PAFOS

CHAPTER 2

READINESS BASED SPARING

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CHAPTER 2

READINESS BASED SPARING

2.1 INTRODUCTION

In the early 1970s, the Chief of Naval Operations (CNO) established a Logistic Review Group (LRG) to review and recommend solutions to Fleet readiness and logistics support problems. Major weapon systems entering the Fleet were experiencing serious readiness problems even though Integrated Logistics Support (ILS) programs were implemented. In the earliest ILS audits, the LRG found that there was no common approach to setting and evaluating material readiness requirements. The LRG further found that programs generally lacked any substantive link between readiness requirements, the reliability levels specified by contract, and their logistics resources and planning necessary to achieve the required readiness in the Fleet. As a result, Operational Availability (A_o) was established as the quantitative measure of material readiness for the Navy.

Since the early 1980s, the Navy implemented various programs to increase Fleet readiness by improving the selection techniques used to determine spare parts for ship outfitting and wholesale supply levels for the Navy Inventory Control Point Mechanicsburg (NAVICP-M). These programs are designed to provide the most effective spares load in terms of readiness and outfitting/ wholesale cost. The evolution of these programs has resulted in the present sparing philosophy known as Readiness Based Sparing (RBS).

The CNO specifies readiness objectives for ships and systems under the cognizance of Naval Sea Systems Command (NAVSEA). RBS was designed to achieve these readiness objectives at minimal cost or maximize readiness for a fixed cost.

2.1.1 Purpose of RBS Chapter

The purpose of this chapter is to provide a general discussion of RBS for informational purposes, and also to provide a review of the specific phases in the RBS process. This includes defining the analyses, outlining the procedures, and defining roles and responsibilities. Each section will begin with an overview, which will provide a basic description followed by procedures and tasks with sufficient detail to guide participation in an RBS analysis.

2.1.2 Scope of RBS Application

This RBS method shall be universally applied throughout the life cycle (including interim support) for new, non-nuclear, and non-SSBN acquisition programs in Acquisition Categories (ACATS) I, II, or III.

The RBS process applies to all new ACAT I, II, III, and selected IV programs that are in Concept Exploration, Demonstration/ Validation, and Engineering/Manufacturing and Development phases of the Acquisition process. Application of RBS is required for ACAT IV programs if the system contributes to the mission success of a critical mission area. For existing weapon systems or new systems, RBS will be utilized when other sparing methods can not attain the required readiness objective. In addition, any ACAT I, II, or III program considering or undergoing a modification--engineering change, field change or ordnance alteration--to an existing system (*that represents a cost greater than 5% of the original hardware costs)* shall consider implementing RBS for the entire system.

RBS involves the integration of engineering and logistics disciplines in analyzing material readiness, as defined in OPNAVINST 3000.12[1], of systems and platforms. It provides methods and procedures for conducting tradeoff analyses on reliability, maintainability, and supportability variations on readiness in order to relate resources to weapon system readiness as defined in DODINST 5000.2[2].

This manual does not apply to:

Nuclear Propulsion Material. As delineated in the NAVSEA organizational manual, the Deputy Commander for Nuclear Propulsion, SEA 08, is responsible for all technical matters pertaining to nuclear propulsion of U.S. Naval ships and craft, including all aspects of integration of the nuclear plant into the ship system. Nothing in this manual detracts in any way from these responsibilities. Accordingly, SEA 08 will be consulted in all matters relating to or affecting the nuclear propulsion plant and associated nuclear support facilities.

Strategic Systems Programs. The provisions of this manual are not applicable to Fleet Ballistic Missile (FBM) submarines, FBM or Strategic Weapon Systems, or any of their supporting activities. Policies and procedures for these platforms, systems, and activities will be issued by the Director, Strategic Systems Programs.

2.1.3 Background

2.1.3.1 Measure of Readiness

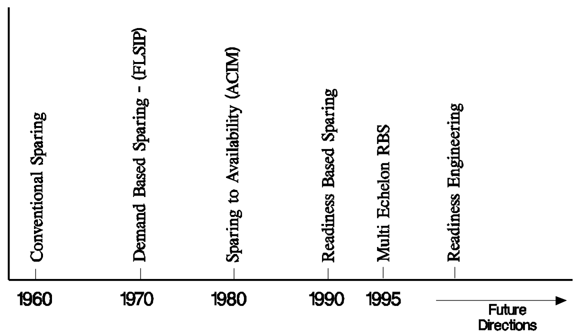
In the early 1980s, the Navy established A_o as the measure of material readiness. The A_o of a system is the probability that the system is ready to perform its intended function in its operational environment when called for at any point during a mission. OPNAV Instruction 3000.12[1] establishes A_o as the primary measure of material readiness for Navy mission-essential systems, subsystems, and equipment installed on platforms (i.e., ships, submarines, shore sites). A tentative A_o threshold is established in the Mission Need Statement early in the acquisition cycle. This value is based on preliminary estimates of the system's performance requirements to meet the mission. The A_o evolves into a firm requirement established by the CNO by Milestone II. This type of analysis is provided by Use Studies and Baseline Comparison Systems.

These readiness targets are to be used by the logistics community as early as possible to design effective logistics support for the life cycle of weapon systems. This would include: maintenance plans; configuration management; manpower, personnel and training; and supply support. RBS should be initiated early in the acquisition process to directly effect readiness (A_o). The major impact of RBS is the supply support decision that contributes to achieving the established readiness targets. Earlier sparing methods did not explicitly relate supply decisions (resources) to readiness.

2.1.3.2 Chronology of Sparing Methods

The methodology of determining which parts to carry as shipboard allowances has evolved from early conventional sparing methods where spares were manually selected during the provisioning process. As the Navy's shipboard systems became more complex, computational techniques based on the probability of demand during a ship's mission were developed to determine allowances. As weapon system complexity and populations of components increased, demand based methods no longer provided the readiness required by Office of the Chief of Naval Operations (OPNAV). As the OPNAV required readiness objectives were imposed on mission critical ship's systems, "Sparing to Availability" on discreetly configured weapons systems with known design parameters and A_o thresholds was implemented.

CHRONOLOGY NAVY SPARING METHODS
LEADING TO READINESS ENGINEERING ANALYSIS



Conventional

Prior to 1960, onboard allowances were determined manually using historical design and maintenance history as a basis for spares selection. This technique was adequate for the complexity and system configurations of the time. These allowances were determined initially and held constant for the life of the weapon system.

Demand Based

During the mid-1970s, with the introduction of automated inventory programs at NAVICP-M, demand-based inventory mathematics models were developed to determine consistent allowances for increased system complexity and varying configurations. Also, Fleet maintenance data collection provided update capability for key input parameters.

The Fleet Logistic Support Improvement Program (FLSIP) is the Navy’s demand-based mathematics model for determining onboard spares allowances. A standard 90-day mission period (as defined by OPNAV) is known as the protection period. The protection level required by CNO is 90%. The FLSIP model computes the allowance quantity to provide a 90% probability (protection level) of having the required part onboard when needed during the protection period. For items considered to be of critical importance to the equipment, an insurance level is provided determined by the item’s expected demand rate.

Modified FLSIP (MODFLSIP) provided an additional level of insurance for highly critical equipment in the ship’s primary mission areas.

Availability Centered Inventory Model

The history of "Sparing to Availability," includes the development, and subsequent March 1981 CNO approval of, the Availability Centered Inventory Rule (ACIR) for determining shipboard level stockage quantities. The ACIR has been implemented in the Availability Centered Inventory Model (ACIM). The original objective of ACIM was to provide the range, depth and location of spares required to reduce the logistics delays given the inherent design characteristics of a system. ACIM computes allowances to meet logistics requirements at least-cost or to achieve least overall logistics delay for a given cost.

While "stand-alone" ACIM provided a link between cost and readiness, which conventional and demand-based policies did not, it had limited capability to assess readiness of complex systems. Limitations of the ACIM model and the requirement to assess readiness at the mission area/system level led to the development of RBS.

RBS

The RBS process combines mission simulation techniques with the optimum spares selection techniques of ACIM to assess readiness of critical ships' systems. The RBS process involves the integration of design, configuration management, maintenance, and supply support across a variety of disciplines. The integration of these disciplines is intended to provide the opportunity to improve communications, share and validate data from logistics and engineering sources, and to more effectively apply the data from the acquisition process to solving logistics problems.

RBS explicitly relates sparing cost to the availability of the system/equipment being analyzed. Allowance candidates are evaluated and selected based on cost and contribution to system readiness. The RBS computation shall include MAMs as available spares. This enables the system to meet its readiness requirements at minimal cost.

Multi-Echelon RBS

Before FY95, RBS was based on determining shipboard retail allowances using the average of all historical supply response time data from the supply system. For some equipment, the overall average may have been a good estimate, while for others it was over or under estimated. Multi-Echelon RBS uses supply response data for each item in the equipment, giving a more realistic estimate for each equipment. The process can then determine the best wholesale (supply centers) levels in combination with retail levels, to support weapon system readiness objectives. Multi-Echelon RBS considerations, such as item supply response time, should be addressed as early as possible in the RBS process.

Future Directions

The RBS process, as a part of Readiness Engineering, is the process of modeling a system in the mission operating environment in conjunction with optimized spares determination.

As the complexity of modern weapons systems has increased, the engineering and logistics communities have had to actively evaluate and manage readiness factors as they specifically relate to the readiness requirements of systems. Readiness Engineering includes analyzing readiness issues, performing tradeoffs, and determining cost-effective logistics (*not only supply*) support requirements to achieve the required readiness objectives. Readiness Engineering analysis should continue throughout the life cycle until disposition of the system.

2.2 READINESS TERMINOLOGY

2.2.1 A_o

A_o is expressed in terms of the percentage of time that a system is capable of performing its intended function. The formula for calculating A_o is:

$$A_o = \frac{\text{Uptime}}{\text{Uptime} + \text{Downtime}}$$

Uptime, as a measure of system reliability, can be defined by Mean Time Between Failures (MTBF). Downtime, defined as Mean Downtime (MDT), represents the time a system is unavailable to perform its intended function due to active repair time and logistics delays. By substituting these definitions into the previous equation, operational availability can be expressed as:

$$A_o = \frac{\text{MTBF}}{\text{MTBF} + \text{MDT}}$$

MDT can be further broken down into maintainability and supportability parameters; Mean Time To Repair (MTTR) and Mean Logistics Delay Time (MLDT) respectively. MTTR includes the time to fault isolate and actively repair a system. MLDT represents administrative delays and delays from logistics elements such as: supply support, maintenance planning, technical data, and training. By replacing MDT with its components MTTR and MLDT, the expression becomes:

$$A_o = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR} + \text{MLDT}}$$

So, $\boldsymbol{A_o}$ is a function of the system's reliability ***(MTBF)***, maintainability ***(MTTR)***, and supportability ***(MLDT)***. Reliability is a function of a system's design parameters. Supportability is a function of the logistics environment provided for the system. Maintainability is a function of both the system's design parameters and the logistics environment provided for the system.

The following sections cover the definitions of reliability, maintainability, and supportability, followed by a description of their functional relationships to A_o.

2.2.2 Reliability

Reliability is the duration or probability of failure free system performance under stated conditions. This is measured by the MTBF. MTBF is the total functional life of a population of an item divided by the total number of failures within the population during a measured interval of time. This value may be predicted by Reliability Analysis and refined by operational experience.

2.2.3 Maintainability

Maintainability is the measure of the ability of an item to be retained in or restored to a specified condition when maintenance is performed by personnel having specified skill levels, using prescribed procedures and resources, at each prescribed level of maintenance and repair. This is expressed by the MTTR. MTTR is the average fault isolation and active repair times. This is determined from the total corrective maintenance time divided by the total number of corrective maintenance actions during a given period of time.

2.2.4 Supportability

Supportability is the measure of effectiveness of the logistics support provided for a weapon system. It represents the remaining downtime where no active maintenance (including fault isolation) is being performed. Supportability is quantified by MLDT, which is the average delay time attributed to waiting for spare parts, documentation, training, deferred maintenance, and all administrative delays. The major component of MLDT is the delay time waiting for spare parts both locally (on-site) and from the supply system. This average delay time waiting for spares is referred to as Mean Supply Response Time (MSRT).

Once the system is designed and in service, supportability becomes the primary factor influencing the achieved availability of the system, which can vary considerably depending on the logistics support in place.

2.2.5 Availability Trade-Offs

In the early design stages of a system, all of the elements of the A_o are estimates. If the preliminary estimate of A_o does not satisfy the mission requirement, then a *trade-off analysis* may be performed. This involves evaluating potential improvements in each of the elements and their associated costs, and resulting change in system availability. If improvement in MLDT (supportability) is not effective or is cost prohibitive in reaching the desired A_o, trade-off analysis should be performed to determine the effects of the system reliability and/or maintainability on A_o. Reliability/Maintainability and Maintainability/Supportability trade-off design analysis is described in OPNAV Instruction 3000.12[1], A_o of Equipment and Weapons Systems. This type of analysis should begin as early as possible during the design process when the design may still be significantly influenced to attain a desirable relationship.

2.3 POLICY

The RBS method shall be universally applied throughout the life cycle (including interim support) for new, non-nuclear, non-SSBN acquisition programs in ACATs I, II, or III. In addition, RBS will be selectively employed both on existing and new weapon systems where it provides an optimal method for attaining the required readiness objective.

a. DODINST 5000.2[2] establishes the weapons system acquisition philosophy which requires DOD activities to specifically relate resources to readiness in design and support decisions. SECNAVINST 5000.2A[3] directs that Navy components use RBS techniques to establish the relationship.

b. DODI 4140.60[4] and DODI 4140.1-R[5] direct DOD components to provide for the relationship between resources and readiness.

c. OPNAVINST 3000.12[1] establishes A_o as the Navy’s primary measure of material readiness.

d. SECNAVINST 5000.2A[3] and OPNAVINST 3000.12[1] require that A_o performance targets be established for all Navy systems.

e. Readiness Engineering Teams should be established which will include representatives from acquisition, in-service engineering, logistics, supply, Naval Sea Logistics Center (NAVSEALOGCEN) and other Fleet data analysis activities.

f. Readiness analysis shall be used to:

(1) Assess readiness of ships, systems or equipment during the entire life cycle beginning with Milestone I;

(2) Evaluate trade-offs between reliability, maintainability, and supportability issues and project costs throughout the life cycle of the program;

(3) Use approved spares optimization methods to determine the required sparing levels to achieve and sustain the A_o objectives specified by CNO, as outlined in NAVSUPINST 4442.14A[6]; and

(4) Minimize life cycle costs while maintaining system readiness.

g. RBS planning, procedures, and funding shall be documented in the Integrated Logistics Support Plans (ILSPs) and Logistic Requirement Funding Plans (LRFPs). All analyses, including any assumptions, data, and models used shall be documented along with the results, in the Navy approved format.

h. Any models, algorithms, or spares computation methods used to determine organizational spares allowances shall be Navy approved. Any deviations shall be approved by Naval Supply Systems Command (NAVSUP).

i. Planned Program Requirements (PPRs) based on RBS analyses will be coordinated with the appropriate NAVICP in time to support stock procurement.

j. All readiness analyses used to determine organizational spares shall be validated by NAVSEALOGCEN and approved by NAVSEA 041 before the allowances are loaded into the Non-Standard Allowance File (NSAF).

k. Approved RBS allowances shall be loaded into the NSAF and documented in ships' Coordinated Shipboard Allowance List (COSAL).

l. Interim spares support shall be determined using RBS, validated by NAVSEALOGCEN, and approved by NAVSEA 041.

2.4 RBS

Historically, readiness analysis has focused solely on determining the supply support requirements which decrease MLDT in order to achieve material readiness objectives. Traditional demand-based sparing methodologies proved inadequate for this purpose due to the complexity of evolving military systems. The ACIM was developed to identify spares required to sustain system's A_o at least-cost.

However, ACIM proved to be limited when modeling large and complex systems or ships. Advancements in computer modeling have provided a capability to simulate mission scenarios, including varying equipment operation and accounting for system redundancies. TIGER, the NAVSEA developed/approved Reliability, Maintainability and Availability (RMA) simulation program, simulates system operations using specified mission operating scenarios and system Reliability Block Diagrams (RBDs).

The RBS process is comprised of three phases: Readiness Appraisal, Sparing Determination, and Life Cycle Maintenance. These phases are integrated and iterated until an optimal availability is achieved at an affordable cost.

2.4.1 Readiness Appraisal

2.4.1.1 Overview

Readiness appraisal is conducted to model the operation of a system, and project the A_o that results from associated design and logistics support parameters. The system RBS model shall incorporate the conditions and characteristics which define a successful mission. This is known as "mission success criteria" and includes:

1) Criticality of individual equipment to the mission of the system;

2) Equipment redundancy within the system;

3) Design reference mission; and

4) Operating profile of the system during each mission phase.

Unique system models can be developed for different user sites when mission success criteria varies due to significant configuration and operating differences. The model also includes reliability and maintainability design parameters, maintenance philosophies, logistics delay times, and other logistics support parameters that have an impact on readiness. Reliability, maintainability, and supportability data used in the model shall be derived from acquisition program documentation and validated with data from testing and actual operations.

A RBD is a graphical depiction of the effects of an item's failure on the system's functional performance. The RBD is developed as part of the Readiness Appraisal phase to be used in conjunction with the mission timeline, operating profile, and related mission success criteria. The system RBS model is evaluated by the simulation computer model, TIGER.

2.4.1.2 Procedures

A sequence of readiness appraisal tasks are:

a. Define system readiness requirements and incorporate contract data requirements;

b. Develop or review other program documents;

c. Ascertain system description and boundaries for all applications;

d. Determine mission timelines for all applications;

e. Determine mission operating profiles and establish mission success criteria;

f. Develop standard Navy RBD;

g. Perform RMA simulation modeling;

h. Evaluate preliminary results; and

i. Perform RMA tradeoff analysis.

A sample process flowchart can be found in Appendix (A). Suggested data sources and outputs are contained in Appendix (B).

2.4.1.3 Discussion

Readiness/Data Requirements

Program objectives for reliability and maintainability will be defined early in the program and used to evaluate the design in development and production. The Operational Requirements Document (ORD) is the top level document that contains the reliability, maintainability, and availability (MTBF, MTTR and $A_{o,}$ respectively) requirements for the system. As the design for a new system matures, reliability and maintainability estimates come from predictions required by the acquisition contracts.

Mission Profile

The Design Reference Mission (DRM) is a timeline which describes the planned use of a system. The timeline consists of a series of mission phases which reflect different modes of system operation.

When performing a RBS analysis the mission profiles are established for the system under analysis for each different user site. The mission profile(s) is the description of the system in each operational mode or phase. This will include equipment required, equipment usage (duty cycle), and conditions for failure. This type of analysis is performed on each subject equipment to determine its total percentage of usage (energized time).

Example:

Using a car as an example of a platform and its ignition system as the system, the phases might be; Starting, Idling, Accelerating, Cruising, Stopping, and Parking. During each phase, different equipment of the ignition system is utilized. During Starting, the battery and starter are used 100% of the time. If the mission is to go to and from the grocery store, this phase will be expected to be used twice, once to go and again to return. The percentage of total time in this phase can be determined depending on the total time of the mission. The starter is not utilized during any of the other phases: Idling, Accelerating, Cruising, Stopping, or Parking.

System Description and Boundaries

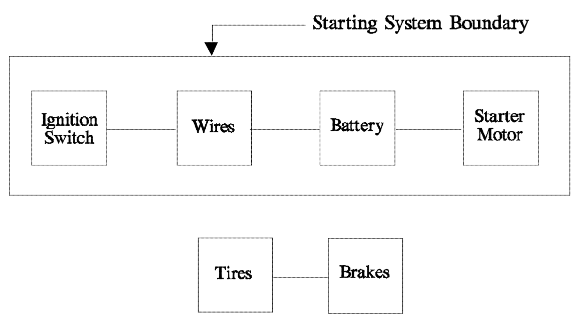
System description should be obtained or developed to describe the scope of the system for the analysis. Next, system boundaries must be determined for the system and its equipment. A system may be defined as a(n):

- Battle Group,
- Ship,
- Set of systems that are intended to fulfill a specified mission,
- Subsystem, or
- Equipment.

The system boundaries constrain the analysis to a discrete set of equipment and functions from the configuration breakdown of the system.

Example:

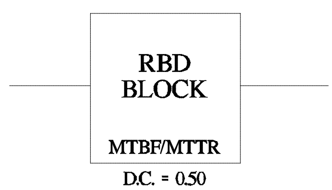
In the case of the car (platform), the mission is going to and from the store (represents DRM). This mission requirement for the starting phase is used in determining the boundaries of the equipment required in starting the car. In this case the ignition switch, wires, battery, and starter motor comprise the starting system. Tires and brakes would be out of the bounds of the starting system analysis.



Establishing the boundaries is necessary for the development of a RBD.

RBD

A RBD is a logic diagram of functions and equipment in a system, arranged with blocks and lines. A RBD depicts the effect of an item's (block) failure on a system's functional performance (i.e., mission success). The RBD illustrates system interdependencies, redundancies, and equipment parameters (e.g., MTBF, MTTR, Duty Cycle-D.C.).



A RBD is a schematic of the path to mission success. It may have parallel and/or series components. The reliability of a component is the probability the component will successfully perform a mission without a failure. For a series system, the reliability mathematics model representing the mission is the product of the reliabilities of each of the components. The total reliability is therefore lower than any individual component's reliability.

In the second case of the starter system example, the reliability mathematics model would be a series path consisting of: the ignition switch, the wires, the battery, and the starter motor. The reliability of turning the engine equates to the reliability of the ignition switch, times the reliability of the wires, times the reliability of the battery, times the reliability of the starter motor.

To illustrate this, assume a reliability of 0.95 for each component.

$$R_{TURNING\ THE\ ENGINE} = R_{IGNITION\ SWITCH} \times R_{WIRES} \times R_{BATTERY} \times R_{STARTER}$$

$$= 0.95 \times 0.95 \times 0.95 \times 0.95$$

$$R_{TURNING\ THE\ ENGINE} = 0.81$$

Parallel mission paths, which represent function redundancies, increase a system's reliability. This is because parallel paths do not result in a simple product relationship for the resultant total reliability.

For our example, suppose the car has two independent batteries, A and B in parallel. The reliability of having power would be:

$$R_{BATTERY} = R_A + R_B - (R_A)(R_B)$$

The reliability of the system with two batteries is therefore higher than with one battery. Again, assume a component reliability for each battery of 0.95. The result is;

$$R_{BATTERY} = 0.95 + 0.95 - (0.95)(0.95) = 0.9975$$

resulting in

$$R_{TURNING\ THE\ ENGINE} = R_{IGNITION\ SWITCH} \times R_{WIRES} \times R_{BATTERY} \times R_{STARTER}$$

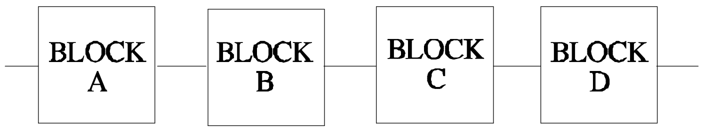
$$= 0.95 \times 0.95 \times 0.9975 \times 0.95 = 0.86$$

The above is a brief description of reliability relationships and mathematical models for both serial and parallel paths.

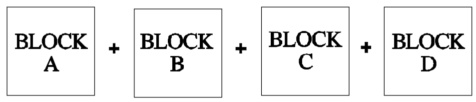
For a complete description of properly developing a RBD, see NAVSEA Report No. 05MR-001-87, Reliability Block Standards[8].

EXAMPLE RBD:

SERIES SYSTEM

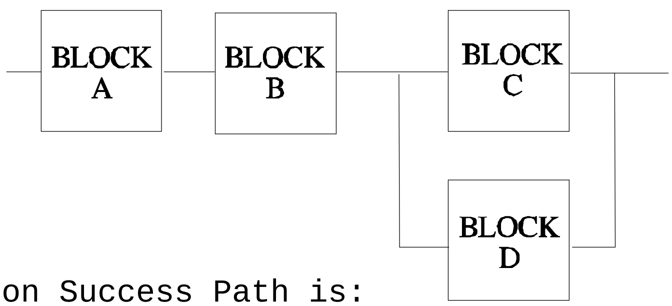


Mission Success Path is:

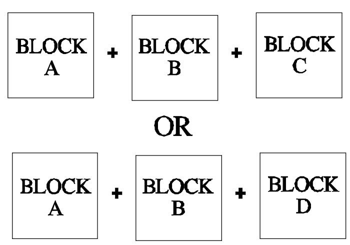


EXAMPLE:

PARALLEL SYSTEM



Mission Success Path is:



TIGER

The readiness analysis performed in RBS requires other logistics and configuration data in addition to RBDs in order to predict system readiness (A_o). For each block of the RBS RBD, the MTBF, MTTR, Equipment Type, Equipment Number, Duty Cycle, and MLDT factors are used. This representation of the reliability relationship is converted into a format which can be evaluated by the TIGER computer simulation model. Version 8 of TIGER (TIGER 8) is currently the Navy approved version for RBS.

TIGER 8 uses a Monte-Carlo simulation technique to generate random values within probability curves of the input data of the RBS RBD. It simulates uptime and downtime of the system over the mission timeline. The simulations are performed for many mission trials (iterations). From this analysis, an expected average operational availability is calculated.

TIGER 8 is used to determine the upper and lower limits of operational availability. With zero spares available on-site (i.e., all spares requirements incur an off-site delay) the lower limit of predicted A_o is established. Based solely on inherent design characteristics, the upper limit to A_o is referred to as Inherent Availability (A_i). This is estimated in TIGER by assuming that 100% of the range and depth of spares required for the mission are on-site. A_i assumes an ideal logistics support environment (MLDT = 0). Its equation is:

$$A_i = \frac{MTBF}{MTBF + MTTR}$$

This is the maximum availability that can be expected from the inherent design of the system. The availability calculated from zero spares on-site is the minimum expected value from the inherent design of the system; the largest MLDT includes the maximum expected delay time awaiting repair parts.

TIGER 8 has been the Navy standard used for years to determine the reliability and maintainability of systems in ship's design studies. It can be used to determine if redesign is necessary early in the acquisition process before any substantial commitment of resources is made. Outputs produced from TIGER 8 can highlight which portions of a system are very reliable, contribute little to unavailability, and require minimal supply support. Other areas of a system may be very unreliable, requiring redesign or a substantial investment in logistics support to maintain readiness.

TIGER 8 accounts for supply system parameters (e.g., offship delay time and supply effectiveness) and predicts their impact on system A_o. High contributors to critical system failures and downtime--readiness drivers--can be readily identified in TIGER's critical equipment list. For complete instructions in the use of TIGER 8, see the TIGER User's Manual, NAVSEA TE660-AA-MMD-010[9].

2.4.2 Sparing Determination

2.4.2.1 Overview

The second RBS phase is known as Sparing Determination. Sparing Determination includes: collecting and validating the required data; establishing a sparing strategy using the approved RBS spares models; determining the spares quantities and costs; and evaluating the impact of the sparing decisions on system A_o. The Readiness Appraisal and Sparing Determination phases may have to be iterated many times until the final A_o and optimized spares loads are determined. For shipboard systems, the final spares allowances are officially listed in the COSAL.

2.4.2.2 Procedures

a. Review and validate the RBS allowance computation results to determine if the system, mission, and platform readiness objectives can be achieved.

b. Quantify allowance costs and review the impact on COSAL and ICP stock budgets with NAVSEA, NAVSUP, NAVICP-M, and the PARM.

c. Review of the allowance space and weight impact on a platform may be required.

d. The RBS sparing results and selected inputs shall be forwarded to NAVSEALOGCEN (N80) for review and validation, and coordinated with NAVSEA 041 for approval.

e. The sequence of sparing determination tasks are:
   (1) Collect data;
   (2) Validate data and allocate to RBD;
   (3) Execute sparing models;
   (4) Calculate A_o resulting from onboard spares determinations;
   (5) Evaluate results;
   (6) Report results;
   (7) Determine interim spares and PPRs; and
   (8) Load NSAF.

A sample process flowchart can be found in Appendix A. Suggested data sources and outputs are contained in Appendix B.

2.4.2.3 Discussion

Collect/Validate Data and Allocate to RBD

Part level data is obtained from either Provisioning Technical Documentation (PTD) or the Weapons System File (WSF). PTD includes Provisioning Parts Lists (PPL) in MIL-STD-1388 (LSA-036) format. LSA and Interactive Computer-Aided Provisioning System (ICAPs) 036 formats are commonly created for Provisioning Parts Lists (PPLs). The RBS workstation software uses the 036 format to create a database file of spare parts candidates.

Data integrity is essential throughout the RBS process (as well as with any sparing process). Key data elements to be validated include:

- Military Essentiality Code (MEC),
- Replacement Factor (RF),
- Source, Maintenance & Recoverability Code (SM&R),
- Unit Price, and
- Population.

Part data discrepancies should be identified and corrected before applying the data in later spares modeling. Further explanation of the key data elements can be found in Chapter 4 (Provisioning) of this manual. A final database file, known as the part file, contains only the onboard spares candidates.

The equipment type file is a listing of the different equipment making up the system. It contains equipment information (such as, equipment type number, MTBF, MTTR, and duty cycle) for each block of the RBD. The equipment type file and the part file are related by a common field--the equipment type number of the block. The equipment type file in combination with the part file data are used to generate inputs to the spares optimization model, ACIM. Currently, ACIM is the only NAVSEA approved optimization model. Typically, ACIM optimizes on cost; however, it should be noted that the model could be used to optimize on other factors such as volume, weight, etc.

ACIM

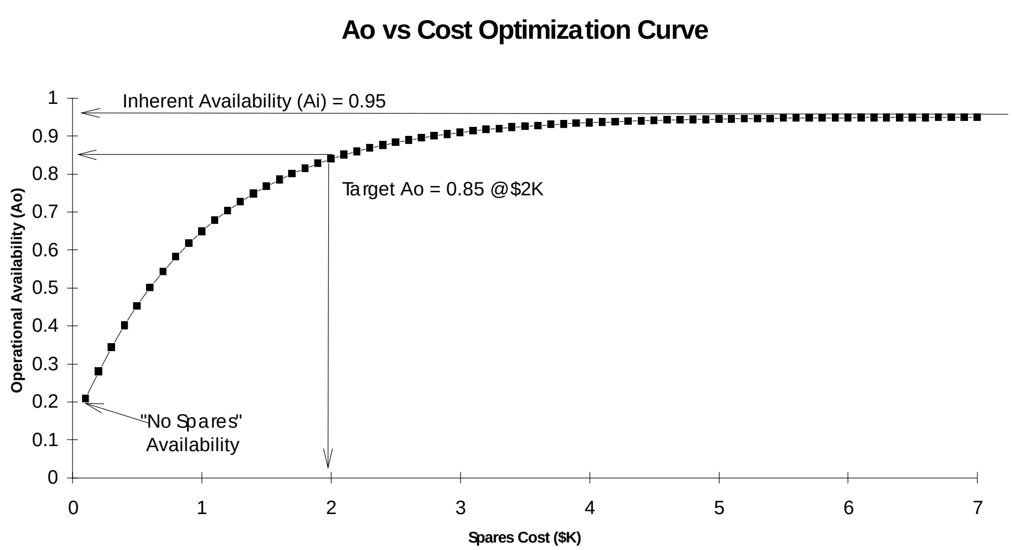
The part file contains piece parts information for each block of the RBD consisting of item cost, SM&R coding, replacement rates, and Military Essentiality Coding (MEC). The part file is used to create item input files for ACIM. MECs establish the parts criticality to the equipment type block(s) to which it is assigned. Only critical items that contribute to the system's A_o are ACIM optimization candidates. Non-critical items (MEC 3) do not affect A_o, are not optimized, but will be considered for allowance by demand-based methods in the COSAL.

ACIM evaluates each critical item in an equipment type and determines the additional A_o obtained for the cost of adding one more of the item as an on-site spare. Then a list of the items in order of greatest improvement in A_o for the least cost incurred is generated for each equipment type.

After all equipment types are evaluated, all of the piece parts are brought together under one system comprehensive, optimized spares list. This list is ranked by decreasing contribution to system A_o per cost, with a tabulation of the cumulative system A_o and cost. A typical graph of A_o to cost curve can be drawn from the tabulated data as shown in Figure 2-1. An A_o versus cost optimization curve shows the relationship between resources (cost) and readiness (A_o). The no spares availability (minimum) and the inherent availability (maximum) value of A_o for the system are shown in Figure 2-1. From this optimized list, an approximate A_o or cost target may be selected by the analyst. The cost or A_o threshold selected represents a point on the optimization curve which results in the assignment of technical overrides. The override of 'A' is assigned for the parts selected, those items below the target cost or A_o threshold (in Figure 2-1, below an A_o of .85). The override of 'Y' is assigned for parts considered but not selected, those items above the cost or Ao threshold (in Figure 2-1, greater than A_o of .85). These overrides are stored in the part file and loaded in the NSAF for use in the production COSAL after the RBS analysis is completed and the results approved.

Part of the RBS process is the generation of a parts sequence list consisting of the onboard spare parts and quantities selected. This reflects the logic applied in the Navy's production COSAL. It includes common part applications, demand based sparing for non-essential items, and non-optimized items.

Figure 2-1



Linking TIGER with ACIM

The spares quantities, expected demands and replenishment times are used to calculate the gross effectiveness by equipment type. The gross effectiveness is the probability the parts needed for repair are stowed on-site for the given equipment type.

Once the gross effectiveness values for each equipment type are determined, these values are re-inserted into TIGER. TIGER computes the final expected A_o from these specific values. If the A_o is below the desired value: a higher A_o or cost point is selected by the analyst from the optimized spares list; a new parts sequence list is generated; and new gross effectiveness values are calculated and reinserted into TIGER. This process is repeated until the desired A_o is obtained with TIGER. Now, the part sequence list items may be documented and the summarized onboard spares, total cost, and expected A_o is reported.

Non-Standard Allowance File

The NSAF is a file used to house the ‘A’ (should be carried) and ‘Y’ (should not be carried) readiness overrides resulting from the RBS process. This data is used as input in the NAVICP production COSAL process for determining storeroom spares. The COSAL formally documents the allowances provided to the ship (for information on allowance computation and COSAL, see Chapter 6).

Each specific site’s RBS allowance overrides and quantities are recorded in the Non-Standard Allowance File. This file allows usage of the RBS allowances without producing additional Allowance Parts Lists (APLs) for individual sites which may have varying RBS allowances. The differences in allowances may be due to variations in the number of systems installed, different design reference missions, platform specific Alterations, and/or Engineering Change Proposals. Additional information on the NSAF can be found in the Non-Standard Allowance File (NSAF) Manual for NAVICP-M Platform/Program Managers[10].

The RBS methodology is fully compatible with the COSAL computation because the COSAL production process accepts allowance override quantities that have been fixed by the engineering and provisioning community. Specifically, RBS-determined allowances are used in conjunction with demand-based quantities to compute aggregate shipboard allowances that will never be less than the RBS override quantities.

2.4.3 Life Cycle Maintenance

2.4.3.1 Overview

As new systems are deployed with the initial outfitting as storeroom OBRPs, the Life Cycle Maintenance phase of a readiness analysis begins. If the configuration of the system never changed and the initial predictions of system reliability/ maintainability/supportability (A_o) parameters were completely accurate and constant for the life cycle of the system; a perfect logistics support system would be in place; and the job of readiness engineers would be finished for that system.

More realistically, what is observed in the operational world of weapons systems is a changing configuration along with changing estimates of system readiness parameters (MTBF, MTTR, MLDT) and part-level parameters (replacement rates, costs). The system design may change due to capability requirements from changing world threats or reliability deficiencies may drive design improvements. Initial predictions of reliability and maintainability may not account for the operating environment actually experienced or the operating stresses actually encountered. New estimates of reliability are obtained from field data which affect the MTBF of the equipment and the replacement rate of the part -- both key parameters in estimating A_o and making readiness-related spares determinations.

Life Cycle Maintenance involves evaluating the actual system's readiness achieved in the Fleet and updating configuration to account for changes and the continuing performance of readiness analyses based upon changing parameters.

The performance data of the system is collected and areas of equipment design and logistics support that are causing problems are highlighted and evaluated for possible solutions.

Life Cycle Maintenance of the system's readiness is conducted by tracking and updating the readiness factors (e.g., system configuration, MTBFs, MTTRs, replacement factors, etc.). A_o is then reassessed using the approved mission scenario, identifying current readiness drivers, and validating the data used in the model. When updating a sparing determination, a cost analysis shall be conducted that considers existing assets before suggesting new allowances.

2.4.3.2 Procedures

The sequence of tasks for Life Cycle Maintenance are:

a. Incorporate all configuration changes into readiness analysis;

b. Update/revise system and part level parameters;

c. Perform system assessment;

d. Evaluate proposed design and logistics support changes on readiness and life cycle costs;

e. Determine the potential readiness improvement and cost effectiveness of re-optimizing the spares allowances; and

f. Update/validate NSAF.

A sample process flowchart can be found in Appendix A. Suggested data sources and outputs are contained in Appendix B.

2.4.3.3 Discussion

RBS is a dynamic process. It is a tool to support the Life Cycle Maintenance of a system/equipment. The process may be rerun to determine the effects of changes in operating conditions. In addition, feedback from the fleet shall be evaluated. Feedback takes the form of Maintenance Material Management (3M) data, Casualty Report data, and the Reliability Assessment process. The sparing load determination is refined from these inputs by incorporating this data into the system's RBS model.

RBS is being applied on new systems, platforms, and existing systems. In addition, special studies are performed to determine new uses for and the effectiveness of RBS analyses.

2.4.3.3.1 Readiness Assessment

The Readiness Assessment Phase of RBS Engineering entails deriving A_o parameters from empirical fleet usage data and assessing the system's achieved A_o. The four primary A_o parameters which will be measured for readiness Assessment are: Mean Time Between Corrective Maintenance Actions (which will be equated to Mean Time Between Failures (MTBF)); Mean Time To Repair (MTTR); Mean Requisition Response Time (MRRT); and Gross Effectiveness (GE).

The achieved A_o will be derived from these four parameters using the following basic formula:

$$A_o = \frac{MTBF * DF}{(MTBF * DF) + MTTR + MSRT}$$

where,

DF = System Duty Factor
MSRT = (GE * $MRRT_1$) + ((1-GE) * $MRRT_2$)

MSRT, $MRRT_1$ and $MRRT_2$ are measured in hours. $MRRT_1$ is the Mean Requisition Time for parts on-site. $MRRT_2$ is the Mean Requisition Time for parts not on-site. A default value of two hours is generally assigned to $MRRT_1$ which represents the average time required to obtain a part from the on-site storeroom. The GE is the probability of the part being available on the ship. If the part is not onboard, an off ship delay time ($MRRT_2$) is incurred.

In actuality, the A_o will be determined by first calculating each of the four parameters (MTBF, MTTR, MRRT, and GE) for each equipment type modeled by the RBS RBD for the system being assessed. These parameters will then be used to update the system's TIGER deck and the A_o determined through the TIGER simulation process.

This methodology will provide the readiness engineer with feedback on how well the system is performing in the "real world" and how well the RBS spares load is supporting the system's requirements. It will also provide feedback on how good the original RBS parameter "estimates" were and how well the system was modeled during the RBS analysis.

The Naval Sea Logistics Center is currently developing an automated RBS assessment tool which will use 3M fleet usage data and an RBS modeling repository database to calculate the A_o assessment parameters cited above, incorporate these parameters into the applicable TIGER deck for a system being assessed, and calculate the achieved system A_o. This tool will also report discrepancies between original parameter assumptions and achieved parameters at the equipment type level, which can then be used to perform "root cause" analyses when merited. This tool, once developed and tested, will be available to all readiness engineers and activities involved in the RBS process. Further details on the NAVSEALOGCEN Readiness Assessment Tool will be provided through updates to this chapter as the development progresses.

2.4.3.3.2 Factors for Revision of Onboard (Retail) Allowances

The issues involved for decision-makers changing any logistics support during the life cycle of a system vary from readiness improvements, budget(s) impacted, activities involved, level of effort required, etc. The question of when to revise supply support decisions, specifically onboard repair parts allowances, does not have a single answer or approach for every weapons system. Additional guidance comes from continued experience on deployed weapons systems and the general guidelines developed from these programs.

The following are some guidelines for revising weapon system spares allowances. The guidelines should account for factors such as configuration change, revised model inputs, operating/mission profile changes, resulting system readiness and cost of On-Board Repair Parts (OBRP) spares, outfitting budgets, commissioning/decommissioning schedules, new item procurement leadtimes, assets/requirements at the NAVICP, and other factors encountered. By accounting for these factors, the readiness of the weapons system can be maintained at the least "life cycle cost" to the Government.

Considerations

The following factors have an impact on the decision to make changes in the onboard allowances for a weapon system:

1) Configuration Changes

The full scope of design changes should be determined for the latest configuration. Incorporating the design changes provides a new baseline to measure projected readiness and cost effectiveness of previous allowances and possible allowance changes. The impact of items added/deleted from the configuration can be ***modeled*** at any time throughout the system's life cycle, but the ***decision to change*** the allowance requirements should be based on a readiness improvement/cost-effectiveness comparison.

2) Revised Model Input Parameters

Key parameters such as MTBF, MTTR, Replacement Factors, and Cost are periodically revised to reflect the actual system operations. These revisions alone can create changes in the model results varying from minor, low cost impacts (e.g., minor BRF or cost updates) to significant, budget-impacting "churn" requiring program office and COSAL budget authorization to implement.

3) Operational/Mission Profile

The Design Reference Mission (DRM) or mission timeline for a platform or system may change during the life cycle of a system. The change in operating profile may have an significant impact on the projected readiness of the system and the supply support required to support the system's readiness objective.

4) System Readiness

The estimated system readiness should be with the latest configuration and model input parameters, including the wartime Design Reference Mission (DRM). System readiness should then be projected based on: the current allowances; the "fully optimized" allowances; and the "enhanced" optimization of allowances. The values and differences of these three options should be listed in a table for comparison.

Independently assessed system readiness parameters (i.e., NWAD or other assessment based on Fleet feedback) should be reviewed and compared with the RBS model's projected values.

5) Range, Depth, and Cost of OBRPs

The total range, depth, and cost of each of the OBRP allowance lists should also be listed in the comparison table cited above. To identify the impact on the outfitting budget for new (ILO) COSALs, the range, depth, and cost of items should be stratified by supply cognizance (i.e., NAVICP-M or DLA cognizance). "Enhanced" allowances will retain the existing spares as "sunk" costs. Fully reoptimizing will cause "churn" with item adds and deletes. The existing allowances and the allowance changes should be summarized for comparison.

6) Outfitting Budgets (COSAL Allotment Fund)

While the best solution for the balance of a weapon system’s life cycle may be to reoptimize, budget considerations are often a driving factor. For example, a fully reoptimized spares set may have $300K in new item requirements (items not currently allowed) and the outfitting budget for an ILO COSAL only allots $100K. In this scenario, one alternative option is to enhance "on top" of the current allowances at an additional cost of $100K, which would provide improved readiness within the allocated budget. A second cost effective alternative would be to optimize allowances to the current readiness level attained by the non-optimized spares mix, thus sustaining current readiness while saving money.

Reoptimizing causes "churn" resulting in items taken off the ship which were previously allowed. The responsibility for these items’ positioning (typically TYCOM) and the associated costs of the churn deletes may also become an issue.

7) Time Remaining In Service (Commissioning/Decommissioning Schedule of the System/Platform)

When a weapon system has been deployed for an extensive period of time, the issue of time remaining in service becomes a factor. The readiness obtained for the cost of fully reoptimizing the system may not be a cost-effective solution for the remaining life of the system. Enhancing the allowances may prove to be more cost-effective; however, the subset of the current allowances that have no demand over a large experience base may have to be considered. Also the problem of storeroom space may need to be addressed.

8) New Item Requirements - Procurement Leadtimes

Along with the time remaining in service, the procurement leadtimes for new items should be considered. A system/platform which has only three years remaining in service will not receive an item that has a two to three year procurement leadtime in time for any reasonable readiness improvement.

9) Assets vs. Requirements (NAVICP)

The assets currently held in the supply system are allocated for various requirements (i.e., planned program requirements for OBRPs, system stock, etc.). Contracts for items may contain termination clauses/penalties that can be additional costs to making allowance changes. When possible, these assets and allocations should be considered.

10) ILO/Availability Schedules

The timing of a ship's Integrated Logistics Overhaul (ILO) availabilities may influence the implementation of a major allowance change. Tied to service life, platforms in the final ILO cycle before decommissioning may require no change to current allowances; platforms with only one or two five-year ILO cycles remaining may achieve reasonable readiness with an enhanced allowance change; and platforms with longer remaining service life may justify full reoptimization.

At the least, the ILO schedule COSAL extract date should be reviewed for deadlines to load the allowance changes into the NSAF. However, it should be noted that changes to the NSAF directly following initial loadout or an overhaul period will not be implemented until the next ILO COSAL extract, unless APL changes occur or ASI (mini-ASI) updates are made.

2.5 RBS ROLES AND RESPONSIBILITIES

An effective RBS program requires a team effort. Inputs are required from: reliability, maintainability engineers and provisioners of the In Service Engineering Activity (ISEA); Integrated Logistics Support (ILS) Managers; HSC Program Managers; NAVICP Program Managers; Item Managers; RBS engineers; and Platform Managers. It must be a concerted effort with absolute participation and cooperation. The Readiness Engineering Team (RET) shall include members from each of these activities. The specific responsibilities for the Program Manager (PM), ISEA, NAVICP, NAVSEALOGCEN, and NAVSEA 041 include the following. The generic term, Program Manager, is used to include: Program Executive Officer (PEO), Direct Reporting Program Manager (DRPM), Ship Program Manager (SPM), and the Equipment/System Acquisition Manager.

2.5.1 Program Manager

The responsible PM (which includes PEO, DRPM, SPM, and the Equipment/System Acquisition Manager) must:

1. Propose and obtain an A_o cost threshold from the CNO Program Sponsor prior to execution. The CNO Program Sponsor will initially identify the A_o threshold in the Tentative Operational Requirement (TOR). This preliminary A_o threshold shall be:

    a. Assigned through a rational allocation process on a new system giving consideration to the interactions between system capability, availability and dependability; and

    b. Established as the firm A_o threshold upon approval in conjunction with the approval of the Integrated Program Summary (IPS) or the Test and Evaluation Master Plan (TEMP) at Milestone II.

2. Follow a life cycle process to meet and measure achievement of the specified A_o objectives.

3. Define system sparing constraints such as total dollar value, total volume, or total weight.

4. Establish, participate and co-chair with NAVSEALOGCEN RETs.

5. Document planning for RBS in the ILSP and funding in the LRFP.

6. Ensure adequate funding is available for RBS analysis.

7. Specify in acquisition contracts that hardware manufacturers:

    a. Submit preliminary technical data required to perform RBS analysis; and

    b. Participate in RETs.

8. Ensure results are documented for all RBS analyses in Navy approved format.

9. Coordinate approval of RBS requirements with NAVSEA 041.

2.5.2 ISEA

Provide technical support functions for the RBS analysis as outlined in NAVSEA 5400.57A[7], including the following:

1. Provide the configuration baseline(s) for the analysis including existing engineering changes.

2. Validate RBS analysis contract deliverables.

3. Be an active member of the RET.

4. Define/develop mission success criteria and RBDs or review/revise contract-delivered RBDs for each configuration in the RBS analysis.

5. Collect, monitor, and review data from technical reports or the fleet to determine the RMA characteristics of the equipment.

6. Conduct RBS analyses for cognizant systems/equipment.

7. Review the results of the RBS analysis to check for consistency with the input parameters and fleet-reported data.

8. Forward changes to provisioning data resulting from RBS analysis to NAVICP-M for inclusion in the WSF.

9. Incorporate RBS analysis in Interim Spares determinations.

2.5.3 NAVICP

1. Participate in the RBS analysis and be an active members of the RET.

2. Perform multi-echelon analysis and coordinate final results with RET.

3. Ensure RET approves multi-echelon results and load NSAF with those results.

4. Make stock purchases using PPRs for all approved RBS requirements.

2.5.4 NAVSEALOGCEN

1. Provide training to the RET.

2. Co-chair the RET with the PM and participate in the RBS analysis.

3. Forward comments/recommendations concerning RBS analysis results to the CNO Program Sponsor.

4. Create/edit documentation to be used by RETs.

5. Analyze/approve the models and software used for RBS analysis.

6. Distribute models, software, and documentation available to users within the Navy.

7. Perform platform level RBS by merging the system level efforts and conducting "mission capable" assessments and tradeoffs at the mission area level.

8. Review and approve all RBS analyses used to compute spares allowances before the spares are loaded into the NSAF.

2.5.5 NAVSEA 041

1. Coordinate approval of RBS requirements with the PM.

2. Be an active member of the RET.

2.6 SUMMARY

A_o is the measure of weapon systems readiness used by the Navy. RBS utilizes analytical techniques to arrive at the most economical and appropriate spares load to attain the A_o specified by the CNO for systems. It does this by using the functional relationship of A_o, Reliability, Maintainability, and Supportability. Other independent analyses provide input into the process such as LSA, Reliability Engineering, and Maintainability Engineering. RBS is a team effort. An exchange of knowledge and ideas is required from a host of individual experts to work toward a common goal. The result is a desirable sparing policy for the Navy that will allow the A_o goal to be optimally met.

References:

1. OPNAVINST 3000.12 of 29 Dec 1987, Subj: Operational Availability of Equipment and Weapon Systems

2. DODINST 5000.2 of 23 Feb 91, Subj: Defense Acquisition Management Policies and Procedures

3. SECNAVINST 5000.2A of 9 Dec 1992, Subj: Implementation of Defense Acquisition Management Policies, Procedures, Documentation and Reports

4. DODI 4140.60 of 5 Jan 1993, Subj: DOD Material Management

5. DODI 4140.1-R of Jan 1993, Subj: DOD Material Management Regulation

6. NAVSUPINST 4442.14A of 4 Jan 1989, Subj: Readiness Based Sparing

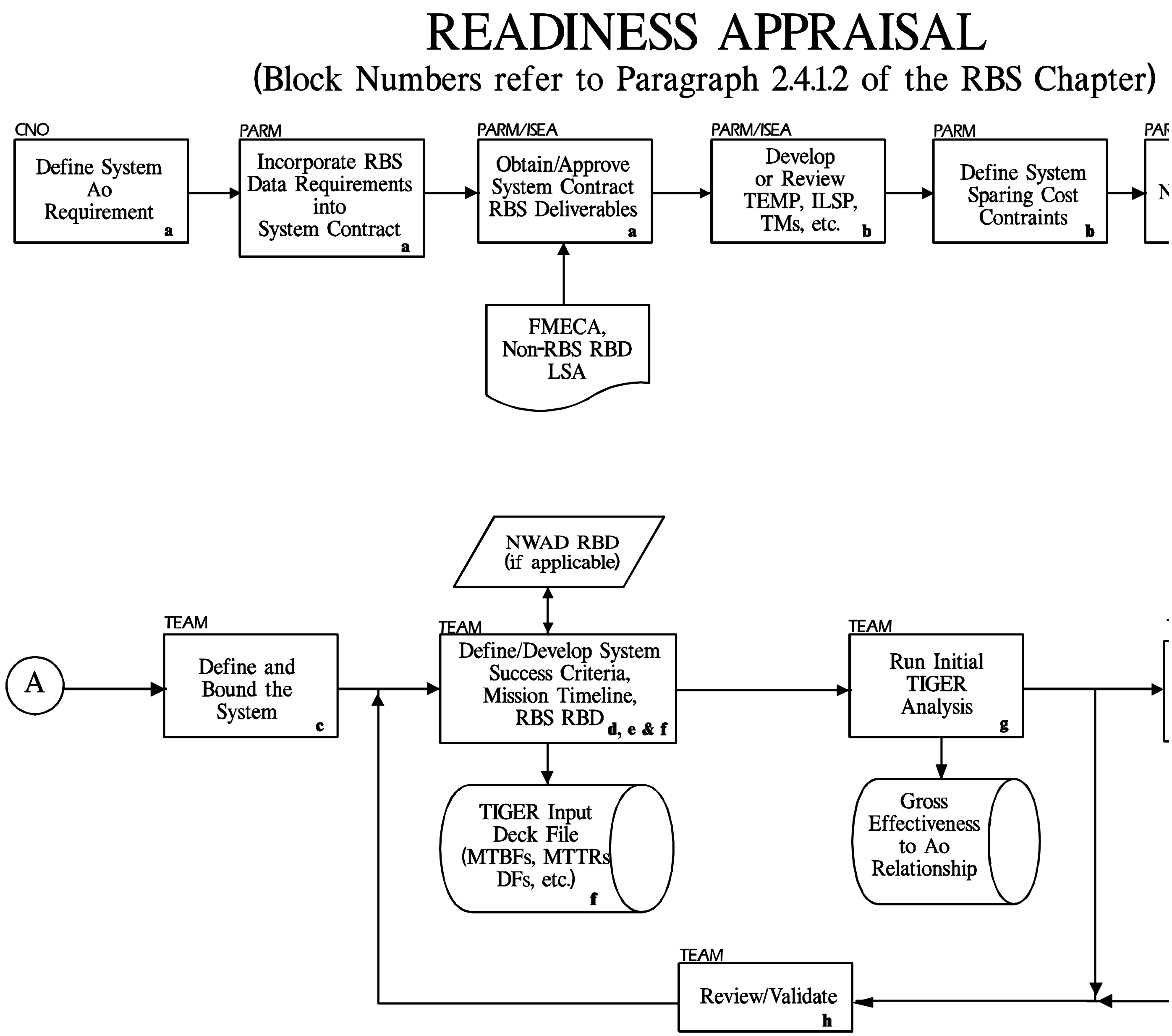
7. NAVSEAINST 5400.57A of 6 Dec 1985, Subj: Delegation of Technical Responsibility and Authority to Engineering Agents

8. NAVSEA Report No. 05MR-001-87 of May 1987, Subj: Reliability Block Standards (available from NAVSEALOGCEN Code 80)

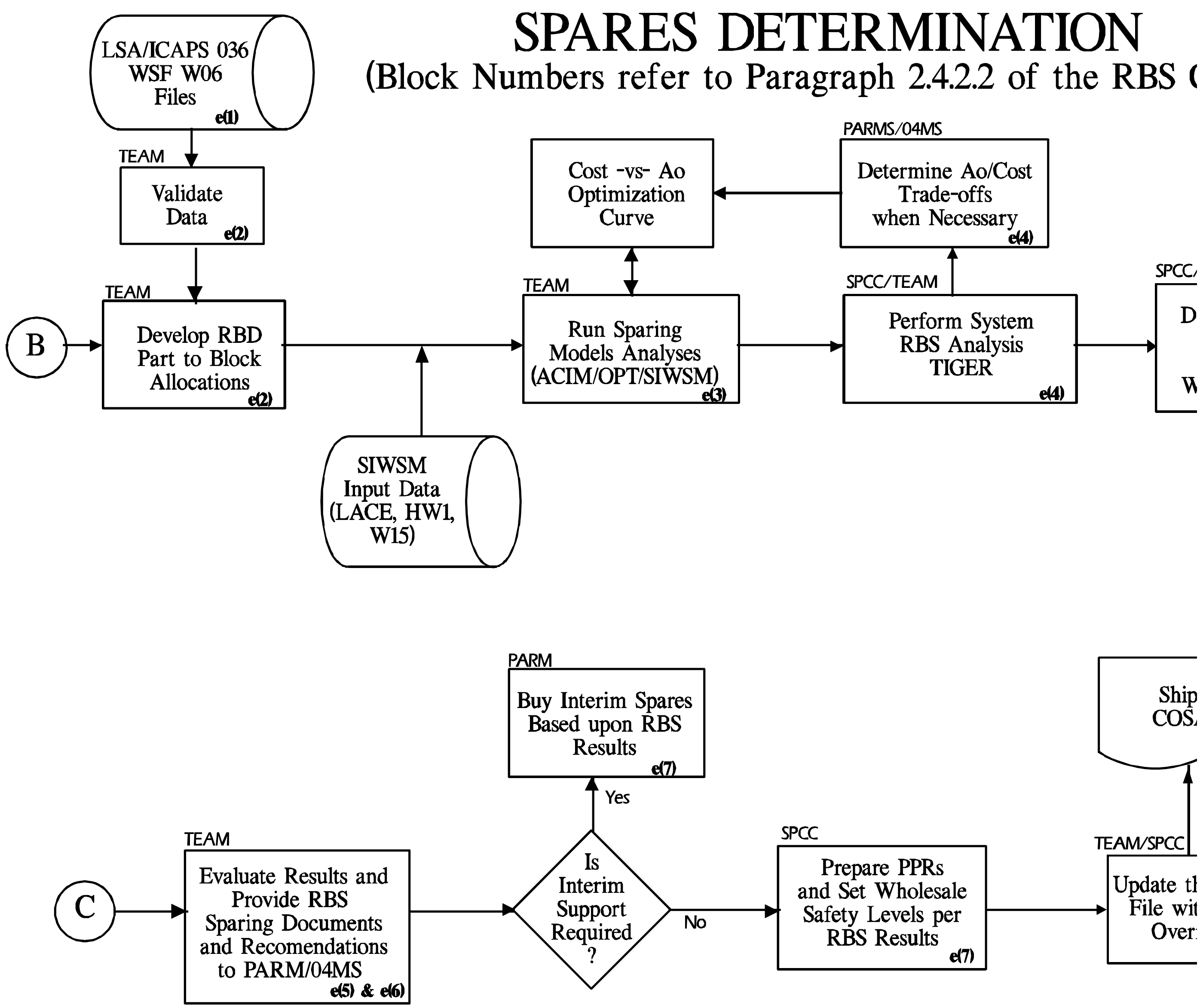
9. NAVSEA TE660-AA-MMD-010 of Sept 1987, Subj: TIGER User’s Manual Version 8.21.

10. SPCC 4400 Ser 0411CR/17 of 8 Feb 1994, Subj: Non-Standard Allowance File (NSAF) manual for NAVICP-M Platform/Program Managers

APPENDIX A FLOW CHART OF TYPICAL READINESS BASED SPARING ANALYSIS PROCES



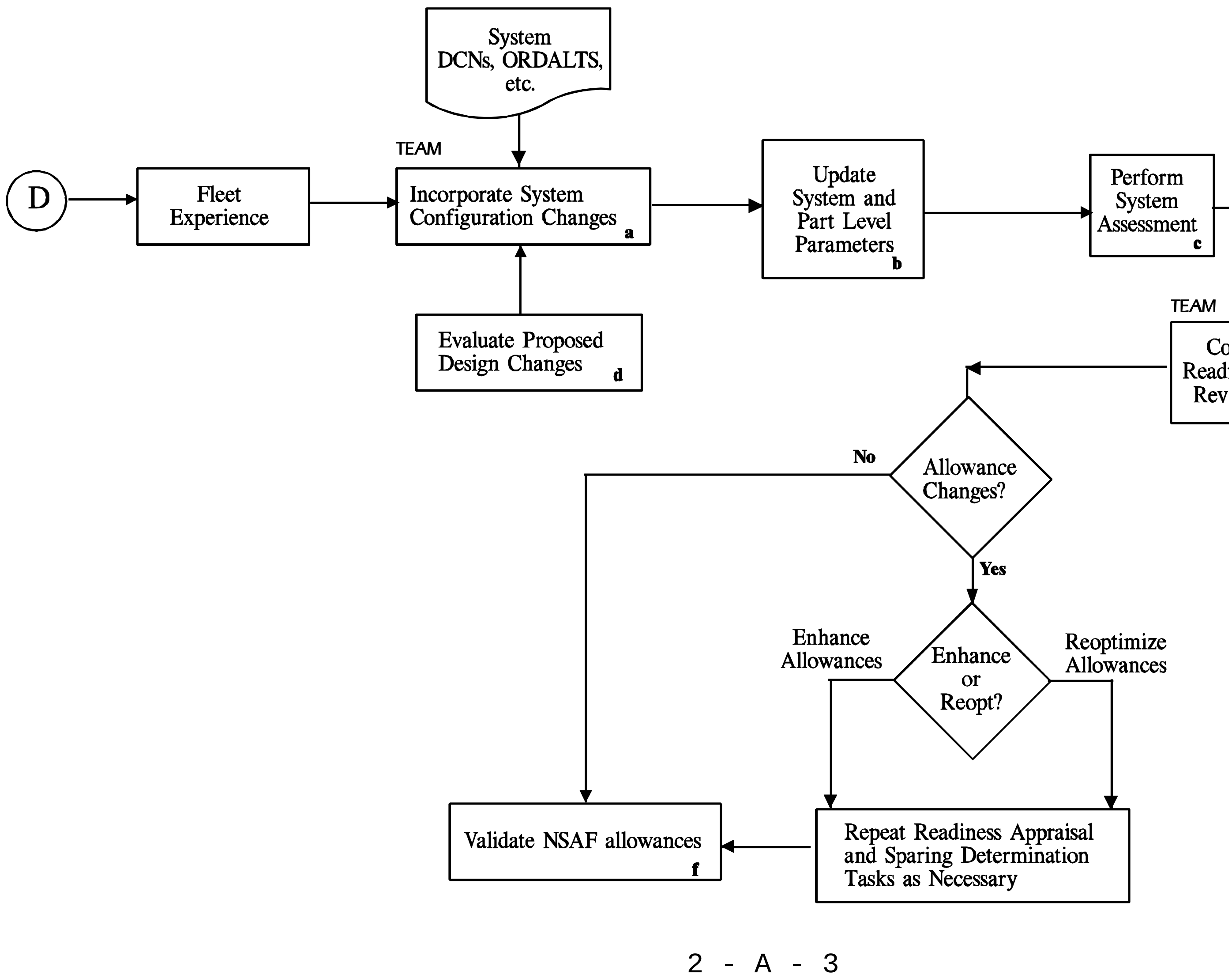
APPENDIX A FLOW CHART OF TYPICAL READINESS BASED SPARING ANALYSIS PROCES



APPENDIX A FLOW CHART OF TYPICAL READINESS BASED SPARING ANALYSIS PROCES

LIFE CYCLE MAINTENANCE

(Block Numbers refer to Paragraph 2.4.3.2 of the RBS Chapter)



APPENDIX B SUGGESTED TASKS AND DATA REQUIREMENTS

Readiness Appraisal Phase

TASK	INPUT TYPE	INPUT SOURCE	TASK DESCRIPTION
2.4.1.2.a **Define System Objectives and Data Requirements**	N/A	- CNO-Provided Readiness Objectives - SOW / CDRL Requirements	* Obtain CNO readiness objectives * Prepare Contract Documents (SOW, CDRL) * Obtain and Review System Contract Deliverables (Ongoing) (e.g., FMECA, RBD, Reliability predictions, LSA reports, etc.)
2.4.1.2.b **Develop or Review Other Program Documents**	- Program Requirements	- TEMP - LRFP - ILSS	* Develop or review other Program Documents (e.g., TEMP, ILSS, LRFP, etc.) * Obtain system spares budget constraint (if required)
2.4.1.2.c **Ascertain System Description and Boundaries for all Applications**	- Mission Requirements - Operational Requirements - Configuration Information	- Mission Needs Statement (MNS) - Operational Requirements Document (ORD) - System Specification - SCLSIS	* Describe the system in terms of a mission profile that includes mission objectives and the system and equipment functions required to achieve these objectives . * A functional narrative should contain: a. System description and boundaries b. Description of System Operations c. Conditions for Critical Failures
2.4.1.2.d **Determine Mission Timeline for all applications**	N/A	- DRM	* Research available sources such as Readiness Improvement Program (RIP) DRM reports, NAVSEA report 05MR-C029-86A, May 1987 (Confidential)
2.4.1.2.e **Determine Mission** **Operating Profile and Establish Mission Success Criteria**	- Operational Requirements - Mission Requirements	- ORD - Mission Needs Statement - Mission Profile	* Define system operations in each operating mode or Mission Phase. * Describe the system in terms of operating rules or data that identify the effects of equipment failures on system and mission success. Consider the capabilities of the logistics support system to repair equipment failures. Include the following: a. Variable duty cycles b. Variable repair time (MTTR) c. Allowable equipment downtime

APPENDIX B SUGGESTED TASKS AND DATA REQUIREMENTS
Readiness Appraisal Phase (cont'd)

TASK	INPUT TYPE	INPUT SOURCE	TASK DESCRIPTION
2.4.1.2.f **Develop RBD**	- Reliability Program - Contract Delivered RBD - R & M Parameters - Rules of Homogeneity (tasks d-g)	- MIL-STD-785B - MIL-STD-756 - NAVSEA Report No. 05MR-001-087 - NWAD RBD - RBD & Mission Timeline	* Describe the equipment graphically using Reliability Block Diagrams (RBDs) and equipment parameters. Develop the following parameters and apply RBS Rules of Homogeneity. a. Duty Factor. The percent of total uptime per year (less overhaul time) the component/system will be stressed. b. Reliability. The predicted or demonstrated Mean Time Between Critical Corrective Maintenance (MTBCMc). c. Maintainability. The predicted or demonstrated Mean Time To Repair (MTTR). d. Series/Parallel (LRUs in series within a block) e. Duty Cycle (Same duty cycle within a block) f. Maintenance Plan (Major non-repairable assemblies) g. Equipment Criticality (Mission Essential/Non-Mission Essential) * Transfer the RBD/Timeline data to TIGER Model formats
2.4.1.2.g **Perform RMA Simulation Modeling**	- RBD Data in TIGER Model Format	- TIGER Input File	* Run RMA simulation to predict reliability, maintainability, and availability performance. Compare results with DRM, RBD, and data matrices to ensure they reasonably represent the mission scenario.
2.4.1.2.h **Evaluate Preliminary Results & Identify Readiness Drivers**	- Simulation Results	- TIGER Output	* Following the critical review of data from the simulation establish the achievable Ao thresholds.
2.4.1.2.i **Perform Tradeoff Analysis**	- Simulation Results	- TIGER Input File - Critical Equipment List	* A sensitivity analysis can be performed to determine if tradeoffs can be made between readiness factors: reliability, maintainability, supportability. For example, tradeoffs may reveal that improvements to maintenance procedures would reduce MTTR and improve Readiness most cost effectively. * Other effectiveness indices such as mission reliability or mission capability shall be reviewed when appropriate

APPENDIX B SUGGESTED TASKS AND DATA REQUIREMENTS
Spares Determination Phase

TASK	INPUT TYPE	INPUT SOURCE	TASK DESCRIPTION
2.4.2.2.e(1) **Collect Data**	- Provisioning Data - Weapons Systems File - Failure Modes - Maintenance Levels	- PTD(LSA-036, ICAPS-036) - WSF(W06DX1) - FMECA - LORA	* Receive and validate input data, provisioning technical documentation (PTD) H and H1, LSAR data records from LSA or other data sources. Compare with existing WSF data. Resolve discrepancies between data sources.
2.4.2.2.e(2) **Review Data and Allocate to RBD**	- Part-level data	- Data from task 2.4.2.2.e(1)	* As a minimum review and validate MEC and RF data. Update as required. Components should be coded MEC 1 only if the failure of the item will result in total failure of a critical component of the next higher assembly (RBD block). - MEC 5 assigned if the item is needed for personnel safety. - MEC 7 if the failure results from wearout or will result in partial degradation of the next higher assembly (RBD block) - MEC 3 assigned for non-critical items * Compare the summation of the (Replacement Factor (RF) X population)of MEC 1, MEC 5 and MEC 7 items to the failure rate of the RBD block * Using a top-down-breakdown methodology (e.g., reference designator - REFDES) allocate parts to the associated block in the RBD.

APPENDIX B SUGGESTED TASKS AND DATA REQUIREMENTS
Spares Determination Phase (cont'd)

TASK	INPUT TYPE	INPUT SOURCE	TASK DESCRIPTION
2.4.2.2.e(3) **Execute Sparing Models**	- Part Data	- RBS Part Files	* Selectively optimize critical blocks in the system using the Availability Centered Inventory Model (ACIM) for ship applications. * Apply a system-level optimization technique (e.g., Override Placement Utility (OPT)) to determine readiness overrides * Use demand-based sparing (i.e. FLSIP) for all other items. * Use a Stock Number Sequence List (SNSL) emulation program to account for commonality in the system/platform and produce a final suggested stock list.
2.4.2.2.e(4) **Calculate Ao Resulting from onboard spares**	- Part Data - Spares List	- Part File - Suggested Stock List - Initial Ao or Budget Goal	* Using existing RBS program utilities, calculate the storeroom effectiveness of the suggested stock list. Return this value to the TIGER RMA simulation and assess the impact of the suggested spares on the projected system Ao. * Perform Ao/Budget tradeoffs when necessary.
2.4.2.2.e(5) **Evaluate results**	- Resulting Spares List & Projected System Ao	- SNSL List - SNSL Summary - TIGER Ao	* Review the results of the analysis for accuracy and completeness. Whenever possible, include Technical and Fleet Representatives in the final review.

APPENDIX B SUGGESTED TASKS AND DATA REQUIREMENTS
Spares Determination Phase (cont'd)

TASK	INPUT TYPE	INPUT SOURCE	TASK DESCRIPTION
2.4.2.2.e(6) **Report Results**	- Analysis Results	- RBD - Critical Equipment List - Data Revisions - Allowance List & Cost Summary - System Ao	* Produce a Final Report documenting the operating profile, RBD, projected Ao, critical equipments lists, data validation results, recommended spares allowances and costs, and any other pertinent assumptions made in the readiness analysis.
2.4.2.2.e(7) **Interim Spares and Planned Program Requirements (PPRs)**	N/A	- SNSL List	* Plan for program requirements (Interim spares & PPRs) Compare SNSL List to NIIN requirements and determine if Interim Spares are required.
2.4.2.2.e(8) **Load Initial NSAF**	- Readiness Overrides	- RBS Part File	* NSLC/NAVICP-M load the NSAF with the approved allowance quantities and overrides for each applicable configuration.

APPENDIX B SUGGESTED TASKS AND DATA REQUIREMENTS
Life Cycle Maintenance Phase

TASK	INPUT TYPE	INPUT SOURCE	TASK DESCRIPTION
2.4.3.2.a **Incorporate all design configuration changes into readiness analysis**	- Design Changes - Provisioning Part Files - RM&A model	- ECP, DCN, Ordalt, Mechalt - PTD (LSA-036, ICAPS-036, or other part files) - RBD & RMA Model Input	* Update configuration data with all valid design changes for each system configuration baseline in the readiness analysis. * Revise the RBD if necessary
2.4.3.2.b **Update/Revise system and part level parameters**	- R&M Predictions - Fleet Feedback	- Revised Prediction Reports - MDS (3M) - CASREP FILES - Reliability Databases - WSF	* Revise parameter estimates such as MTBF, MTTR, MRRT as required. * Use Fleet Feedback (e.g. 3M, CASREP, Reliability Databases) to revise demand estimates (i.e., BRF, ARF, SCRF) * Use WSF to update part parameters (e.g., cost)
2.4.3.2.c **Perform System Assessment**	- Readiness Model Inputs - Fleet Feedback	- Revised Model Inputs (from para a & b) - MDS (3M) - CASREP Files - Other Fleet reports	* Run the revised data through the wartime mission simulation to determine the system Ao and the revised critical equipments list. * Obtain operations assessment of system Ao from Fleet data. This may come from the Naval Weapons Assessment Division (NWAD) or directly from 3M/CASREP reports of system downtime. Compare the operations assessed values with the modeled war-time Ao values using updated parameter estimates. (Note: the assessed Ao may vary due to peacetime operations)
2.4.3.2.d **Evaluate proposed design and logistics support changes on readiness and life cycle costs.**	- Simulation Results	- Critical Equipment List - Proposed ECPs/Support Changes	* Run the revised data through the wartime mission simulation to determine the system Ao and the revised critical equip-ments list. Incorporate the proposed ECPs in the model. Assess the impact of the ECP on Ao and determine the associated cost.

APPENDIX B SUGGESTED TASKS AND DATA REQUIREMENTS
Life Cycle Maintenance Phase (cont'd)

TASK	INPUT TYPE	INPUT SOURCE	TASK DESCRIPTION
2.4.3.2.e **Determine the potential readiness improvement and cost effectiveness of reoptimizing**	- Spares Lists	- RBS SNSL Outputs	* Perform cost/readiness analysis comparing reoptimized spares allowances to existing and "enhanced" allowance lists. Develop decision criteria to determine if revised allowances are necessary. * Considerations may include: - Expected Readiness Improvement and Cost - Existing Assets - Remaining system life (Decommissioning) - COSAL Allotment (New Item) Budgets - Allowance deletions - Leadtimes for new items and potential contract termination costs - Technical Factors (e.g., Volume/Weight constraints) - ILO Schedules - Time Since Initial Installation
2.4.3.2.f **Update/Validate NSAF**	- Revised onboard allowances	- RBS part file - NSAF Input File	* NSLC/NAVICP-M load NSAF with revised allowances

APPENDIX C GLOSSARY

036 Format	MIL-STD-1388 (LSA) Provisioning Parts List
3M	Navy Maintenance Material Management Tracking System maintained by NAVSEALOGCEN
ACAT	Acquisition Category assigned by dollar value and complexity
ACIM	Availability Centered Inventory Model
ACIR	Availability Centered Inventory Rule
A_i	Inherent Availability
Allowance	Spare part aboard ship (and quantity of the item)
A_o	Operational Availability
APL	Allowance Parts List
ARF	Application Replacement Factor
ASI	Automated Shore Interface
BCS	Baseline Comparison System
Block	A block within a Reliability Block Diagram
BRF	Best Replacement Factor
CARAT	Computer Aided Reliability Analysis Tool
CASREP	Casualty Report
CDRL	Contract Data Requirements List
CNO	Chief of Naval Operations
COSAL	Coordinated Shipboard Allowance List
Critical Item	An item which upon failure causes its parent equipment to lose primary function(s)
DC	Duty Cycle
DCN	Design Change Notice

Demand Based	Method of spares determination based on estimates of an item's replacement factor
DF	Duty Factor
DODI	DoD Instruction
DODINST	Department of Defense Instruction
DLA	Defense Logistics Agency
Downtime	Measured time the system is considered unavailable to perform its primary mission
DRM	Design Reference Mission
ECP	Engineering Change Proposal
Enhanced	An increase in optimized allowances Optimization above an existing assets level to achieve the target A_o
Equipment Number	A unique number assigned to each block in the RBD
Equipment Type	A unique number assigned to each occurance of a block in the RBD that represents the same reliability and maintainability parameters in all applications
Equipment Type File	A file used to store the equipment type parameters in order to link TIGER with ACIM
FBM	Fleet Ballistic Missile
FLSIP	Fleet Logistics Support Improvement Program
FMECA	Failure Mode, Effects, and Criticality Analysis
Fully Optimized	An optimized spares set without considering existing assets
FY	Fiscal Year
GE	Gross Effectiveness (also known as Supply Effectiveness)
ICAPS	Interactive Computer-Aided Provisioning System

ICP	Inventory Control Point
ILO	Integrated Logistics Overhaul
ILS	Integrated Logistics Support
ILSP	Integrated Logistics Support Plan
ILSS	Integrated Logistics Support Summary
IPS	Integrated Program Summary
ISEA	In-Service Engineering Activity
LORA	Level Of Repair Analysis
LRFP	Logistics Requirement Funding Plan
LRG	Logistics Review Group
LRU	Lowest Replaceable Unit
LSA	Logistics Support Analysis
LSAR	Logistics Support Analysis Record
MDT	Mean Downtime
MEC	Mission Essentiality Code
Mission Critical	A function or equipment which is required for mission success
Mission Operating Profile	The operational requirements of the system to meet the mission success criteria throughout the mission timeline
Mission Success Criteria	The criteria used to establish the functional requirements for a successful mission
Mission Timeline	The sequence of unique mission phases and durations defining the "average" mission requirements
MLDT	Mean Logistics Delay Time
MNS	Mission Needs Statement
MODFLSIP	Modified FLSIP
MRRT	Mean Requisition Response Time

MSRT	Mean Supply Response Time
MTBCMc	Mean Time Between Critical Corrective Maintenance
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
NAVICP-M	Navy Inventory Control Point, Mechanicsburg (formerly SPCC)
NAVSEA	Naval Sea Systems Command
NAVSEALOGCEN	Naval Sea Logistics Center
NAVSUP	Naval Supply Systems Command
NIIN	National Item Identification Number
NME	Non Mission Essential
NSAF	Non Standard Allowance File
NSLC	Naval Sea Logistics Center
NSN	National Stock Number
NWAD	Naval Warfare Assessment Division
O/R	Override
OBRP	On Board Repair Part
OPNAV	Office of the Chief of Naval Operations
OPNAVINST	OPNAV Instruction
OPT	Override Placement Utility
Optimize	Determining the best combination of items to achieve a desired objective while expending the least amount of resources
ORD	Operational Requirements Document
ORDALT	Ordnance Alteration
PARM	Participating Manager
PPL	Provisioning Parts List

PPR	Planned Program Requirements
PTD	Provisioning Technical Documentation
R&M	Reliability and Maintainability
RBD	Reliability Block Diagram
RBS	Readiness Based Sparing
REFDES	Reference Designator
RET	Readiness Engineering Team
RF	Replacement Factor
RIP	Readiness Improvement Program
RMA	Reliability, Maintainability, and Availability
SCLSIS	Ship Configuration and Logistics Support Information System
SCRF	Ship Class Replacement Factor
SECNAVINST	Secretary of the Navy Instruction
SIWSM	Secondary Item Weapon System Management
SM&R	Source, Maintenance & Recoverability
SNSL	Stock Number Sequence List
SOW	Statement Of Work
SRI	Storeroom Item
TEMP	Test and Evaluation Master Plan
TIGER	NAVSEA's RMA simulation program for ships and systems
TM	Technical Manual
TOR	Tentative Operational Requirement
TRF	Technical Replacement Factor
TYCOM	Type Commander

UIC	Unit Identification Code
Uptime	Measured time the system is considered available to perform its primary mission
WSF	Weapon Systems File