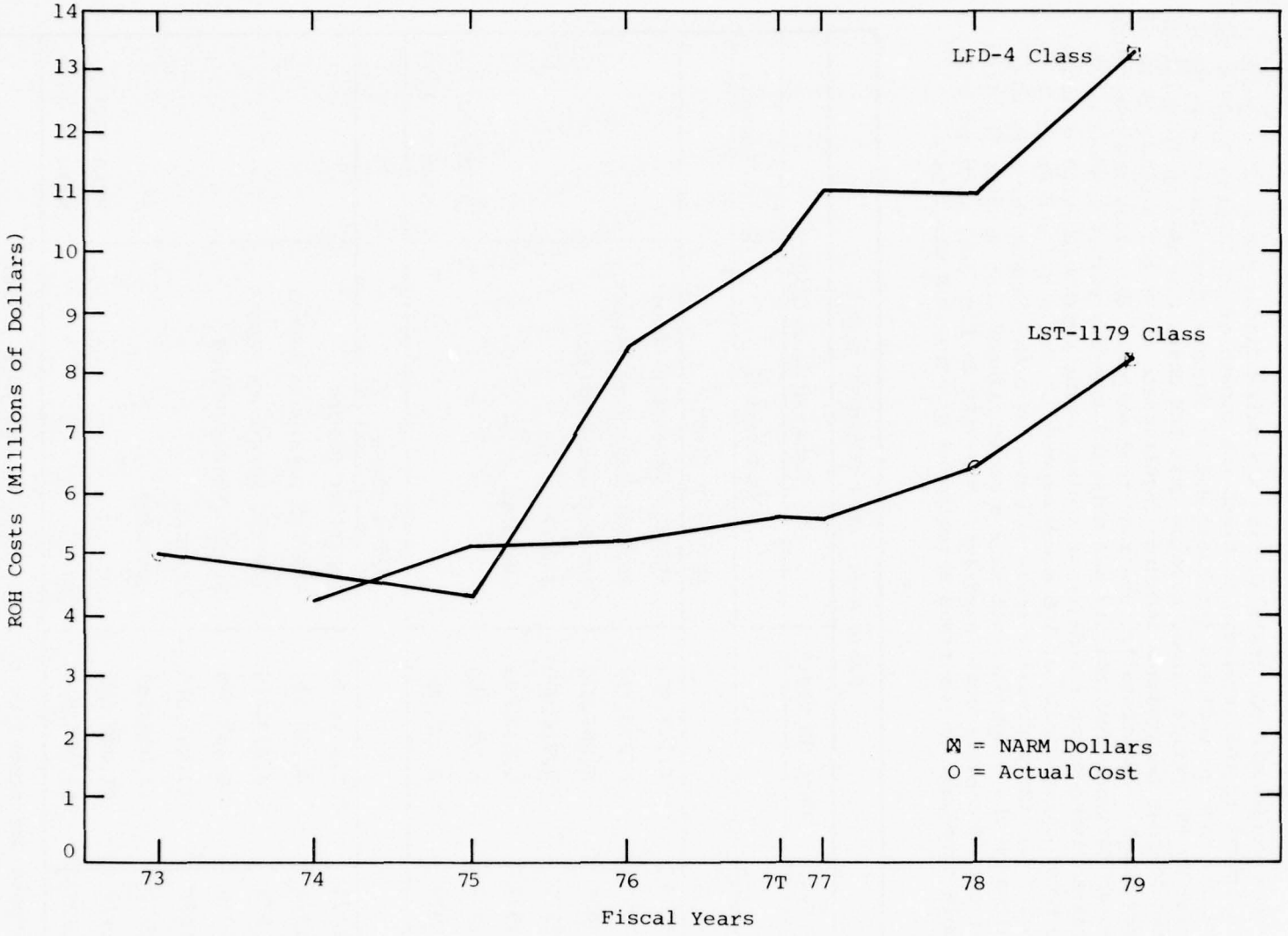


Figure B-1. LST-1179 AND LPD-4 CLASS AVERAGE COSTS PER ROH

4.2 RA/TA Costs

By definition of RA/TA funding, it is extremely difficult to predict all expenditures in this category. Most repairs funded by RA/TA dollars have displayed a reasonable probability of occurrence within a given time-frame but past experience does not provide specific enough information to provide inputs to a precisely developed advanced schedule. The following definitions taken from the Navy Program Factors Manual help explain the way these funds are obligated.

> "Restricted availability funds are money set aside for accomplishment of specific items of work by a repair activity, normally with the ship present. Most are not scheduled in advance, but occur only when needed. The types of repairs involved are not as complex as those that take place during overhauls, but the ship in question is still rendered incapable of fully performing its assigned mission due to the nature of the repair work.
>
> "Technical availability funding is defined as money set aside for the accomplishment of specific items of work by a repair activity, normally with the ship not present. None are scheduled in advance, but occur only when needs arise."

Because TYCOM planners realize these types of availabilities are a necessity and funding must be provided, the funding requests are submitted as a yearly projection and used as needed throughout the year. The implication is that funds could be expended in any part of the year if a great deal of unexpected RA/TA repair activity is incurred by a class.

Figure B-2 is a graphic presentation of the data from Table B-3. It highlights a drop in RA/TA spending during FY 197T from previous years for both classes. Additionally, a rather substantial funding increase is projected for FY 1979 in the NARM data, especially for the LPD-4 Class.

The drop in spending depicted for FY 197T can be attributed to the following: first, FY 197T consisted of only three months (other fiscal years contain twelve months), and second, FY 197T was a period of transition from fiscal years starting 1 July to fiscal years starting 1 October. The significant increases in RA/TA funding indicated by the NARM 1979 projections appear consistent with intended spending during FY 1978.

Initial spending in FY 1978 as reported by the SURFLANT financial management branch for SURFLANT LST-1179 Class (10 ships) and LPD-4 Class (6 ships) indicates the combined NARM projectsions for FY 1978 will be exceeded by actual spending. For the first 3 1/2 months of FY 1978,

Table B-3. RA/TA COST DATA

FY	RA/TA Cost*	Data Category/Source	
		Historical	Planning
LST-1179 Class			
1973	$175,556	SURFPAC	
1974	116,548	SURFPAC	
1975	142,518	SURFPAC	
1976	267,473	SURFPAC and SURFLANT	
197T	144,342	SURFPAC	
1977	181,894	SURFPAC and SURFLANT	
1978	191,500		NARM FY 1978
1979	432,500		NARM FY 1979
LPD-4 Class			
1973	$278,901	SURFPAC	
1974	285,046	SURFPAC	
1975	310,420	SURFPAC	
1976	226,913	SURFPAC and SURFLANT	
197T	107,008	SURFPAC	
1977	269,418	SURFPAC and SURFLANT	
1978	354,500		NARM FY 1978
1979	490,500		NARM FY 1979

*Costs are stated in corresponding fiscal year dollars

SURFLANT financial records show an average of $144,450 per ship of the LST-1179 Class and $153,364 per ship of the LPD-4 Class was spent. The SURFLANT budget for RA/TA funds in FY 1978 are $2,190,000 for the LST-1179 Class ($219,000 per ship) and $4,284,000 for the LPD-4 Class ($714,000 per ship). These amounts and the NARM FY 1978 projections differ because the NARM dollars are planning, not budgeting figures. At present expenditure rates, the LST-1179 RA/TA funds will be obligated before the end of the second quarter of FY 1978 and the LPD-4 Class will obligate only 85 percent of dedicated RA/TA funds by the end of the fiscal year. This trend could

result in the need for utilization of LPD-4 RA/TA funds on the LST-1179 Class. Comparable data for SURFPAC were not made available.

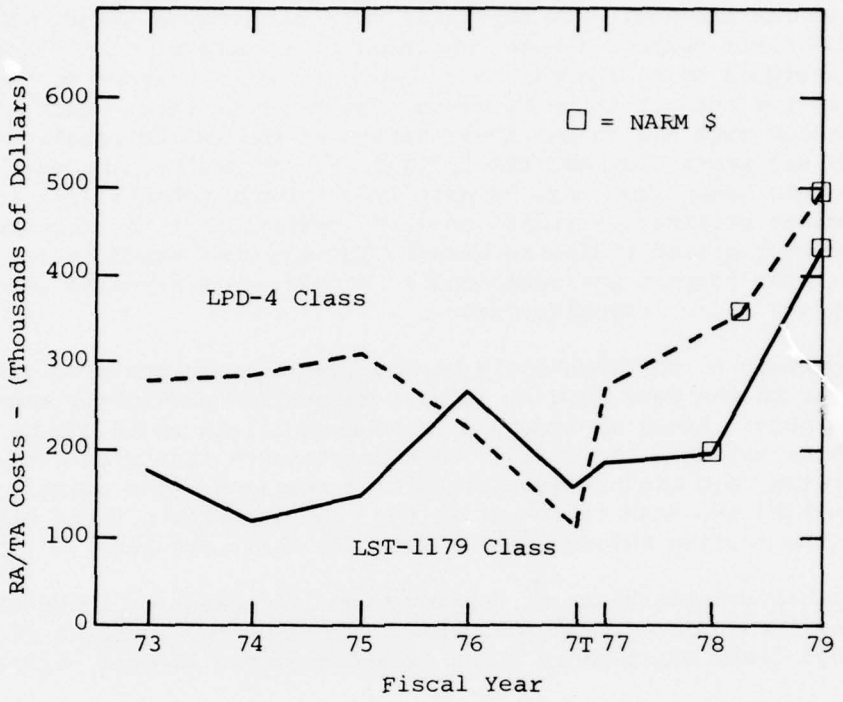


Figure B-2. ANNUAL RA/TA COSTS

Figure B-2 also shows that RA/TA expenditures have been fairly erratic over the data period. The accepted explanation of marked downward trends after periods of sustained expenditure increases is associated with the fact that significant ROH costs for a given year cut into RA/TA funds. SURFLANT financial records indicate the RA/TA expenditures were low in FY 197T and FY 1979 because of a large number of ships in both classes receiving overhauls - 6 of the LST-1179 Class and 2 of the LPD-4 Class. It seems prudent to plan for RA/TA costs to continue to rise. As ships of the class continue to age, the probability increases that RA/TA repairs will occur more frequently. The cost to accomplish these repairs should also increase as labor and material costs continue to rise.

Review of total RA/TA costs and ROH costs makes clear that RA/TA expenditures are relatively small by comparison.

4.3 IMA Costs

To initiate the costing of IMA activity maintenance-resource requirements, a search was conducted for an accurate definition of an accepted Navy-wide rate for an IMA man-hour. The purpose was to correlate the extensive IMA man-hour data to dollar totals. Various OPNAV, NAVSEASYSCOM, and TYCOM staff personnel were contacted in an attempt to learn the dollar figure assigned to an IMA man-hour. These sources offered no conclusive figure as the authoritative Navy-wide IMA man-hour rate. Lack of a firm IMA man-hour rate led to an investigation of the IMA utilization by LST-1179 and LPD-4 Classes (LHA-1 Class was not analyzed because of its limited data base) from year January 1970 through October 1977 in an attempt to correlate utilization trends to NARM predictions. The research of MDS data for that period indicated erratic IMA man-hour expenditures for both classes. The graphic presentation of IMA man-hours expended (see Figure B-3) depicts these irregularities.

No direct correlation could be obtained between the predicted estimates called out in the Navy Program Factors Manual and previously recorded IMA level support. Since an accepted IMA man-hour rate could not be identified by which to validate the FY 1979 NARM maintenance cost prediction, the NARM figures were used without further costing research. The primary rationale for selecting the NARM estimates is the wide acceptance these planning predictions receive throughout the Navy for their accuracy.

Another consideration in dealing with IMA costs for these classes is that they represent only approximately 1 percent to 4 percent of the calculated total maintenance costs expended over a 20-year period.

4.3.1 IMA Utilization

Since costing information could not be obtained from reported man-hour utilization, the utilization of the IMA level maintenance support was analyzed. As a result of the analysis, two observations could be made about the LST-1179 and LPD-4 Classes. First, IMA utilization by these classes have not over-burdened the IMAs. Second, the scheduling of IMA availability periods for these classes does not reflect uniform utilization of IMA level repairs in the current maintenance strategy. These two oberservations will be expanded in the following discussions.

The IMA data on the LST-1179 and LPD-4 Classes indicate these classes have not over-burdened the IMA facilities with excessive workloads during scheduled availabilities. Additionally, these classes do not appear to be scheduled into the allotted number of IMA availabilities as planned in the Type Commanders' scheduling template. IMA utilization by the LST-1179 Class can be broken into two distinct periods for the given data period (January 1970 through October 1977.) From FY 1970 through the third quarter of FY 1973, the average class utilization of IMA support was low. A significant factor affecting this low level of IMA data was the commissioning of 90 percent of this class between January 1970 to August 1972.

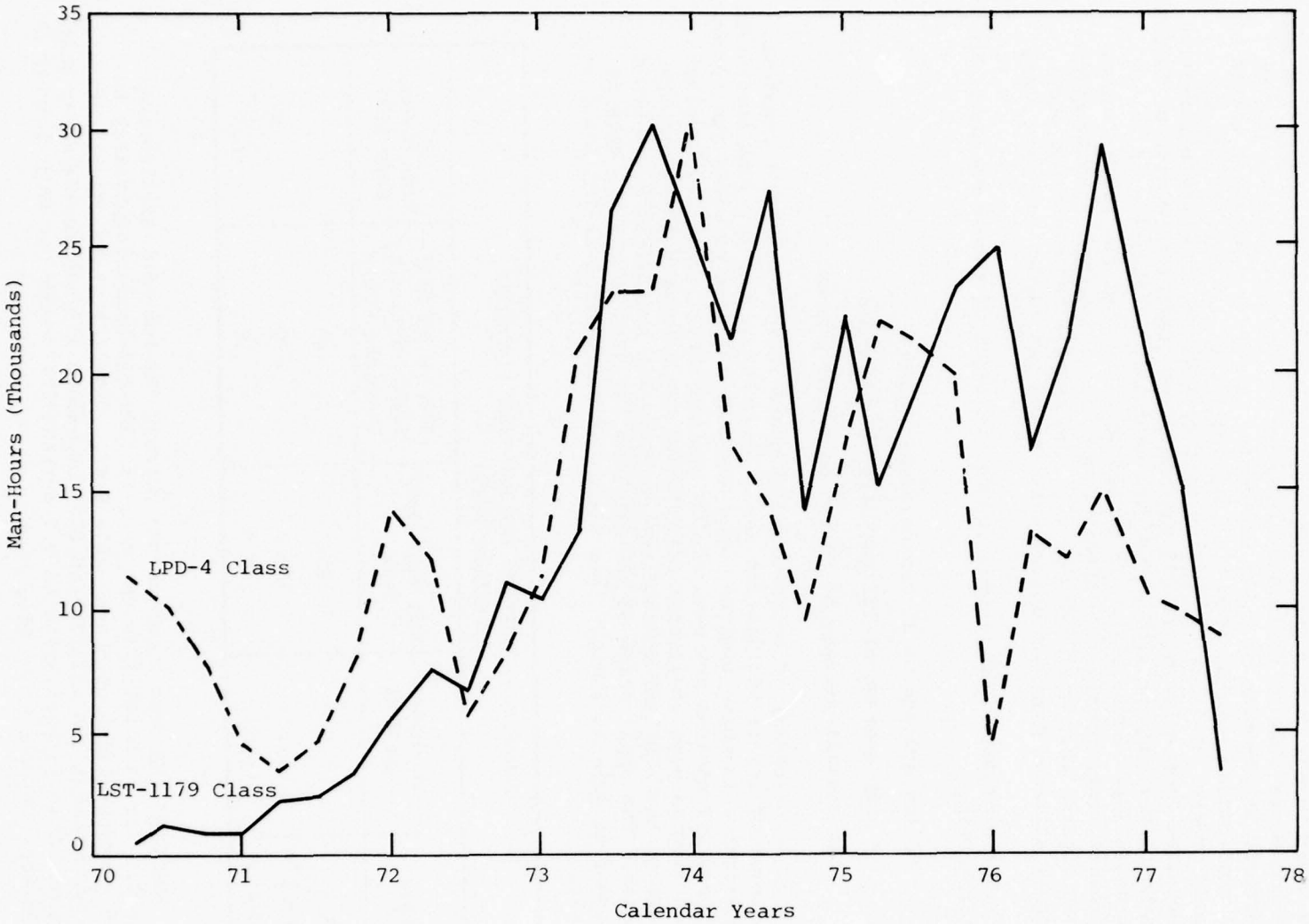


Figure B-3. TOTAL IMA MAN-HOURS UTILIZED BY LST-1179 CLASS AND LPD-4 CLASS AS REPORTED BY MDS

The class totals during the first period fluctuated erratically from 400 man-hours per quarter to 14,500 man-hours per quarter with an average quarterly utilization of 5,082 man-hours. The second distinct period of IMA utilization extends from the last quarter of FY 1973 through the second quarter of FY 1977. During this period, the man-hour utilization fluctuated from a low of 15,388 man-hours per quarter to a high of 30,153 man-hours per quarter with an average quarterly utilization of 22,448 man-hours (see Figure B-4). It should be noted that the above figures represent class totals. To obtain comparable individual ship averages those figures must be divided by 20. The average IMA man-hours per quarter utilized over the entire data period was 14,664 for each class.

The aforementioned figures equate, in terms of single man-days, to the following:

A low average of 31 man-days/ship quarter

A high average of 133 man-days/ship quarter

An overall average of 89 man-days/ship quarter

It is necessary to establish a standard against which the previous IMA level of repair utilization can be measured to provide some meaningful significance to these figures. The SURFLANT IMA desk provided the current man-hour allocations per week of IMA availability. Table B-4 displays those figures plus additional data on how the allocated IMA man-hours relate to the SURFLANT scheduling templates for the LST-1179 and LPD-4 Classes. The application of the SURFLANT IMA data to the MDS data is designed to gain an insight into trends of utilization of IMA level of repair.

Table B-4. CURRENT IMA MAN-HOUR PLANNING (SURFLANT DATA)

Class	Man-Hours/ IMA Week	IMA Man-Days/ Week	IMA Weeks/SURF-LANT Scheduling Template Cycle	IMA Weeks/ NARM Year
LHA-1	1,500	187.5	44	11.4
LST-1179	1,500	187.5	36	9
LPD-4	1,500	187.5	38	10.1

SURFLANT IMA desk reported the current IMA man-hour utilization projected for each LST-1179 IMA week is 1500 man-hours (equivalent to 187.5 man-days/IMA week - see Table B-4). LST-1179 Class IMA historical data showed that IMA utilization did not exceed 133 IMA man-days per ship quarter. This is equivalent to 0.7 current IMA weeks per ship quarter or 2.8 current IMA weeks per ship year.

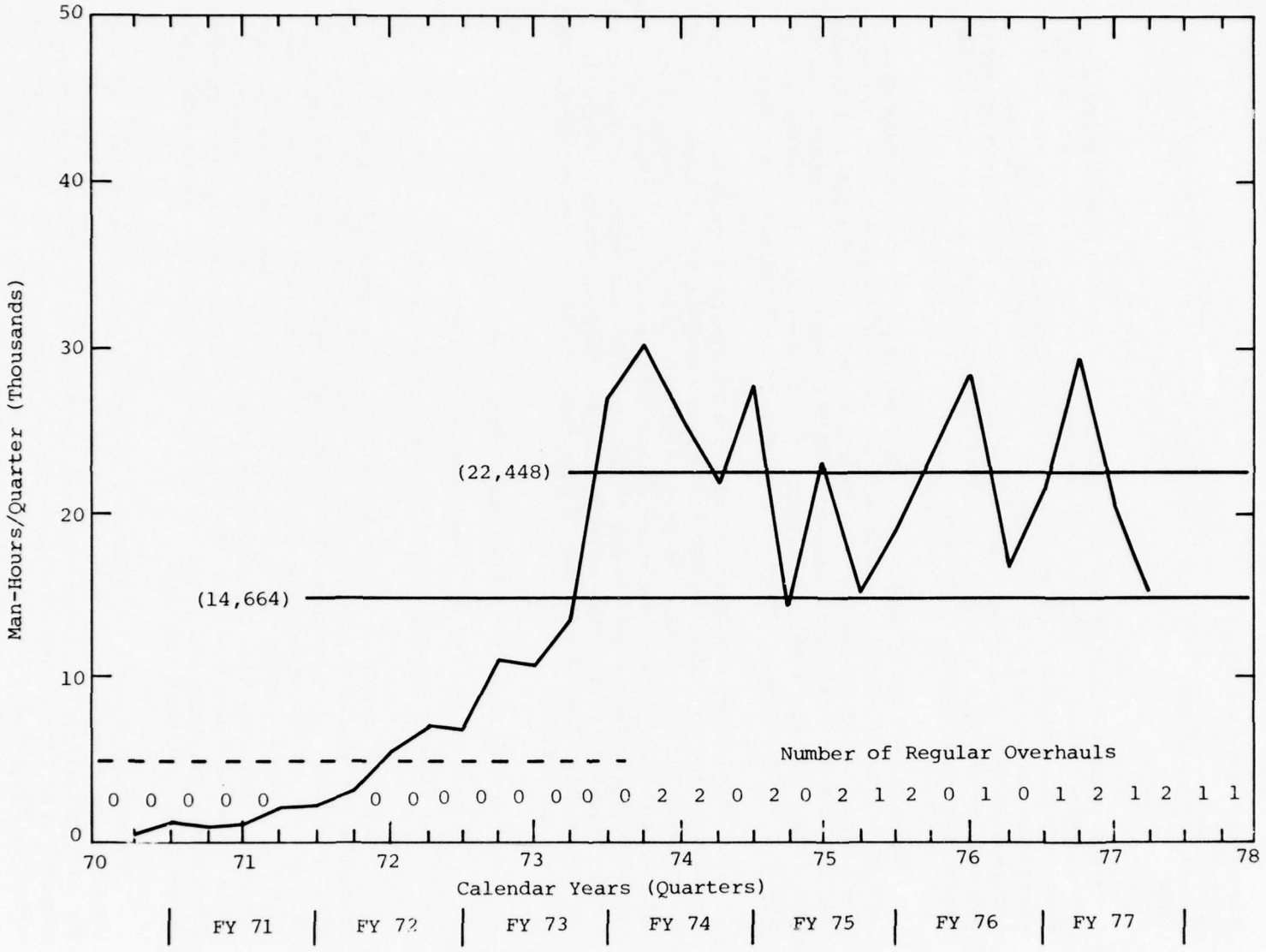


Figure B-4. LST-1179 CLASS IMA MAN-HOURS (MDS DATA)

$$\frac{\text{Historical man-days/ship quarter}}{\text{Man-days/current IMA week}} = \frac{133 \text{ man-days quarter}}{187.5 \text{ man-days/week}} = 0.7 \text{ IMA weeks/ship quarter}$$

The current LST-1179 SURFLANT scheduling template states there are 36 IMA weeks/cycle. Each ship should be provided 9 IMA weeks/year. In all cases the planned level of IMA support (9 weeks per year) far exceeds the previously documented levels of support (2.8 weeks per year maximum). The information depicted in Table B-4 gives the level of IMA support currently planned for the PEOC classes from COMNAVSURFLANT's IMA desk, based on the scheduling templates for each PEOC class.

The notional cycle lengths are approximately the same as NARM cycle lengths -- for LHA-1 Class, 46.25 months (rounded to 46 months), and for LPD-4 Class, 44.75 months (rounded to 45 months). For the LST-1179 Class the SURFLANT notional cycle length is 44.25, compared to 48 months for the NARM. Thus for the NARM cycle length, the data on IMA utilization would call for 2 percent more IMA weeks per year or 9.18 IMA weeks per year.

The LPD-4 Class IMA man-hour utilization indicates more stability over the data period than did the LST-1179 Class man-hour utilization. One of the reasons for this is that 75 percent of the ships in the LPD-4 Class were commissioned before the start of the data period. The LPD-4 Class IMA man-hour utilization showed a low figure of 3,221 man-hours per quarter to a high figure of 30,480 man-hours per quarter with an overall quarterly average of 13,111 man-hours (see Figure B-5. These figures relate to IMA man-days as follows:

A low average of 33.5 man-days/ship quarter

A high average of 317.5 man-days/ship quarter

An overall average of 136.5 man-days/ship quarter

Current IMA repair activity for this class is established as 1,500 man-hours per IMA week (see Table B-4). This equals 187.5 man-days per IMA week. The high average of 317.5 man-days/ship quarter is equivalent to 1.69 current IMA weeks/ship quarter of 6.77 IMA weeks/ship year. The notional cycle scheduled for this class calls for 38 IMA weeks per cycle providing each ship 10.1 IMA weeks per year. The average IMA support these ships have received over the data period indicates each ship received 2.9 current IMA weeks per year. This is far short of the amount designated by the class notional schedule.

The second observation addressed concerned the apparent lack of coordination scheduling of the IMA availabilities over the data period. The lack of uniformity in the high and low man-hour utilization quarters suggests that IMAs or IMA workloads are not being scheduled in a coordinated manner by the LST and LPD type desk over any extended period of time.

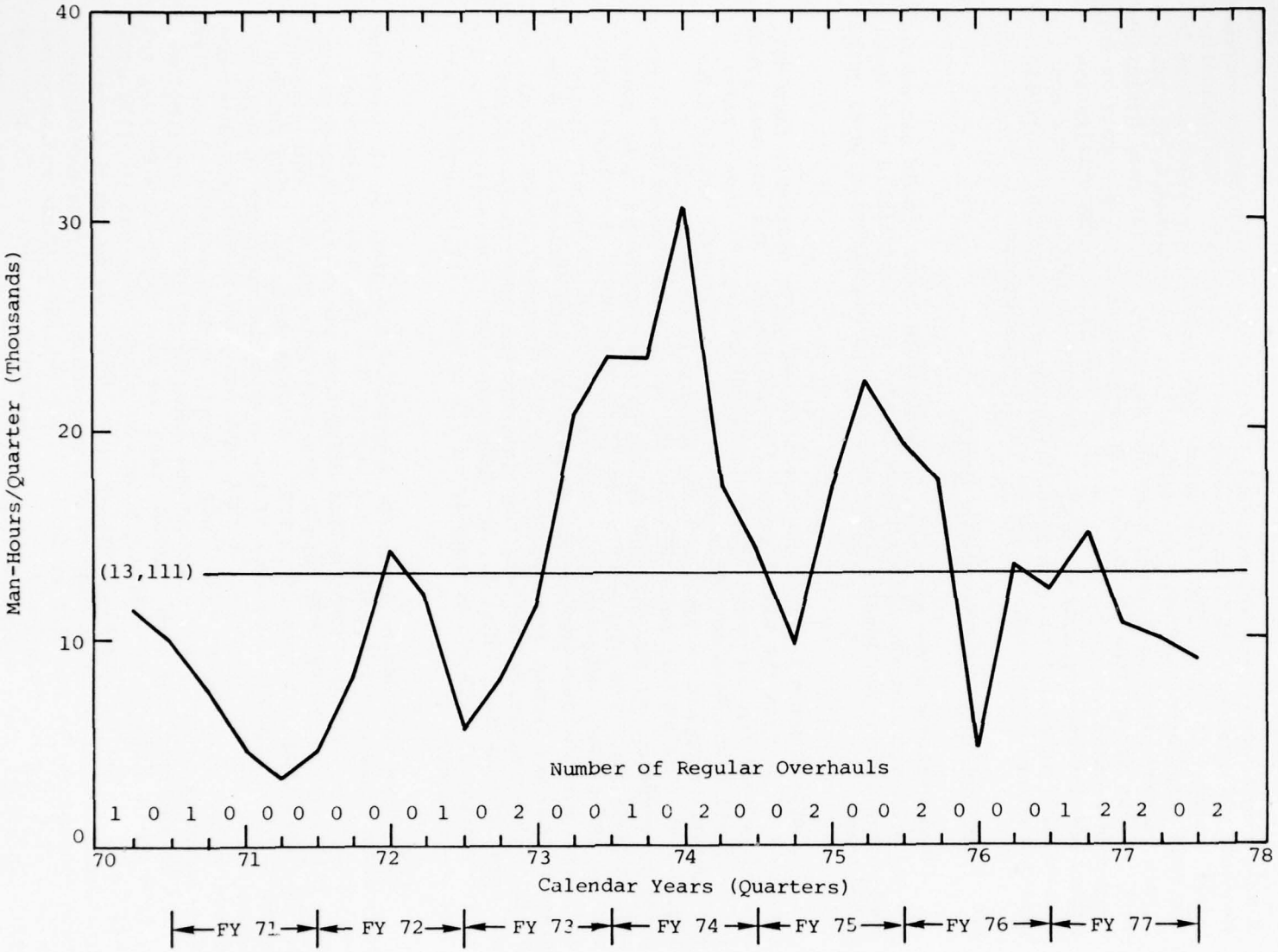


Figure B-5. LPD-4 CLASS IMA MAN-HOURS (MDS DATA)

A well coordinated class IMA availability schedule should provide increased man-hour utilization stability. Advantages to coordinated IMA scheduling would include: (1) avoidance of possible IMA facility overloads caused by too many ships simultaneously in availability, (2) opportunity for advanced repair package planning by both ship and facility, and (3) more efficient work results for a given IMA dollar. A significant step in resolving this suspected problem should be an analysis of the current IMA utilization called out for the respective classes. If IMA availabilities are not specifically scheduled to optimize utilization of this level of repair, planning should be updated to include this consideration.

4.4 Organization Level Maintenance Costs

Considerations given to a ship's maintenance costs should not overlook the costs incurred at the organization level. An identifiable cost associated with Ship's Force level maintenance was the organization level repair parts costs.

The organization level parts cost information is available from MDS data as well as from the Navy Program Factors Manual. The MDS data provided the information for compiling a historical average of repair parts costs to which the NARM estimates were compared. The data utilized for the comparison appear in Table B-5 and are displayed graphically in Figure B-6. The overall rationale for the use of the NARM FY 1979 estimates is twofold. First, the NARM estimates are considered to be reasonable because the trend of the LST-1179 Class was toward increasing costs and the LPD-4 Class had previously experienced costs not significantly different from the NARM estimates. Second, the NARM estimates, as programmed from the inputs developed for the Navy Program Factors Manual, are of an accepted accuracy that may take into account some of the suspect MDS data deficiencies. That is, the data suspected to be missing from the fourth quarter FY 1977 MDS records is in all probability included in the NARM projections.

An obvious observation made from looking at the graph is the relative separation between NARM estimates and the FY 1977 MDS data. A partial explanation of the significant dollar difference can be attributed to the data utilized for the FY 1979 total. The available MDS data were limited to the first three quarters of FY 1977. Of that data, the third quarter appeared to be incomplete because of the significant drop-off in reported transactions for both classes. A full data year for FY 1977 was developed by adding the totals of FY 1977 (July, August, September 1976) to the first three quarters of FY 1977. Assuming the data for FY 1977 is not complete, it can be inferred, for both classes, that the cost trend from FY 1976 to FY L977 would continue to indicate a postive slope. For the LST-1179 class this would follow the overall positive slope developed during the entire data period. That positive slope would fundamentally support the higher costs planned for by the NARM estimates. For the LPD-4 Class an increased FY 1977 cost figure could approach the total costs recorded in FY 1972 and 1973. In either case, the slope from FY 1976 to FY 1977 would be positive.

Another supporting factor in the LPD-4 NARM estimates it that the NARM estimates are not considerably higher than the costs experienced in FY 1971.

TABLE B-5 PEOC CLASSES ORGANIZATIONAL LEVEL PARTS COSTS

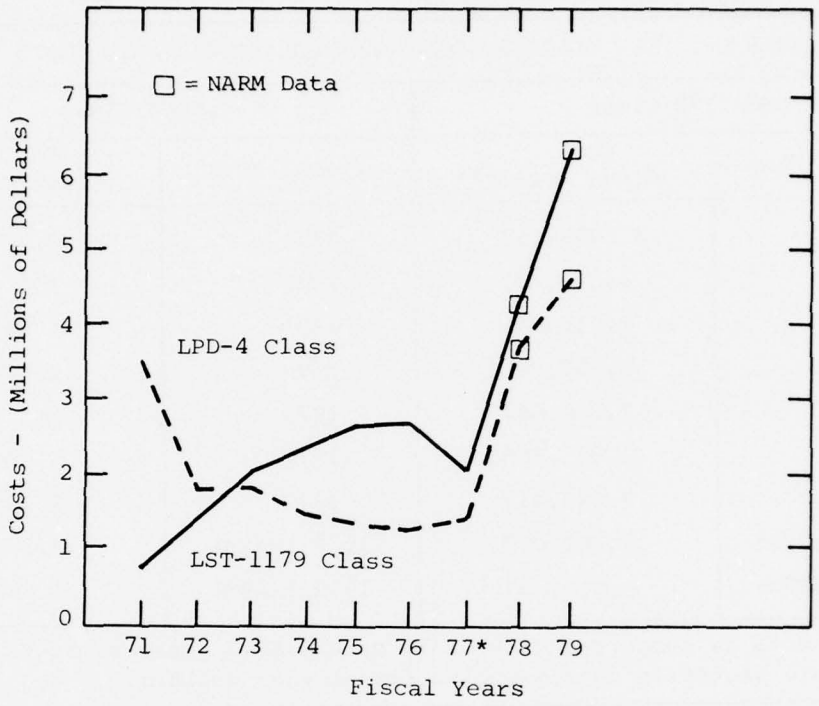
LST-1179 Class		LPD-4 Class	
Fiscal Year	Cost (Class Total)**	Fiscal Year	Cost (Class Total)**
1971	$ 715,217	1971	$3,512,419
1972	1,368,793	1972	1,824,605
1973	2,015,301	1973	1,845,449
1974	2,352,301	1974	1,464,901
1975	2,810,647	1975	1,347,803
1976	2,871,258	1976	1,286,387
1977*	2,043,412	1977*	1,398,062
1978 (NARM)	4,200,000	1978 (NARM)	3,642,000
1979 (NARM)	5,030,000	1979 (NARM)	4,758,000

* FY1977 data is comprised of FY 197T data plus 3 quarters of FY 1977 data.
**Costs are stated in corresponding fiscal year dollars.

5. LHA-1 CLASS

Before the procedure for analyzing the current maintenance strategy resource requirements for this class is developed, the reasoning behind separation of this class from the other designated PEOC classes should be addressed. The primary reason for a different treatment of the LHA-1 Class is the difference in the amount of data available. The LST-1179 and LPD-4 Classes have maintenance related data available on all ships of both classes covering no less than a 5-year period, including at least one complete overhaul cycle for each ship. The LHA-1 Class presently has only two ships that have been delivered to the Navy and commissioned. These are USS Tarawa (LHA-1), commissioned in May 1976, and USS Saipan (LHA-2) commissioned in October 1977. The lack of LHA-1 Class historical data prevented comparing prior data trends against the NARM 1979 maintenance costs dollars, as was done for the LST-1179 and LPD-4 Classes.

Analyzing the feasibility of initiating an Engineered Operating Cycle for any surface ship class requires investigation into the current or designed operational maintenance strategy and recommending EOC-oriented changes. For the LHA-1 Class these operational data are limited to the period from June 1976 through December 1977 and includes only two ships of the class.



*FY 1977 data is comprised of FY 197T data plus three quarters of FY 1977 data.

Figure B-6. LST-1179 and LPD-4 CLASS REPAIR PARTS COSTS (CLASS TOTALS)

The data covered in that period represent 43 percent of the current cycle length. Although that data period is not totally representative of the cumulative operational and maintenance data experience a typical LHA-1 Class ship will experience in a complete cycle, the data are still considerable valid.

Analysis of LHA-1 MDS data was focused on the data period of June1976 through May 1977 as reported by USS Tarawa (LHA-1). That year's data period very closely approximated the planned operational schedule the LHA will experience during the post delivery years of operation, and that period contained 76 percent of the Ship's Force man-hours and 91 percent of the IMA man-hours reported for the entire class MDS records. Although June 1976 to May 1977 appeared to be an exceptionally representative operational year, there was insufficient costing information to make

across-the-board extrapolation of costs of organizational level repair parts, IMA, RA/TA, and ROH. The data are lacking because these ships have not undergone an ROH nor significant IMA level activity. Another factor that appears to bias the data is the reporting of post consutruction shakedown related costs and man-hours to the MDS system. In all likelihood these types of problems are one time occurrences for the LHA and will not be reflected in future data after corrective action has been initiated.

The NARM estimates were selected after a thorough research for quantitative information on the current LHA-1 maintenance strategy. Quantitative information related to LHA-1, IMA and organizational level repair costs is available in limited amounts. Information reflecting ROH and RA/TA costs was not available due primarily to the absence of reported activity at these levels. A very important consideration in the selection of the NARM data as LHA-1 Class maintenance strategy costs was that the data provided commonality and direct comparability with the data used for the LST-1179 and LPD-4 Classes. The commonality is derived from the use of one data source modeled in the same manner for all PEOC Classes. The comparability results from the exact similarity in data categories, costs breakdowns, and types of funded dollars.

The newness of the LHA-1 Class precluded comparison of historical data with the NARM estimates to the extent possible with the LST-1179 and LPD-4 Classes. Where historical or planning information was available, comparisons were made. These comparative analyses resulted in no significant findings primarily because trends could not be developed from LHA-1 Class experience.

The design data similarly were not acceptable for determining maintenance strategy costs. As previously discussed, the process required to extract maintenance strategy costs from design data would be incompatible with the initiation study. Although the NARM FY 1979 maintenance costs were not extensively compared with historical data, they do provide specific costing information for all the maintenance categories (organizational, IMA, RA/TA, and ROH) used in this analysis of maintenance cost formulas.

6. SUMMARY

The comparative analysis conducted in this appendix analyzed the available historical data and compared it with the NARM FY 1979 projected maintenance resource requirements costs. This process was applied to each of the maintenance categories included in the current maintenance strategy of the PEOC Classes.

The initial and most significant conclusion that can be stated as a result of this analysis is that the NARM maintenance resource requirements cost predictions serve as a valid basis upon which to formulate the PEOC maintenance costs. Conclusions from the analysis of the individual PEOC Classes can be summarized in the following statements.

For LST-1179 and LPD-4 Classes ROH maintenance cost, the historical data conformed closest with the NARM FY 1979 maintenance costs figures of all the maintenance categories. This is significant because the ROH costs exceed 50 percent of the 20-year total maintenance requirements costs (refer to Table 7-5).

Although RA/TA NARM costs did not demonstrate as close a correlation with historical data as did ROH expenditures, they did represent a substantially smaller portion of total class costs. However, TYCOM projections indicate that actual RA/TA expenditures will approach, and possibly exceed the NARM projections.

IMA costs represent only 1 percent to 4 percent of the total 20-year projected costs, with a resulting relatively low utilization of IMA facilities by the LST-1179 and LPD-4 Classes. Additionally, quarterly utilization totals fluctuated widely, indicating that benefits could be gained if availabilities were more regularly distributed.

The LHA-1 Class had insufficient historical data to permit extensive comparative analysis of the NARM FY 1979 maintenance resource requirements cost totals. For this reason the LHA-1 Class cost predictions should be re-evaluated as sufficient data are accumulated and class wide averages and costing predictions can be developed.

APPENDIX C

SYSTEM MAINTENANCE ANALYSIS PROCEDURE

1. GENERAL

The System Maintenance Analysis (SMA) is a process to identify known and potential shipboard maintenance problems that will have a PEOC Program impact, to develop an economical and effective maintenance program to solve those problems, and to report the problems and solutions in a format compatible with other PEOC Program documents.

2. SYSTEM MAINTENANCE ANALYSIS OVERVIEW

Figure C-1 illustrates the essential elements of the SMA process. The first step is to define precisely the system to be analyzed. This entails the identification of system configurations [normally denoted by specific sets of Allowance Parts List (APL) numbers]. The next step is to identify problems that may affect the PEOC program. This can be done through an examination of the system's maintenance history for those ship classes that have had sufficient operating experience to develop the necessary historical data. For ships of recent construction without historical data, system problems must be predicted from the design and engineering information that is available. Combining information such as Maintenance Engineering Analyses, manufacturer's technical manuals, and experience with similar ships and equipments with engineering judgment will permit the identification of problems that are likely to occur during the Engineered Operating Cycle. These problems are divided into four categories: technological failures to be prevented or predicted, conditions to be improved by restorative maintenance modifications, conditions to be improved by Planned Maintenance System modifications, and maintenance burdens to be reduced.

The evaluation of alternative solutions is the next step. Decision processes are used to identify feasible alternative solutions and establish, to the maximum extent practical, the cost and effectiveness of each. Selection of a maintenance program to resolve the problems is based on the findings of this process. The results of the SMA consist of Integrated Logistic Support (ILS) changes, PMS changes, overhaul requirements, and inputs to other PEOC Program documents (e.g., Class Maintenance and Modernization Plan and Post-Overhaul Analysis Program).

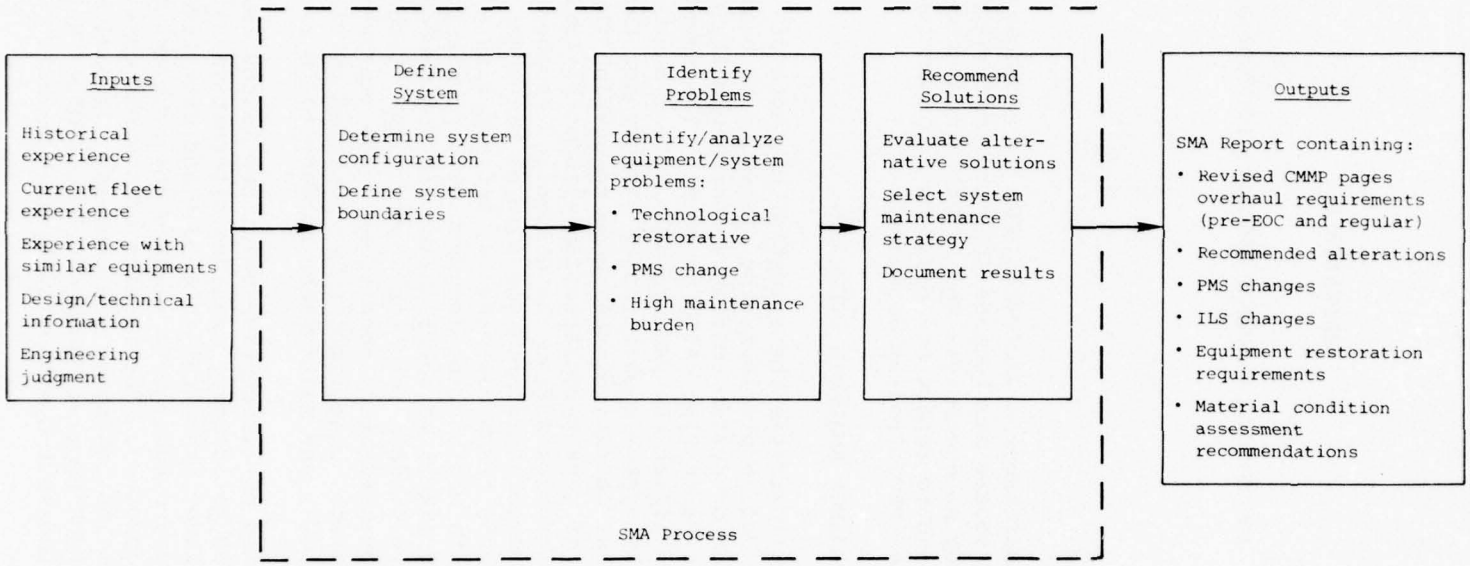


Figure C-1. SYSTEM MAINTENANCE ANALYSIS PROCESS

3. SMA ELEMENTS

The individual steps of the SMA process, as identified above, are discussed in detail in the following sections.

3.1 System Definition

In order to define the system in detail, reference may be made to Technical Manuals, the Type Commander's COSAL, SECAS reports, Ship Information Books, and other pertinent data sources. The configuration (i.e., the major components making up the system on individual ships within the class) must be specified by APL number or noun name. The configuration expected after the baseline overhaul should be determined by using lists of alterations and field changes and by discussions with NAVSEA and the Type Commander.

3.2 Problem Identification

The collected maintenance information is next examined to identify problems that will affect the PEOC Program. The processes to be used divide problems into four categories for identification and analysis: technological failures, conditions requiring restorative maintenance modifications, conditions requiring Planned Maintenance System (PMS) changes, and high aggregate maintenance burdens. These problems must be identified and analyzed in a coordinated manner. The approach and method employed for each problem category may differ in detail, but findings in all categories must be reviewed collectively to ensure accurate and complete problem definition.

Findings should be documented to the extent necessary to establish that either the problem will not have an effect on the Engineered Operating Cycle, or that it will have an effect on the cycle and further analysis and evaluation are required.

3.2.1 Technological Problem Category

Technological problems are directly related to system and equipment material degradation or failure. There are two basic kinds of technical failures to be identified: those that have been experienced in the past, and those that are expected to result from a longer operating cycle.

Not all past actions (i.e., degradation and failures) are of interest; random failures, requirements for minor upkeep, infrequent occurrences, and similar considerations are generally beyond the scope of analysis. Additionally, it is not practical to examine every action with the hope of preventing all failures. A screening procedure must select problems of potential EOC interest. Once technological problems have been identified from such sources as MDS and CASREP data, test and inspection reports, and other engineering design studies and have been screened, the optimum maintenance plan or strategy must be selected to correct them.

One approach that may be used in selecting a maintenance strategy is to consider the situation resulting from the problem and select the best alternative for preventing that situation. "Situation", as used here, means an occurrence which, if not prevented, will be an obstacle to the successful completion of the extended operating cycle. There are six possible maintenance strategies:

- Situation can be prevented by assessment and prediction made by Ship's Force from information obtainable during normal system operation.
- Situation can be prevented by modification of PMS practices.
- Situation can be prevented by periodic restoration or replacement.
- Situation can be prevented by assessment and prediction made by a specialized group from information especially collected and analyzed.
- Situation can be prevented by equipment alteration.
- Situation cannot be economically prevented (run to failure).

One or more of these alternatives should be selected as the means for prevention, depending on the complexity of the situation. As can be seen, the first question to be answered is "Can Ship's Force prediction prevent the situation?" The answer to this question is important because these predictions offer the most economical method of prevention. However, preventing some specific failures in this manner may not prevent the effect which caused the problem to be analyzed. For example, sudden, abnormally high noise from a bearing would normally be observed by Ship's Force and cause the equipment to be shut down. This action would prevent seizing of the shaft and further consequences of bearing failure. If, however, the bearing were a long-lead-time part, at least one consequence, a long system downtime, would be the same. No further alternatives should be considered if a Ship's Force prediction will prevent the situation.

As the decision process implies, the desired effect of each strategy alternative is the same, prevention of the situation. Hence, the decision between strategies is based primarily on estimates of cost including estimated resource and man-hour expenditures and long-lead-time aspects. Of course, the last alternative does not prevent the situation, so it would be selected only when it is clear that the other alternatives would be more costly.

3.2.2 Restorative Requirements Category

Restorative requirements refer to actions that need to be taken to bring an equipment or a part of it back to an "as accepted" or "like new" material condition. Actions presently scheduled for planned intervals of less than those planned for the PEOC Program under development, or which

have been historically accomplished more frequently, are potential PEOC problems. Sources that should be reviewed for selection of restorative actions as candidates for further analysis include:

- Planned Maintenance System documents, paying particular attention to cyclic requirements
- Shipyard overhaul documents, for actions that have been performed as a result of inspection, test, or request, and actions designated as routine overhaul items
- Maintenance Data System records for maintenance actions that required outside assistance or were deferred because of a need for assistance (e.g., Current Ship's Maintenance Project)
- ILS documents for the class (e.g., Plan for Maintenance)

An analytical method that may be used to determine actual restorative needs is a maintenance comparison of components that have been overhauled with those that have not and, if possible, an identification of particular piece part failures that have generated the need for overhaul. Preventive maintenance measures should first be considered, together with technological changes, as prospective methods of eliminating or reducing restorative requirements. If changes to preventive maintenance measures or technological changes will not provide the required problem solution, then renewal or replacement and on-condition renewal or replacement should be considered. The most economical strategy that can be accomplished within identified constraints should be selected.

3.2.3 PMS Change Requirements Category

Although PMS change requirements are a separate category of problems, their review is closely related to all other problem categories and should be coordinated with them. All system PMS requirements should be reviewed as potential problems, paying particular attention to the possibility of reducing open-and-inspect requirements and decreasing overall burden. The primary data sources for identification of PMS requirements are the PMS Maintenance Index Pages (MIPs) and Maintenance Requirement Cards (MRCs). Close liaison with the technical community is necessary to ensure that the most current MIPs and MRCs are used in the analysis.

Problems in the planned maintenance for a system are of three types: potentially damaging actions, potentially unnecessary or too frequent actions, and necessary actions not specified in written instructions.

3.2.4 Aggregate Burden Category

In extending an operating cycle, the overall resources needed to maintain a system must be considered. If greater and greater resources must be expended to support the system during the cycle, then the components requiring these increases must be identified and subjected to further individual analysis. Those components are PEOC problems. Man-hours and parts usage are primary measures of aggregate problems. Other measures are the

number of actions initiated within a time period and the number of outstanding deferrals at a particular time. MDS data are the principal source for the identification of aggregate problems; however, study of design data and liaison with the technical community and Fleet units are necessary to determine CSMP deferral levels experienced and other measures of aggregate problems.

Analysis of aggregate burden problems must be closely aligned with the identification and analysis of technological problems. If an aggregate problem can be attributed to a specific group of system components, those components should be subjected to technological analysis. If the aggregate problem cannot be solved in that manner, there are three alternative methods: assess the condition of the system or component and repair it as necessary, renew all or part of the system during the operating cycle, or renew it during overhaul periods.

During the entire SMA process and the development of recommended corrective actions, current and projected ship resources should be considered. Skill levels of technicians, ship manning, watch standing procedures, additional test equipment, and record keeping should not be changed unless a positive benefit sufficient to compensate for the change can be realized.

3.2.5 Solution Recommendations

Solutions to system problems will be defined by analyzing potential corrective actions, defining the approximate cost and effect of that action, and choosing the best action to take. The "best" potential solution will be that solution that is the most cost effective.

Analysis and evaluation of the potential solutions will result from asking the following questions about each problem:

- Is there a fix established or proposed by the Navy?
- Can a design change reduce or eliminate the problem?
- Is the problem PMS-related? Can a change to PMS reduce or eliminate the problem?
- For this problem, is Material Condition Assessment a viable maintenance strategy?
- Can a change to the system's Integrated Logistics Support reduce or eliminate the problem?
- Can a change to the Ship's Force, Intermediate Maintenance Activity, or Depot Facility capabilities reduce or eliminate the problem?
- For this problem, is run-to-failure a viable maintenance strategy?

A negative answer to a question will prompt the analyst to go to the next question. An affirmative answer will lead the analyst to define the solution and to estimate, when possible, the approximate cost of developing

and implementing it. After all questions have been asked of each problem, the analyst will determine which potential solution is the "best". Accomplishment of this phase of the analysis includes the development of the following:

- Overall System Maintenance Concept
- Maintenance Profile
- Material Condition Assessment Requirements
- Detailed Maintenance Requirements
- Maintenance Improvements

Recommendations for maintenance improvements resulting from the system maintenance analysis are categorized as follows:

- Reliability and Maintainability Improvements
- Planned Maintenance System Changes
- IMA Requirements
- Depot Level Improvements
- Integrated Logistic Support Improvements

APPENDIX D

GENERAL INFORMATION LST-1179, LPD-4, and LHA-1
CLASSES OF AMPHIBIOUS WARFARE SHIPS

1. GENERAL INFORMATION LST-1179 CLASS SHIPS



The Newport (LST-1179) Class ships are powered by six diesel engines and are capable of speeds in excess of 20 knots. With a full load displacement of 8,400 tons these ships are the largest and fastest LSTs ever built. New design features include the clipper bow, over-the-bow ramp instead of bow doors, an automatic between-decks ramp that connects the tank deck with the main deck, and twin variable pitch propellers. The Newport is also the first USN combat vessel equipped with a bow thruster. Two derrick arms at the bow support a 40-ton 112-foot aluminum bow ramp. The LST-1179 Class ships have a stern gate that opens to a tank deck, enabling offload of cargo into landing craft or discharge or tank landing vehicles (LVTs). The LST-1179 is 567 feet long with a 68-foot beam and accommodates a crew of 174 enlisted and 12 officers. Its armament includes two twin 3-in./50 cal. mounts. The last ship of this 20-ship class was commissioned on August 5, 1972, and a summary of the entire class is shown in Table D-1.

Table D-1. NEWPORT CLASS LANDING SHIP TANK (20 SHIPS)

Name	Number	Builder	Commissioned	Fleet
Newport	LST-1179	N.S.Y. Phila.	6/7/69	Atlantic
Manitowoc	LST-1180	N.S.Y. Phila.	1/24/70	Atlantic
Sumter	LST-1181	N.S.Y. Phila.	6/20/70	Atlantic
Fresno	LST-1182	National Steel	11/22/69	Pacific
Peoria	LST-1183	National Steel	2/21/70	Pacific
Frederick	LST-1184	National Steel	4/11/70	Pacific
Schenectady	LST-1185	National Steel	6/13/70	Pacific
Cayuga	LST-1186	National Steel	8/8/70	Pacific
Tuscaloosa	LST-1187	National Steel	10/24/70	Pacific
Saginaw	LST-1188	National Steel	1/23/71	Atlantic
San Bernadino	LST-1189	National Steel	3/27/71	Pacific
Boulder	LST-1190	National Steel	6/4/71	Atlantic
Racine	LST-1191	National Steel	7/9/71	Pacific
Spartanburg County	LST-1192	National Steel	9/1/71	Atlantic
Fairfax County	LST-1193	National Steel	10/16/71	Atlantic
La Moure County	LST-1194	National Steel	12/18/71	Atlantic
Barbour County	LST-1195	National Steel	2/12/72	Pacific
Harlan County	LST-1196	National Steel	4/8/72	Atlantic
Barnstable County	LST-1197	National Steel	5/27/72	Atlantic
Bristol County	LST-1198	National Steel	8/5/72	Pacific

2. GENERAL INFORMATION LPD-4 CLASS SHIP



The Austin (LPD-4) Class ships are twin-boiler, twin-propeller, steam-turbine-powered ships capable of a maximum speed of 21 knots. The Austin is 569 feet long, with a beam of 105 feet 2 inches and a full load displacement of 16,900 tons. Its flight deck has the capacity to carry six CH-46 helicopters and its well deck measures 168 feet by 50 feet. The LPD-4 Class also has a stern gate to enable onload/offload of landing craft; it can also load cargo via overhead monorails in the well deck. The ship accommodates a crew of 446 enlisted and 27 officers. LPD-4 Class armament includes four twin 3-in./50 caliber mounts located fore and aft. The last ship of this 12 ship class was commissioned on July 10, 1971. A summary of the entire class is shown in Table D-2.

Table D-2. AUSTIN CLASS AMPHIBIOUS TRANSPORT DOCKS (12 SHIPS)

Name	Number	Builder	Commissioned	Fleet
Austin	LPD-4	N.S.Y. New York	2/6/65	Atlantic
Ogden	LPD-5	N.S.Y. New York	6/19/65	Pacific
Duluth	LPD-6	Ingalls	12/18/65	Pacific
Cleveland	LPD-7	Ingalls	4/21/67	Pacific
Dubuque	LPD-8	Lockheed	9/1/67	Pacific
Denver	LPD-9	Lockheed	10/26/68	Pacific
Juneau	LPD-10	Lockheed	7/12/69	Pacific
Coronado	LPD-11	Lockheed	5/23/70	Atlantic
Shreveport	LPD-12	Lockheed	12/12/70	Atlantic
Nashville	LPD-13	Lockheed	2/14/70	Atlantic
Trenton	LPD-14	Lockheed	3/6/71	Atlantic
Ponce	LPD-15	Lockheed	7/10/71	Atlantic

3. GENERAL INFORMATION LHA-1 CLASS SHIPS



The Tarawa (LHA-1) Class ships are twin-boiler, twin-screw, steam turbine powered general purpose assault ships that combine the features of the LPD, LSD, and LPH class ships. The primary mission of the LHAs is to embark, deploy, and land elements of a landing force in an amphibious assault by helicopters, amphibious vehicles, and landing craft, or by a combination of these methods.

The Tarawa has an 820-foot-long flight deck, a 106-foot beam, and displaces nearly 40,000 tons when fully loaded. The flight deck has 41 percent more capacity than that of an LPH, and the 265-foot long hanger deck is large enough to accommodate 30 CH-46 helicopters. Its stern is fitted with a stern gate/well deck similar in design to that of the LPD/LSD class, which can handle small amphibious landing craft up to and including the LCU. In an effort to reduce crew size (which is 90 officers and 812 enlisted) the LHA-1 class was designed with many automated features, including computer fed debark and weapons control stations. Each ship has nine elevators for cargo, helicopter and personnel handling as well as a 5,000-square-foot-troop acclimatization room for Marines. The ship's armament includes three 5-in./.54 caliber automatic mounts, two Basic Point Defense missile launchers, six Mk 67 machine guns and two 40 mm. saluting mounts. The Tarawa has a maximum draft of 26 feet and a maximum speed of 24 knots. The first of five ships of the class was delivered to the Navy May 5, 1976. A summary of the entire class is shown in Table D-3.

Table D-3. TARAWA CLASS AMPHIBIOUS ASSAULT SHIPS (5 SHIPS)

Name	Number	Builder	Commissioned	Fleet
Tarawa	LHA-1	Ingalls	5/5/76	Pacific
Saipan	LHA-2	Ingalls	8/11/77	Atlantic
Belleau Wood	LHA-3	Ingalls	(Under Construction)	
Nassau	LHA-4	Ingalls	(Under Construction)	
Pelelieu	LHA-5	Ingalls	(Under Construction)	

APPENDIX E

DEFINITIONS

This appendix provides definitions of terminology associated with the PEOC Program.

Alteration - Any change in the hull, machinery, equipment, of fittings that involves a change in design, materials, number, location, or relationship of an assembly's component parts whether the change is separate from, incidental to, or in conjunction with repairs. Categories of alterations are:

Approved Alteration - Alteration approved for accomplishment, but funding and year of accomplishment not identified.

Authorized Alteration - Alteration approved for accomplishment with funding and year of accomplishment identified.

Concurrent Alteration - An alteration that should be accomplished at the same time as another alteration.

Conjunctive Ship Alteration - An alteration that describes the industrial support and work to be accomplished concurrent with, prior to, or subsequent to the work required by alterations under the cognizance of other commands such as ordnance alterations, air alterations, or special project alterations. An example is an OrdAlt that, for installation, requires a ShipAlt to provide an increase in ship's power, cooling, or compartment rearrangement.

Electronic Field Changes - Any modifications or alterations made to electronic equipment after delivery to the government.

Military Alteration - An alteration that changes or improves the military characteristics of a ship (CNO-managed).

Ordnance Alteration (OrdAlt) - Alteration to ordnance equipment under the technical cognizance of NAVSEA and composed of:

- Ordnance Alteration Instruction - Technical document containing instructions, drawings, test procedure, and directions to accomplish a material change, modification, repositioning, or alteration in the physical appearance of an installation of different parts in subassemblies, assemblies, or components in a weapon or system. Technical publication changes are supplied as part of that data package.

- OrdAlt Kit - Provides all the material and documentation required to perform an OrdAlt, may include testing, operating, and maintaining the equipment after alteration. OrdAlt Kits include complete hardware, special tools if required, and a copy of the OrdAlt instruction. In some cases a conjunctive ShipAlt may be required with an OrdAlt.

Package Alteration (Title P) - Assigned to those Title K ShipAlts prepared under the package ShipAlt Program.

Programmed Alteration - An alteration that is listed for accomplishment in one of the fiscal years in the Fleet Modernization Program (FMP).

Technical Alteration - An alteration that affects safety, maintainability, reliability, or system performance (CHNAVMAT-managed).

Title D Alteration - An alteration equivalent to a repair, approved by NAVSEA. Title D ship alterations are authorized by the Type Commander and funded under O&M,N as operating expenses.

Title K Alteration - An alteration authorized for accomplishment through the FMP and usually requiring special program material. It is accomplished by industrial activities and approved by CNO through the FMP process.

Ship Alteration (ShipAlt) - Any change in the hull machinery, equipment, or fittings which involves change in design, materials, number, location, or relationship of the component parts of an assembly. ShipAlts are classified by title, such as Title A alteration.

Unprogrammed Alteration - An alteration not listed for accomplishment under one of the fiscal years in the FMP and listed in the "unprogrammed" section in the FMP.

Alterations Equivalent to a Repair (AER) - An alteration that has one or more of the following attributes:

- Uses different materials that have been approved for like or similar use, and such materials are available from standard stock.
- Replaces obsolete, worn-out, or damaged parts, assemblies, or equipments requiring renewal by those of later and more efficient design previously approved by the Systems Command concerned.
- Strengthens parts that require repair or replacement in order to improve reliability of the parts and of the unit, provided no other change in design is involved.
- Makes minor modifications involving no significant changes in design or functioning of equipment but considered essential to prevent recurrence of unsatisfactory conditions.
- Replaces parts, assemblies, or equipments with like items of later or more efficient design where it can be demonstrated that the cost of installation and maintenance of the new parts, assemblies, or components will be lower.

Only the Systems Command exercising technical control over the article, or the authority to whom such technical control has been delegated by that command, shall designate an alteration as equivalent to a repair and approve it for accomplishment.

Allowance Equipage List (AEL) - A document prepared for various categories of equipage (tools, etc.) or for operating systems. It includes items required for the operation of the system or repair parts for support of the system. Generally, AEL items are Operating Space Items in the custody of department heads.

Allowance Parts List (APL) - A document prepared for individual equipments/components listing their associated repair parts and corresponding allowance and maintenance information.

Amphibious Engineered Operating Cycle - An operating cycle for destroyers (about five years long) consisting of three periods of overseas deployment and scheduled periods of maintenance. Engineering analyses are the basis for defining maintenance to be performed during periods of shore-based maintenance availabilities.

Appropriated Funds - Funds that are appropriated for obligation in specific areas, such as funds for overhaul (ROH), availabilities (RA/TA), repairs (ROV), or modernization (FMP).

Availability - Assignment of a ship to a repair activity for the purpose of accomplishing repairs or performing maintenance. Specific types of availabilities assigned ships are:

> Restricted Availability (RAV) - A restricted availability is assigned for the accomplishment of specific items of work by an industrial activity with the ship present, during which time the ship is rendered incapable of fully performing its assigned missions and tasks. Restricted availabilities are assigned by Type Commanders.
>
> Selected Restricted Availability (SRA) - A restricted availability that is scheduled by the Chief of Naval Operations to permit effective advance planning so that time and funds may be more effectively utilized. In the DDEOC Program, two SRAs are assigned during the operating cycle between regular overhauls.
>
> Technical Availability (TAV) - An availability for the accomplishment of specific items of work by a repair activity, normally with the ship not present, during which the ship's ability to fully perform its assigned mission and tasks is not affected.

Intermediate-level-activity availabilities can be classified as:

> Alongside (Restricted) Availabilities - Scheduled availabilities during which IMA personnel work on board the customer ship. Ships assigned alongside availabilities are berthed either physically alongside or in the immediate vicinity of the IMA. Availabilities of this nature with DATC/FMAG are referred to as "restricted" availabilities and are at least 15 consecutive work days in duration.

Emergent (Emergency) Availabilities - Those unscheduled availabilities assigned for voyage repairs or for the correction of CASREPs that significantly impair operational readiness. Ships assigned an emergency availability are berthed either physically alongside or in the immediate vicinity of the IMA.

Ship-to-Shop Availabilities - Those unscheduled availabilities assigned for significant repairs not of an emergency nature and that do not normally require IMA personnel to work on board the customer ship. A ship-to-shop availability is automatically assigned to all U.S. Navy ships in port with the IMA. To control IMA loading when more than one IMA is present, the TYCOM will control the designation of ship-to-shop availabilities.

Tender Availabilities - Scheduled alongside availabilities where the ship is assigned to a tender (AD, AR, etc.) - type IMA.

Casualty Report - System which provides a timely method for reporting equipment failures and the effect of these failures on the capability of the reporting unit to perform its assigned mission(s).

Class Maintenance & Modernization Plan - A document that identifies and schedules the periodic required maintenance approved alterations, and repairs of specific ship classes at times of overhaul and during their operating cycle.

Classes of Ship Systems and Component Overhauls

Class A - Work that requires such overhaul or repairs, modifications, field changes, OrdAlts or ShipAlts as will sustain or improve the operating and performance characteristics of the system, subsystem, or component being repaired or altered to meet the "most recent" design and technical specifications for that item. It is intended that the end product be in "like new" condition in appearance as well as in operation and performance. All manufacturer's and technical manual performance standards and specifications, unless superseded by proper authority, will be met, as will all technical documentation. The repair activity will demonstrate that the end product successfully meets all performance criteria specified by the governing specifications. Defining an overhaul as Class "A" means that all actions required to meet the definition are authorized. The definition is applicable to all components, subsystems, and systems whether machinery, electrical, hull, electronics, or weapons, without regard to equipment cost, size, or complexity. Thus, a Class "A" overhaul of a 10-horsepower motor is just as much Class "A" as that of a radar set or a boiler, although the demands on resources differ greatly.

Class B - Work that requires such overhaul or repairs as will restore the operating and performance characteristics of a system, subsystem, or component to its "original" design and technical specifications. If it is required to restore the operating and performance characteristics of an item to other than its original design and technical specifications, it must be so specified and the performance criteria defined. ShipAlts, OrdAlts, field changes, and modifications, even

if applicable, are not to be accomplished unless specified by the customer. Maintenance adjustment and calibration routines specified by the applicable instruction manual, unless superseded by authority, are required. The repair activity will demonstrate that the end product successfully meets all performance criteria specified by the governing specifications.

Class C - Repair work on a system, subsystem, or component specified by the work request or that work required to correct the particular deficiencies or malfunctions specified by the customer. The repair activity must demonstrate that the work requested has been accomplished or that the conditions or malfunctions described have been corrected, but the repairing activity has no responsibility for the repair or proper operation of the associated components of the equipment or for the operation of the system/subsystem equipment as a whole.

Class D - Work associated with the "Open, Inspect, and Report" type of work request in which the customer cannot be specific about what is or may be wrong with the item. This class of work is intended to be diagnostic and thus may require various tests, followed by inspection, to assist in a complete diagnosis. The repair activity will report findings, recommendations, and cost estimates to the customer for authorization prior to any repair work. When requested by the customer, minor repairs and adjustments may be accomplished without prior authorization to the extent specified.

Class E - Work required to incorporate all alterations and modifications specified for a designated system, subsystem, or component. The repair activity will demonstrate the successful checkout of the work accomplished to assure compliance with the performance standards established for the modification only to the extent of the work performed. When required by the customer, the repair activity will conduct system tests to prove system operability through affected interfaces. Repairs, if any, are minor.

Component Maintenance Analysis (CMA) - An engineering analysis of the maintenance requirements for components of a system. It is a part of a System Maintenance Analysis.

Condition Standards - See Material Condition Standard.

Coordinated Shipboard Allowance List (COSAL) - The COSAL is an authoritative document listing:

- The equipments/components installed on a ship
- The repair parts and special tools required for the operation, overhaul, and repair of the equipments/components
- The Operating Space Items (OSIs) and consumables necessary for the safety, care, and upkeep of the ship

The COSAL contains a consolidation of the various equipment APLs and AELs and provides a list of Onboard Repair Parts (OBRPs) required for the ship to achieve maximum self-supporting capability during extended operations.

Corrective Maintenance (CM) - The sum of those actions required to restore equipment to an operational condition within predetermined tolerance limits.

Current Ship's Maintenance Project (CSMP) - Provides shipboard maintenance managers with a consolidated listing of deferred corrective maintenance with which to manage and control its accomplishment. The CSMP is the basic 3-M management tool used on board ship.

Defense Logistics Supply Center (DLSC) - The agency that provides consolidated cataloging services for all DoD items of supply.

Deployment - The routine extended cruise of a ship to waters remote from home port. When deployed, a ship is usually under the command of an area Operational Commander.

DDEOC Program Office - A program office established to develop and implement the plans and procedures needed to satisfactorily maintain certain destroyer classes while in the DDEOC.

DDEOC Site Team - A team composed of military personnel, established at major DDEOC ship home ports, that will either conduct or assist Ship's Force in the performance of DDEOC assessment procedures.

Destroyer Engineered Operating Cycle (DDEOC) - An operating cycle for destroyers (about five years long) consisting of three periods of overseas deployment and scheduled periods of maintenance. Engineering analyses are the basis for defining maintenance to be performed during periods of shore-based maintenance availabilities.

Engineered Operating Cycle (EOC) - The operating cycle for ships between overhauls, consisting of periods of at-sea operations and in-port scheduled periods of maintenance. Engineering analyses are the basis for defining maintenance to be performed during the cycle. Engineered Operating Cycles are often of longer duration than previous operating cycles.

Equipment Identification Code (EIC) - A four-digit alpha-numeric code that identifies the system or subsystem and equipment associated with a maintenance action or repair part usage.

Failure Mode and Effects Analysis - A systematic examination of all components of the system or equipment to identify their function, the manner in which they might fail, and the effects of failure on the overall system in relation to mission performance and personnel safety.

Feedback - The return to the input of a part of the output of a process, for purposes of producing changes that improve the performance of the process.

Fiscal Year (FY) - An accounting period of twelve months beginning on 1 October each calendar year (starting calendar year 1976). Fiscal years are referred to as:

> Past Year (PY) - Fiscal year most recently completed; fiscal year preceding current year.
>
> Current Year (CY) - Present fiscal year that immediately precedes the two fiscal years being budgeted for.

Apportionment Year (AY) - The fiscal year to succeed the current fiscal year and the first fiscal year for which fund requirements are submitted as prescribed.

Budget Year (BY) - Second of the two fiscal years for which fund requirements are submitted.

POM Years - A five-year fiscal year period for which funds are programmed. The first POM year is the fiscal year following the budget year.

Fleet Modernization Program (FMP) - The FMP is the process that installs alterations on U.S. Navy ships, both active and reserve, and provides a funding base for alteration planning and support.

Functional Organization Chart - A graphic presentation of the functions of an organization by organizational units, with relationship indicated and a description of the functions included.

Inspection and Survey (INSURV) - An inspection team made up of Naval Officers whose responsibility it is to periodically inspect Navy ships, both new and operational, and assess their material condition and state of maintenance for initial or continued operational service.

Intracycle Maintenance Management System - An ADP maintenance management system for scheduling of and accounting for repair work accomplished during the Destroyer Engineered Operating Cycle (DDEOC) currently named RMMS. A similar system is planned for the Amphibious Engineered Operating Cycle (PEOC).

Level of Repair - The level of maintenance activity most likely to possess the necessary skill levels to achieve satisfactory repairs, i.e., depot, intermediate, or organizational level. Synonymous with level of maintenance.

Long Lead Time - Delivery time for material in excess of 60 days.

Maintainability - A quality of the combined features and characteristics of equipment/system design and maintenance resource planning that contributes to the speed, economy, ease, and accuracy with which the system can be kept in or restored to specified operating condition in the planned maintenance environment.

Maintenance - The function of sustaining material in an operational status, restoring it to a serviceable condition, or updating and upgrading its functional utility through modification. Maintenance consists of the following:

- All actions taken to retain material in a serviceable condition or to restore it to serviceability. It includes inspection, testing, servicing, classification as to serviceability, repair, rebuilding, and reclamation.
- All supply and repair action taken to keep equipment in condition to carry out its mission.
- The routine recurring work required to keep equipment in condition to carry out its mission.

Maintenance Burden - The average cost of maintaining a system or item of equipment over a period of time. Cost is measured in terms of manpower or dollars or both.

Maintenance Burden Factor (MBF) - Numerical sum of the MDS and MCRI Rank for a particular system/equipment. Represents the total combined maintenance burden for that system.

Maintenance Concept - A general strategy for conducting maintenance. For example, the "hard-time" concept requires the initiation of maintenance after a fixed time period.

Maintenance-Critical Equipments - Equipments that historically either have established themselves as essential in the successful completion of the mission of the ship or have imposed a significant maintenance burden on the Navy's maintenance resources. These equipments were identified using the following critiera:

- CASREP frequency
- Maintenance attention during past overhauls
- Expended Ship's Force and IMA maintenance actions, man-hours, and material costs

Maintenance Engineering - That activity of equipment maintenance that develops concepts, criteria, and technical requirements during the conceptual and acquisition phases to be applied and maintained in a current status during the operational phase to assure timely, adequate, and economic maintenance support of weapons and equipments.

Maintenance Engineering Management - The process of planning, organizing, staffing, directing, and controlling those maintenance resources engaged in the engineering and technical support of equipment maintenance.

Maintenance Levels - The three levels of ship maintenance are:

Organizational (Shipboard) Maintenance - Maintenance that is the responsibility of and performed by the Ship's Force on assigned equipment.

Intermediate Maintenance - Maintenance normally performed by Navy personnel on tenders, repair ships, and aircraft carriers, Fleet support bases, and FMAGs. It normally consists of calibration, repair, or replacement of damaged or unserviceable parts, components, or assemblies; the emergency manufacture of unavailable parts; and provision of technical assistance to using organizations. Additional Shore IMAs (SIMAs) are programmed for operational use in the early 1980s to augment existing facilities.

Depot (Shipyard) Maintenance - Maintenance performed by industrial activities on material requiring major overhaul or a complete rebuild of parts, assemblies, subassemblies, and end items, including parts manufacture, modification, testing, and reclamation as required. This is normally accomplished on ships at commercial facilities or Naval shipyards, including ship repair facilities, during restricted availabilities, technical availabilities, and regular overhauls.

Maintenance Management - The process of planning, budgeting, coordinating, scheduling, and controlling the maintenance, repair, and alteration activities for a ship or unit and its various on-board systems and equipments.

Maintenance Philosophy - The practical wisdom involved in keeping material in a specified state.

Maintenance Plan - A description of the maintenance concepts applied to a specific system, the detailed maintenance actions to be taken, the estimated manpower needed for each action, and the expected occurrence of maintenance during the ship's operational cycle.

Maintenance Resources - Consists of personnel, materials, tools and equipment, facilities, technical data, and funds provided to carry out the equipment maintenance mission.

Maintenance Strategy - Statement of philosophy of and approach to the conduct of maintenance. The maintenance strategy includes the general rules that initiate the performance of maintenance, criteria to shape the allocation of maintenance resources, and the assumptions to be used during maintenance planning.

Major Maintenance - Maintenance actions that require significant maintenance resource expenditure.

Management Information System - The exchange of information by means of which management objectives are established, schedules for achievement are developed, tasks are assigned, progress and status are reported, and performance is appraised in relation to the achievement of the objectives.

Master Cross Reference List (MCRL) - The MCRL is a two-part document that crosses National Stock Number (NSN) to Manufacturer/Part Number and Part Number to NSN.

Material Condition Assessment Procedure (MCAP) - A means of determining and projecting the material condition of an item based upon periodic observations of performance, operating, or maintenance parameters.

Material Condition Readiness Index (MCRI) - Numerical value used in Casualty Report (CASREP) System which represents the degree of unreadiness imposed on a ship suffering a casualty.

Material Condition Standard (MCS) - The condition characteristics and performance criteria of items (system, subsystem, or equipment) that produce acceptable operation.

Maintenance Data System (MDS) Factor - Numerical value that indicates the magnitude of the total experienced maintenance burden for a particular system or equipment as identified in the MDS data.

Material Readiness - A measure of the equipment (or system) readiness of a ship to go to sea and perform its assigned missions. It is also a measure of a ship's ability to maintain high operational availability.

Mean Time Between Failures (MTBF) - The average time interval between failures for repairable equipment, usually measured in terms of operating hours. The MTBF is the reciprocal of the failure rate. For example, if

an equipment has a failure rate of 10 per 100 hours, or 1 per 10 hours, then the mean time between failures is the reciprocal of 1/10 hour or 10 hours.

Mean Time Between Repairs (MTBF) - The average time between repairs or corrective maintenance for an equipment, measured in terms of operating hours.

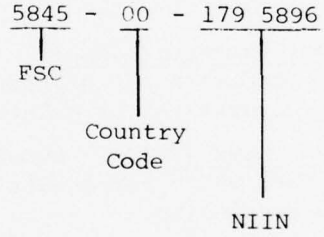
Mean Time To Failure (MTTF or MTF) - The average time until a nonrepairable device fails, expressed in operating hours.

Mean Time To Repair (MTTR or MTR) - The average time interval to repair an equipment and restore it to normal operation with required repair parts available.

Military Improvement Plan (MIP) - A priority listing of desired and approved changes in the military characteristics of ships, promulgated by CNO for guidance of programming, preparing budget requests, progressing design work, and authorizing procurement and installations during particular fiscal years. It lists in order of priority the applicable project number, brief description, types of ships in which installation is planned, and other pertinent information.

Mission-Critical - Items the failure of which would cause significant or total degradation of mission capability.

National Stock Number (NSN) - The National Stock Number is a 13-digit number that uniquely identifies an item of supply. It is made up of a four-digit Federal Supply Class (FSC) that describes the general commodity nature of the item, a two-digit country code (for U.S. it is always -00-), and a sequentially assigned National Item Identification Number (NIIN).



Operating Cycle Material Condition Standard - A standard of condition at which an item is still acceptable for use; however, when this condition is reached, restorative maintenance is required to ensure that a desirable material condition is maintained.

Navy Resource Mode (NARM) - Computers factors designed for use in estimating the dollar and manpower resources required to operate and support a single ship or aircraft. These factors are found in the Navy Resources Factor Manual.

Operational Availability - The fraction of time a ship is available for conducting normal operations. Operational availability (Ao) can be defined as:

$$Ao = \frac{\text{Total overhaul cycle length-Unavailable time}}{\text{Total overhaul cycle length}}$$

Ordnance Alteration - See Alteration.

Overhaul Cycle - Period starting with the completion of one overhaul and ending with the completion of the next overhaul.

Overhaul Work - The work that must be accomplished for the ship to operate satisfactorily during the operating cycle following the overhaul (and before the next overhaul). The work required for a thorough overhaul encompasses:

Routine Corrective Maintenance - The repair or overhaul of equipments or systems that are defective, malfunctioning, unsafe, or exhibiting sufficient signs of weakness, old age, etc., such that it is reasonably predictable that, unless repaired, overhauled, or replaced, they will not operate trouble-free or will become unsafe for the next operating cycle.

Insurance Maintenance - The overhaul of mission-essential equipments or systems to prevent their untimely failure during the next operating cycle. The likelihood of failure is established by reasonable engineering predictions or failure analysis study of similar equipments.

Habitability Defect Correction Work - The correction of habitability defects that constitute substandard health, sanitary, or living conditions. Work requests are prepared for only those items deemed cost-effective with reference to the improvement gained, and assigned priorities and accomplishing activities in the same manner as other overhaul work. However, an extract of all habitability work will be prepared and reviewed separately prior to final determination of the overhaul work package.

Technical Improvements - Alterations that provide a significant improvement in equipment performance, personnel safety, reduced maintenance costs, or improved reliability. These technical improvements are classified as K, D and F Alts and are programmed in advance by the Type Commanders in conjunction with NAVSEA and CNO.

Military Improvements - Alterations to the ship's military characteristics. As such, they are designated as Title K Alts and funded by NAVSEA.

Overhauls - A major ship availability established for general maintenance and alterations at a Naval shipyard or other shore-based depot-level repair activity. During this period, the ship generally undergoes the installation of alterations and modifications to update its capabilities and large-scale maintenance that cannot be undertaken at other times. The categories of overhauls are:

Baseline Overhaul (BOH) - The performance of all maintenance actions necessary to restore a ship's systems, subsystems, and equipments to a condition where, with a well-engineered and executed maintenance program, they can be expected to perform satisfactorily over an extended operating cycle.

Regular Overhaul (ROH) - An availability for the accomplishment of general repairs and alterations at a Naval shipyard or other shore-based repair activity, normally scheduled in advance and in accordance with an established cycle.

Complex Overhaul (COH) - An overhaul that, due to money, time or manpower constraints or the complexity or interrelationship of the various ship subsystems affected by the overhaul work packages, requires coordinated and extensive management of both the planning and industrial phases of the overhaul in order to provide a high level of confidence that the overhaul can be satisfactorily completed.

Supply Overhaul (SOH) - The work involved in improving the material readiness of a ship by bringing storeroom repair part inventories up to the level prescribed in updated allowance and load lists or to the endurance level prescribed by appropriate Fleet authority. Attainment of this broad objective requires the successful conduct of many separate but related actions, all of which are appropriately part of the supply overhaul as conducted under the Supply Operations Assistance Program (SOAP).

PEOC Program Office - A program office established to develop and implement the plans and procedures needed to satisfactorily maintain certain amphibious classes while in the PEOC.

PEOC Site Team - A team composed of military personnel, established at major PEOC ship home ports, that will either conduct or assist Ship's Force in the performance of PEOC assessment procedures.

PERA (Planning and Engineering for Repairs and Alterations) - A program for improving the advance planning, integration, and control procedures associated with overhaul. The primary objective of the PERA Program is to provide intensive management for the accomplishment of effective, efficient, orderly, and timely ship overhauls. There are currently five PERAs:

- PERA (SS) - Submarine, located at Portsmouth NAVSHIPYD
- PERA (CV) - Aircraft carriers and other aviation-type ships, located at Puget Sound NAVSHIPYD
- PERA (CRUDES) - Cruiser/Destroyers, located at Philadelphia NAVSHIPYD
- PERA (CSS) - Combatant Support Ships, located at NAVSEA Industrial Support Office (NISO), San Francisco
- PERA (ASC) - Amphibious Ships and Craft, located at Norfolk NAVSHIPYD

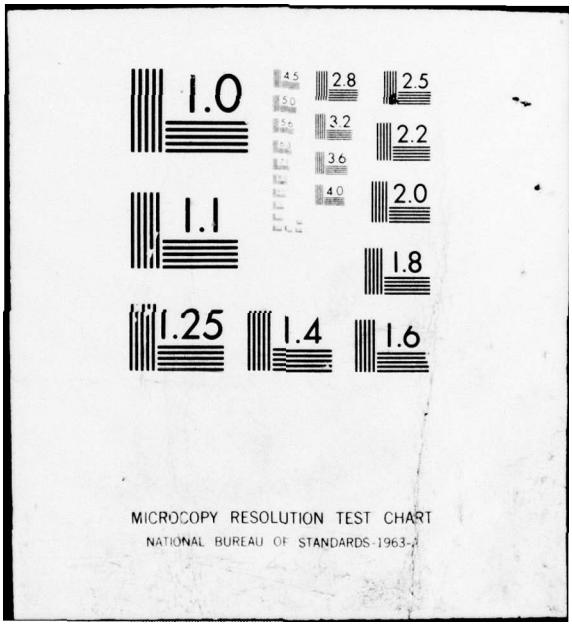
The PERA Offices, as extensions of the NAVSEA Ship Logistic Divisions, integrate the requirements of the various System and Type Commands and manage the planning and engineering efforts for overhauls of assigned ship types and vital interrelated programs pertaining thereto. On the basis of ship modernization planning documents they assist the Ship Logistic Divisions and Type Commanders in the development of class modernization and maintenance packages for assigned ships. The PERAs develop a complete and integrated ship overhaul planning work package that is usable by an overhauling activity with minimum translation and minimum additional planning.

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Planned Maintenance (PM) - Maintenance defined by the Navy's Planned Maintenance System. Includes preventive maintenance (e.g., changing oil) and other activities/inspections that do not improve or restore equipment but do indicate the condition of the equipment. Planned Maintenance has been defined as "maintenance that has been systematically prearranged".

Post-Overhaul Analysis Program - Records the ship configuration changes and material condition on entering an EOC. This is accomplished by identifying the repair and alterations performed during the overhaul, then comparing them to the Pre-PEOC overhaul requirements document to identify the deficiencies (i.e., repairs and alterations required but not accomplished).

Pre-Overhaul Test and Inspection (POT&I) - Performed to determine overhaul and RAV work requirements. It is necessary for some equipment to undergo a test in order for technicians to determine its repair requirements. A simple inspection by technicians, supplemented by discussion with operating personnel, is usually sufficient to determine such requirements. POT&I will be limited to equipments or systems for which tests will yield significant and not otherwise available information for determining overhaul work requirements. POT&I will not normally be conducted on machinery known to require overhaul or that is determined to fall into the "essential" or "insurance" categories.

Prepare for Overseas Movement (POM) - That period of time immediately prior to deployment devoted to ensuring that the material condition of the ship, the levels of on-board spare parts and consumables, and the readiness of assigned personnel are adequate to support the deployment.

Preventive Maintenance (PM) - Maintenance that improves the performance of an equipment and prevents incipient failures. The OPNAV definition is "the sum of those actions performed on operational equipment that contribute to uninterrupted operation of equipment within design characteristics".

Process Chart or Diagram - A graphic representation of the major steps of work in process. The illustrative symbols may represent documents, machines, or actions taken during the process. The area of concentration is on where or who does what, rather than how it is to be done.

Program Objectives Memorandum (POM) - A document which displays total Navy requirements for a seven-year period. Submitted annually to SECDEF for use in structuring the annual budget.

Propulsion Examining Board/Light-Off Examination (PEB/LOE) - CNO established the 1200-psi Examining Boards to ensure that strict adherence to 1200-psi propulsion plant readiness standards is maintained and that these plants are operated properly and safely. The PEB accomplishes this with two types of examinations:

Initial Light Off Examination (LOE) - Conducted prior to lighting the first fire in any boiler during a regular overhaul, major conversion, or fitting-out availability.

Operational Propulsion Plant Examination (OPPE) - Conducted no more than six months after the initial LOE and approximately every year thereafter.

Readiness-For-Sea (RFS) - A seven-day RFS period is established as the standard for all active Fleet ships, commencing immediately after every regular overhaul. This period may be varied by the Fleet Commander in Chief or Type Commander as necessary for any specific ship. During this period no shipyard work is to be performed without approval of the Type Commander or without the specific purpose of ensuring that the ship is, in all respects, loaded and made ready for sea.

Red "E" Project - A CNO Program to improve the material condition of the Fleet. Subsequently renamed the Ship Support Improvement Project (SSIP).

Refresher Training (REFTRA) - A period of intense operational training conducted when a ship is assigned to a Fleet Training Group. This training is normally accomplished after a ship completes an extended period in overhaul, and prior to deployment.

Reliability - The probability that material will perform its intended functions for a specific period under stated conditions.

Repair Requirements for Pre-EOC Overhaul - A document that identifies BOH repair requirements that are essential to support an extended operating cycle for ship classes in the PEOC Program.

Restorative Maintenance - Within the PEOC Program, restorative maintenance has the same meaning as corrective maintenance.

Routine Maintenance - Maintenance actions performed on a regular basis by all maintenance levels; includes planned, preventive, and corrective maintenance as well as routinely accomplished shipyard maintenance actions.

Ship Alteration (ShipAlt) - Any change in the hull machinery, equipment, or fittings that involves change in design, materials, number, location, or relationship of the component parts of an assembly.

Ship Alteration and Repair Package (SARP) - A document developed from the CSMP, POT&I, and work requests and published by PERA, or its designated agent, giving a system-by-system breakdown of approved repairs and authorized alterations to be accomplished during overhaul. For all repairs and for alterations, shipyard man-day/cost estimates are provided. Work screened for the Ship's Force is included in the SARP.

Ship Manning Document (SMD) - A series of documents applicable to individual ship classes that sets forth the required rates, skill levels, and numbers of personnel required to effectively operate a specific class of ship.

Ship System Definition (SSDI) - An orderly identification and structuring of the systems and subsystems that make up a total ship. The SSDI defines the systems as well as their boundaries and interfaces, creating a common language for communicating information about a ship's configuration (under development).

Ship Work Breakdown Structure (SWBS) - The functional segments of a ship, as represented by a ship's structure, systems, machinery, armament, outfitting, etc., are classified using a three-digit system of numeric groupings. There are ten major groups, the last two of which are utilized primarily for cost estimating and progress reporting.

Shore-Intermediate Maintenance Activities (SIMA) - Shore-based maintenance facility. Existing FMAG facilities will be expanded and modernized or new facilities will be established at Norfolk, Charleston, Mayport, San Diego, and Pearl Harbor.

Shore-Based Repair Activities - Naval Ship Repair activities ashore under the management control of the Chief of Naval Material, of Fleet Commanders in Chief, and commercial ship repair yards under contract to the Navy.

System Maintenance Analysis (SMA) - An engineering process that evaluates the design and experience of a selected ship system and develops an overall maintenance plan describing those maintenance actions necessary to support an item's material condition.

Technical Repair Standard (TRS) - A standard that specifies the minimum requirements for the acceptable repair and refurbishment of an item.

Technical Support - Engineering or technical assistance provided to achieve a specified goal.

Tenders (AD, AR, AS, etc.) - Classes of ships capable of providing mobile intermediate-level repair facilities to both CONUS-based and deployed ships.

3-M (Maintenance and Material Management) System - Provides for managing maintenance and maintenance support in a manner that will ensure maximum equipment operational readiness. OPNAVINST 4790.4 prescribes policies and procedures for the installation and operation of this system on board ship. The 3-M System consists of two subsystems:

- Planned Maintenance System (PMS) - Provides each ship with a simple standard means for planning, scheduling, controlling, and performing planned (preventive) maintenance on all equipment.
- Maintenance Data System (MDS) - Provides a means by which maintenance personnel report deferred and completed maintenance actions for use in maintenance planning and maintenance support actions by various levels and areas of management throughout the Navy.

Type Commander (TYCOM) - The Administrative Commander for all ships of a common type (i.e., COMNAVSURFLANT, COMSUBPAC, etc.). He is responsible for the scheduling and implementation of alterations, maintenance, repairs, industrial and tender availabilities, overhauls, and the general logistic support of ships under his command.

Upkeep Period - A period of time assigned a ship, while moored or anchored, for the uninterrupted accomplishment of work by the Ship's Force or other forces afloat.

Voyage Repairs - Emergency work necessary to enable a ship to continue on its mission and that can be accomplished without requiring a change in the ship's operating schedule or the general steaming notices in effect.

Work Package - A collection of repairs and alterations for accomplishment during a maintenance period. A less formal definition and procedure for a SARP.

APPENDIX F

ABBREVIATIONS AND ACRONYMS

This appendix lists abbreviations and acronyms commonly used in the PEOC Program.

ADP	Automatic Data Processing
ALT	Alteration
AMT	Amalgamated Military/Technical Improvement Plan (MIP/TIP)
APL	Allowance Parts List
APS	Automated Propulsion System
AVL	Availability
BOH	Baseline Overhaul
C-2/C-3/C-4	CASREP Severity Codes
CASREP	Casualty Report
CDRL	Contract Data Requirements List
CG	Guided Missile Cruiser (Nuclear Propulsion)
CHASN	Charleston, South Carolina
CID	Component Identification Designation
CINC	Commander-In-Chief
CINCLANTFLT	Commander-In-Chief Atlantic Fleet
CINCPACFLT	Commander-In-Chief Pacific Fleet
CM	Corrective Maintenance
CNO	Chief of Naval Operations
CO	Commander Officer
COMNAVLOGPAC	Commander Naval Logistics Pacific
COMNAVSEASYS-COM	Commander, Naval Sea Systems Command
COSAL	Coordinated Shipboard Allowance List
CMMP	Class Maintenance and Modernization Plan

CSMP	Current Ship's Maintenance Project
CTG	Central Technical Group
CY	Calendar Year, Current Year
D ALT	Alteration authorized and funded by the TYCOM
DDEOC	Destroyer Engineered Operating Cycle
DDG	Guided Missile Destroyer
EIC	Equipment Identification Code
EOC	Engineered Operating Cycle
EQUIP	Equipment
F ALT	Alteration funded by TYCOM and accomplished by Forces Afloat
FARADA	Failure Rate Data
FAT	Final Acceptance Trials
FF	Fleet Frigate
FFG	Fleet Frigate Guided Missile
FILS	Fleet Integrated Logistics Support
FMAG	Fleet Maintenance Assistance Group
FMP	Fleet Modernization Program
FOA	Fitting Out Availability
FY	Five Year Defense Program
FSN	Federal Stock Number
FY	Fiscal Year
GIDEP	Government Industry Data Exchange Program
HM&E	Hull, Machinery, and Electrical
IC	Interior Communications
IDD	Interim Drydocking
ILS	Integrated Logistic Support
ILSS	Integrated Logistic Support System
IMA	Intermediate Maintenance Activity
IMAMN	IMA Man-Hours
IMMS	Intermediate Maintenance Management System
INSURV	Inspection and Survey
ITAWDS	Integrated Tactical Amphibious Warfare Data System
JCN	Job Control Number
JSN	Job Sequence Number
K ALT	An alteration authorized and funded by NAVSEA

LHA	Amphibious Assault Ship (General Purpose)
LLTM	Long Lead Time Material, with a delivery time in excess of 60 Days
LOE	Light-Off Examination
LOR	Level of Repair or maintenance level
LRR	Logistics Readiness Review
LSD	Dock Landing Ship
LST	Tank Landing Ship
MAINT	Maintenance
MBF	Maintenance Burden Factor
MCA	Material Condition Assessment or Machinery Condition Analysis
MCAP	Material Condition Assessment Procedure
MCI	Material Condition Index
MCRI	Material Condition Readiness Index
MDS	Maintenance Data System
MEA	Maintenance Engineering Analysis
MHR	Material History Report
MIP	Military Improvement Plan (Program), Maintenance Index Page
MIS	Management Information System
MMD	Maintenance Man-Days
MOE	Measure of effectiveness
MOGAS	Motor Gasoline
MOR	Method of Repair
MRC	Maintenance Requirement Card
MR/PA	Make Ready/Put Away
MSO	Maintenance Support Office
MTBF	Mean Time Between Failures
MTBR	Mean Time Between Repairs
MTT	Mobile Training Team
MTTF (or MTF)	Mean Time to Failure
MTTR (or MTR)	Mean Time to Repair
N/A	Not Available/Applicable
NARM	Navy Resource Model
NAVMACPAC	Navy Manpower and Material Analysis Center Pacific
NAVMAT	Naval Material Command

NAVSEA	Naval Sea Systems Command
NAVSEC	Naval Ship Engineering Center
NMHD	Negative Man-Hour Differential
NORVA	Norfolk, Virginia
NSTM	Naval Ship's Technical Manual
NTPI	Navy Technical Proficiency Inspection
NWAI	Nuclear Weapons Acceptance Inspection
OPEVAL	Operational Evaluation
OPNAV	Office of the Chief of Naval Operations
OPPE	Operating Propulsion Plant Examination
OrdAlt	Ordnance Alteration
OVHL (or O/H)	Overhaul
PC	Parts Costs
PEARL	Pearl Harbor, Hawaii
PEB	Propulsion Examining Board
PEB/LOE	Propulsion Examining Board/Light-off Examination
PEOC	Amphibious Engineered Operating Cycle
PERA	Planning and Engineering for Repairs and Alterations: (ASC) Amphibious Ships and Craft, Norfolk NSYD (CRUDES) Cruisers/Destroyers, Philadelphia NSYD (CSS) Combat Support Ships, NAVSEA Industrial Support Office (NISO) San Francisco (CV) Aircraft Carriers, etc., Puget Sound NSYD (SS) Submarines, Portsmouth NSYD
PFM	Plans for Maintenance
PHM	Patrol Hydrofoil (Guided Missile)
PM	Planned Maintenance or Program Manager
PMS	Planned Maintenance System or Project Management System
POA&M	Plan of Action and Milestones
POM	Program Objectives Memorandum or Preparation for Overseas Movement
POT&I	Pre-Overhaul Test and Inspection
PRAV	Planned Restricted Availability
PSMO	Preliminary Ships Manning Document
PSA	Post Shakedown Availability

RAMSIM	Reliability and Maintainability Simulation Program
RAV	Restricted Availability
RA/TA	Restricted and Technical Availabilities
REFTRA	Refresher Training
RFS	Readiness-for-Sea
RM&A (RMA)	Reliability, Maintainability, and Availability
RMMS	Repair Maintenance Management System
ROH	Regular Overhaul
SAFO	Ships Available for Operation
SARP	Ship Alteration and Repair Package
SDIEGO	San Diego, California
SECAS	Ships Equipment (Electronic) Configuration Accounting System
SEOC	Submarine Extended Operating Cycle
SFLT	Ship's Force Labor Transactions
SFMH	Ship's Force Man-Hours
ShipAlt	Ship Alteration
SIMA	Shore-Based Intermediate Maintenance Activity
SMA	System Maintenance Analysis
SMD	Ship Manning Document
SMMS	SSBN Shipsystem Maintenance Monitoring and Support
SNSB	Senior Navy Steering Board
SQT	Ship Qualification Trials
SRA	Selected Restricted Availability
SSBN	Fleet Ballistic Missile Submarine (Nuclear Propulsion)
SSDI	Ship Systems Definition and Index
SSN	Submarine (Nuclear Propulsion)
SURFLANT	Type Commander for Surface Forces Atlantic Fleet
SURFPAC	Type Commander for Surface Forces Pacific Fleet
SWABS	Ship Work Authorization Boundaries
SWBS	Ship Work Breakdown Structure
TA	Technical Availability
TAV	Technical Availability
3-M	Maintenance and Material Management
TIP	Technical Improvement Plan (Program)

TOR	Timing of Repair
TRS	Technical Repair Standard
2K	Maintenance Action Form (OPNAV 4790/2K)
TYCOM	Type Commander
UROH	Unit Regular Overhaul
UIC	Unit Identification Code
WSAT	Weapons System Accuracy Test