DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, D.C. 20350-2000

IN REPLY REFER TO

OPNAVINST 3000.12A
N40
02 SEPT 03

OPNAV INSTRUCTION 3000.12A

From: Chief of Naval Operations

Subj: OPERATIONAL AVAILABILITY OF EQUIPMENTS AND WEAPONS SYSTEMS

Ref: (a) CJCS Instruction 3170.01C dated 24 June 2003
(b) DODD 5000.1 of 12 May 2003
(c) DODI 5000.2 of 12 May 2003

Encl: (1) Operational Availability Handbook, June 2003

1. Purpose

a. Provide policy regarding Operational Availability (A_o) as a primary measure for readiness of naval systems, subsystems, and equipment.

b. Provide definitions and equations for calculating A_o and identifying sources of data for calculating and monitoring A_o.

2. Cancellation. OPNAVINST 3000.12 dated 29 Dec 1987.

3. Scope. This instruction applies to all naval systems, subsystems, and equipments, excluding systems and equipments under the cognizance of the Director, Naval Nuclear Programs. For brevity in this instruction and the enclosed Handbook, the terms "system" or "systems" are used. Policy, equations and definitions remain essentially unchanged; however, the guidance is updated.

4. Concepts. A_o provides a measure of time or probability that a system's capabilities will be available for operational use when needed. A_o is a critical, dominant element of the overall capability a system provides. It determines the real and sustainable capability that system users can realistically achieve in an operational environment within planned resource levels.

5. Discussion

a. Early and consistent focus on A_o benefits resource sponsors and Program Managers (PMs). It helps sponsors balance real capabilities and total costs. It enables PMs to design, develop and deliver to the operational users systems that provide affordable, sustainable capabilities. It also enables them to improve system capabilities periodically, while maintaining or improving readiness and cost performance.

b. For weapon systems and equipments in design, development, production and test, focusing on A_o provides information on relative costs and readiness benefits for use in making trade-off decisions in and among design and support alternatives.

c. For systems in operational use, A_o analyses highlight operational performance as measured against expected performance. This provides input to PMs for potential design or support improvements.

6. Policy

a. A_o is a primary measure of readiness for weapon systems and equipments. It is determined by reliability (Mean Time Between Failure), maintainability (Mean Time to Repair), and supportability (Mean Logistics Delay Time).

b. A_o thresholds and objectives shall be established for weapon systems and equipments and included in all statements of required or desired capabilities per references (a), (b) and (c).

c. The definitions, methods and criteria contained in enclosure (1) will be used to estimate, establish, analyze, and measure A_o.

d. A_o analyses shall be conducted concurrently with system design and development for the purpose of guiding and validating system design, support planning, and resource management.

e. A_o analyses shall be a program management responsibility inherent to total system life cycle management for the purpose of ensuring that fielded systems are effectively and affordably sustained and improved over time.

7. Actions

a. Resource sponsors within the Chief of Naval Operations (CNO) shall establish A_o thresholds and goals for all weapon systems and equipments under their cognizance and ensure compliance.

b. CNO (N4) shall assess requirements and resources for new and fielded systems (including modifications and modernizations) and shall advise resource sponsors and CNO on what actions may be taken to improve cost or readiness of naval systems, or to better manage risks.

c. Commander, Naval Supply Systems Command shall provide assistance when requested in defining supportability data suitable for use in A_o analyses and assist with analyses of A_o throughout the system's life cycle.

//s// CHARLES W. MOORE JR.
By direction

Distribution:

SNDL	A1A	(SECNAV)
	A1B	(UNSECNAV)
	A1F	(ASSTSECNAV FMC)
	A1G	(ASSTSECNAV IE)
	A1H	(ASSTSECNAV MRA)
	A1J	(ASSTSECNAV RDA)
	A1J1	(all PEOs)
	A2A	(DON Staff Offices (AUDGEN, CNR, OLA, NAVINSGEN, OPA, DONPIC only))
	A5	(Chief of Naval Personnel)
	A6	(Commandant of the Marine Corps)
	B1B	(Offices of the Secretary of Defense) (USD(AT&L), DUSD(L&MR), DoD/COMP, ASD/PA&E, IG/SD, ASD/FM&P, ASD/P&L, USD/P, SECDEF//MILPERSDIV only)
	21A	(Fleet Commanders)
	24J1	(Marine Corps Force LANT)
	24J2	(Marine Corps Force PAC)
	41A	(Commander, Military Sealift Command)
	E3A	(Laboratory Research)
	FH1	(Medicine and Surgery)
	FKA1A	(Air Systems Command)
	FKA1B	(Space and Naval Warfare Systems Command)
	FKA1C	(Facilities Engineering Command)
	FKA1F	(Supply Systems Command)
	FKA1G	(Sea Systems Command)
	FT1	(Chief of Education and Training)
	V12	(Marine Corps Combat Development Command)
	V23	(Marine Corps Logistics Base)
	V24	(Marine Corps Reserve Support Command)
	V28	(Marine Corps Systems Command)
		OPNAV (Principal Officials only)

Copy to:

SNDL	B5	(Coast Guard) (COMDT COGARD only)
	22A	(Fleet Commanders)
	23C	(Reserve Force Commander) (Commander, Naval Reserve Forces only)
	24	(Type Commanders)

26F3	(Operational Test and Evaluation Force)
E7A	(Audit Service)
FD	(Shore Activities under the Command of COMNAVMETOCCOM as delegated by the CNO)
FF5	(Safety Center)
FF42	(Postgraduate School)
FA2H	(Communications Security Material System)

Operational Availability Handbook

A Practical Guide for Military Systems, Sub-Systems and Equipment

June 2003

Enclosure (1)

Acknowledgments

Project Sponsor

Mr. Mark W. Honecker, Deputy Chief of Naval Operations, Fleet Readiness & Logistics (DCNO (FR&L)), Director, Logistics Planning and Innovation Division (N40)

Project Manager

Mr. James G. Smith, Deputy Chief of Naval Operations, Fleet Readiness & Logistics (DCNO (FR&L)), Logistics Planning and Innovation Division (N40), Strategic Planning, Logistics Processes and Acquisition Logistics Cell (N401A)

Technical Editors

Mr. Joel M. Manary, SAIC, Senior Systems Engineer

Mr. Andrew T. Price, RGS Associates, Inc. Principal Policy Advisor

Mr. Louis W. Weinstein, RGS Associates, Senior Policy Advisor

TABLE OF CONTENTS

SECTION ONE - Introduction to Operational Availability

SECTION TWO - Operational Availability Studies and Analyses

Appendices

List of Figures and Tables

SECTION ONE

INTRODUCTION TO OPERATIONAL AVAILABILITY

1.1 Introduction

This handbook addresses the concept of operational availability and its impact on system design, operational supportability and life cycle cost.. Operational Availability is a calculation of various supportability functions at the systems level. The desired result of performing these calculations, coincident with system design, is to provide fielded systems with greater capability for the warfighter and enhanced support at the best possible value. Operational Availability (A_o) provides a method of predicting and assessing system performance and readiness during the acquisition process and then becomes the performance benchmark during initial operational capability (IOC), deployment and operations/maintenance cycles. This handbook is a practical guide, providing several useful equations and checklists to assist a Program Manager to understand and use A_o is a useful metric in the design and support of a weapon system.

The A_o of war fighting systems and equipment is a key component to DoD's ability to prevail in battle by ensuring readiness. Operational Availability is a Key Performance Parameter (KPP) that the weapon system is suitable for production and sustainable through its life cycle. As a KPP, an Acquisition Program Manager must calculate A_o and demonstrate that the supportability strategy selected for the weapon system will achieve the required A_o threshold. Supportability and life cycle cost considerations are integral to all trade-off decisions.

1.2 Understanding A_o

A_o is a probability function of reliability, maintainability and supportability components. Very simply, this equation is:

$$A_o = \text{System Up Time / Total Time (Up Time + Down Time)}$$

Total Time has two sub-factors, UP time and DOWN time. UP time is the time a system is operational between failures. DOWN time is the time the system is not operational

Now, what does this statement mean? First, Operational Availability is a **supportability goal**; the satisfaction of this goal will be determined during the system's design/test, and then the goal becomes a metric for evaluating operational performance through-out the system life cycle. Operational Availability is the supportability calculation of the equipment/system (hardware & software) in terms of predicted Reliability (R) called Mean Time Between Failure (MTBF) and predicted Maintainability (M) in terms of Mean Time To Repair (MTTR) and designed supportability, called Mean Logistics Delay Time (MLDT). As the hardware and software are designed (or selected in the case of COTS), the logistics support system must also be designed (selected concurrently to meet program requirements. Figure 1.1 displays the interaction of the measures calculated to determine A_o.

The first calculations performed to generate an A_o determine inherent system reliability excluding consideration of support functions (e.g., re-supply, transportation, and repair); this metric is called **Inherent Availability (A_i).** The predicted R&M values are used in a basic A_i equation as shown in Figure 1-1.

After A_i has been determined, we now are ready to add the supportability calculation to consider logistics support system impacts on system performance. This is described as 'Mean Logistics Delay Time' (MLDT). Figure 1-1 helps us to better understand the difference between A_i and A_o:

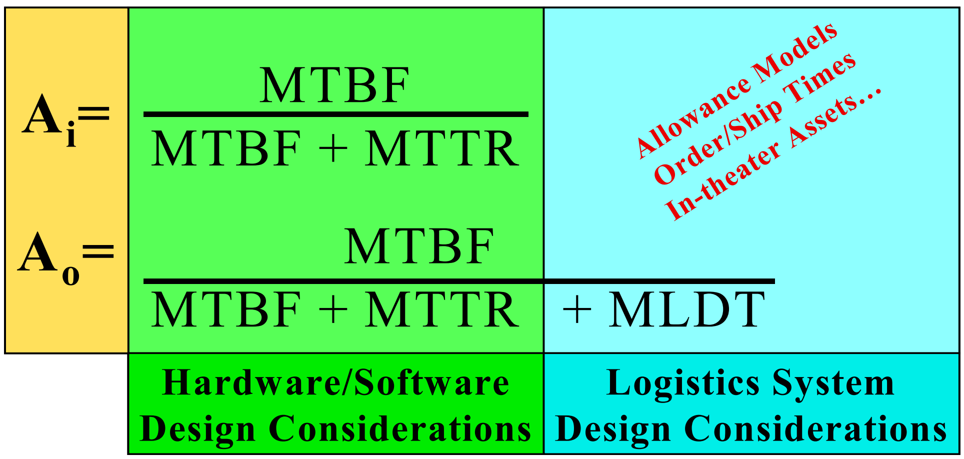


Figure 1-1: Logistics Impact on Operational Availability

The benefits of calculating A_i principally apply to the design and support of electronic systems. A_i calculations for Hull, Mechanical and Electrical (HM&E) systems are based on very predictable wear and tear experience. For example, a bearing will have a historical wear-out rate based on values for temperature, pressure and operating time. Using these type variables allows development of preventive maintenance schedules based on predictable failures. With this information, the supply chain can anticipate demand and procure and position spares and repair parts in anticipation of the wear-out. On the other hand, electronics components have random failure rates and failures can only be described as the probability of failure over a period of time.

Now let's look at where we obtain the information required to determine the variables shown in Figure 1-1. We start with the A_i or reliability calculation. Reliability is a probability function based on the actual physical components in the design and how often they randomly fail during a fixed time period. The equation is:

$$R = e^{-\lambda t}$$

With R being a decimal of less than one, e is the natural logarithm, λ (lambda) is the component failure rate and t is the time period over which the failures are tracked. Often R is defined as MTBF. This is a simple concept based on the component failure rate (λ) over some time period. For example, if a component failure rate is 500 failures per million hours it follows that the reliability (MTBF) is equal to a million hours (test time) divided by 500 failures, which generates an MTBF of 2000 hours. Therefore, MTBF is the reciprocal of the failure rate.

Now that we have the reliability based MTBF the next component to calculate is the MTTR. This is the time it takes to remove interference, remove, replace and test the failed component, return the equipment to its original condition, and replace and retest any system/interference removed to get to the failed equipment. Next is MLDT, the cumulative time required by all logistics processes to support the requisite repair. MLDT may be a difficult factor to quantify because it includes parameters such as depot repair turn around time (TAT), administrative delay time, supply response time and other factors that impact the maintenance/repair effort (see appendix 3 for definitions). MLDT factors generally are combined measures that include Customer Wait Time (CWT) that is made up of three possible measures - Mean Supply Response Time (MSRT), mean outside assistance delay time (MOADT) and mean administrative delay time ($M_{adm}DT$). Thus, the A_o equation can be restated as:

$$A_o = MTBF / (MTBF + MTTR + MLDT)$$

Or

$$A_o = MTBF / (MTBF + MTTR + MSRT + MOADT + M_{adm}DT)$$

It is easy to see that because MTBF is both above and below the equation line, changes in its value have relatively limited impact on the A_o. MTTR, which is usually a small number (for electronic systems), also has minimal impact on the overall A_o value. The main driver of A_o is MLDT, which is often called the **support system effectiveness measure**. Changes in MLDT such as transportation times and depot TATs, typically have large values usually measured in days, weeks or months and, thus, have a major impact on the denominator for the calculation. Provided below is a simplified example inserting values for the variables:

XY system: MTBF of 1000 hours
MTTR of 3 hours
MLDT of 3000 hours

$$A_o = 1000 / (1000 + 3 + 3000) = .25$$

To a fleet user, this A_o would be viewed as exceptionally poor and in all likelihood would not meet the needs of the war fighter.

So where would we apply focus to improve the A_o value? Using this same example, let's look at a major weapon system capability improvement program that has a significant impact on the Fleet in terms of time to install and costs millions of dollars to implement. Let’s say for this example that the improvement in Reliability (MTBF) increases by 30% (a very significant improvement in reliability) but does not improve the supportability factors of the system. Using this new MTBF figure (1300 hours) to recalculate A_o:

$$A_o = 1300/ (1300 + 3 + 3000) = .30$$

Fleet users will not notice this .05 increase in the A_o value even though the reliability has been improved by 30%. Therefore, a large increase in reliability has little measurable impact on A_o.

Now, if an investment is made in improving the supply chain (an action having minimum direct impact on the Fleet) and MLDT is reduced from 3000 to 1200 hours, the impact on A_o is more significant and results in an A_o value of .45:

$$A_o = 1000 / (1000 + 3 + 1200) = .45$$

This reduction in MLDT results in an 80% improvement in the A_o from .25 to .45. From this example, we clearly see that once a system is fielded, increasing the effectiveness of the logistics support pipeline is more effective than enhancing the system reliability. When MTTR is a large number, maintenance improvements/time reductions can also have a significant impact.

To illustrate what a PM must understand regarding A_o, let us set up a typical A_o optimization problem as an example:

Assume the Navy has 148 of a certain type of weapon system for performing a certain mission that is considered essential to national defense. The Navy needs all 148 of these weapons to be ready to satisfy mission requirements. Originally, over 200 of these weapons were procured because it was predicted that about 50 would be down at any given point in time for scheduled and corrective maintenance.

Currently only 74 are available for missions. The 50 % Operational Availability (A_o) (74/148) indicates that all Integrated Logistics Support (ILS) elements are not performing as planned. Failure rates have increased over time and material obsolescence has resulted in many needed items no longer being manufactured. This weapon system still performs its mission at a cost of $10M per ship/year. Parts obsolescence and diminishing manufacturing sources are expected to become worse each year.

The Fleet is preparing a Initial Capabilities Document (ICD) expressing the need for a replacement weapon system. The Resource Sponsor and Fleet representatives have identified replacement systems and are determining how many of the newer, more reliable systems it would take to replace the existing system.

You, the program team member responsible for determining A_o, have been asked for your recommendation considering the following:

- Alternative system (A) costs $30M per copy, and is expected to deliver an A_o of 85%. The vendor for alternative (A) reports that it is estimated that the system will require $5.5M per system/per year to operate and maintain.
- Alternative system (B) costs $28M per copy, and is expected to deliver an A_o of 80%. The vendor for system (B) says their system will cost $7M per system/ per year to operate and maintain.
- Both systems offer A_o improvements over the current system. Assuming a 20-year life cycle, which system and how many systems should be procured?

The scenario presented above is typical of the type of analysis that a Program Manager will be expected to complete in order to present a supportability strategy. This guide will provide the process to make the necessary tradeoffs.

1.3 Primary Acquisition Program Manager / Resource Manager Responsibilities

This handbook was prepared to help Program Sponsors, Program Managers, Resource Sponsors, In-Service Engineering Agents (ISEA), and other systems acquisition participants optimize operational availability. This handbook focuses on the supportability aspects of A_o and will introduce new support concepts such as Contractor Logistics Support (CLS) and Full Service Contracting (FSC) coupled with Commercial-Off-The-Shelf (COTS) that are currently being implemented in order to reduce MLDT and reduce system cost. The following key points are provided as a preview of the major issues, which will be addressed in this guide:

1. The Navy Resource Sponsor must document A_o as a Key Performance Parameter (KPP) in requirements documents to form the basis for decision support analyses. If A_o is not a KPP, a waiver is required from the Navy Requirements Oversight Council (NROC).

2. System Effectiveness (SE), which is the direct link to warfare requirements, provides the basic foundation on which the entire system acquisition decision support process is based.

3. A_o, as defined and used in this handbook, is a relatively simple concept. Underlying the A_o index, however, are a number of supporting assumptions, data relationships, and support system interactions. These support system interactions are not only more specific but also more complex than the basic A_o index seems to imply.

4. To understand and effectively evaluate A_o and cost during the systems acquisition process, the Resource Sponsor and others must become familiar with the separate components of the A_o index. These are Reliability (R) defined in terms of MTBF, Maintainability (M) in terms of MTTR, and Supportability in terms of MLDT.

5. Every effort should be made to explicitly consider each element of the A_o metric in early threshold development and throughout the system life cycle. The Program Team and the Fleet must understand that major changes/deviations from, or to the Operational Requirements Document (ORD) or the designed operations tempo (OPTEMPO) requirements may have an impact upon the observed A_o

6. In the concept study period, the Resource Sponsor and others should concentrate on the integrity and soundness of the mission or systems effectiveness requirements established for the system.

7. In the early technology development activities, the Resource Sponsor and others focus the greatest effort on refining the system MTBF estimate at the system level and

calculating Ai. This is because the support system (which determines MLDT and spares requirements - a major cost driver) has not been designed yet.

8. For the hardware & software development and demonstration phases, specific A_o and cost thresholds must be proposed and allocated by the Program Manager, included in the related program documentation, and approved by the Resource Sponsor. These A_o and cost thresholds are based on specific system unique considerations of maintenance and supportability concepts.

9. Prior to the production, and deployment phases, the Resource Sponsor should confirm (through system tests and related documentation) that the A_o, and other KPPs for the system, are achievable in the actual Fleet environment in which the system is expected to operate.

10. Throughout the project, the PM must monitor A_o and total ownership costs to ensure that the demonstrated system A_o continues to meet the user requirements. Where deficiencies exist, the support organization must put in place plans, programs and budgets to remedy the deficiencies and improve the system A_o to meet user's needs.

11. The Resource Sponsor and PM must understand the underlying data supporting A_o estimates, the methods used to analyze the data, the assumptions, and potential deficiencies throughout the systems acquisition and life cycle process. Sensitivity analyses and risk analyses should be integral parts of the Resource Sponsor's evaluation procedures. The processes in Section 2 and the questions/checklists in Appendix 4 will assist the Resource Sponsor and others in guiding the required activities.

1.4 Handbook Scope

The handbook is to be used to influence the design for readiness, supportability and life cycle affordability. Pure design-related analysis is left to other references. Weapon systems are described in terms of a number of important performance parameters in today's "performance-based business environment." Examples of many of these parameters are shown in Figure 1-2. This handbook concentrates on just three of these parameters: Reliability, Maintainability, and certain aspects of the logistics support system. These three are the drivers of a pair of metrics, A_o and Total Ownership Cost (TOC), which can focus the design and management teams at all levels of program decision-making.

1.5 Historical Perspective

This handbook was first developed in December 1987 to introduce operational availability as a critical consideration in the design, development, and deployment of a weapon system. This updated version incorporates the tenets of acquisition reform, organizational re-alignment, changes in policy and provides additional clarity to the interaction between A_o and total cost of ownership.

Material readiness became the prime DoD metric in the 1970's. During this period, DoD/Navy Integrated Logistics Support (ILS) concepts were applied to major weapon systems after the Fleet encountered severe readiness and supportability problems. In many cases, the Fleet did not receive required logistics support products and/or resources. To determine why the Navy had ILS policy but did not have ILS products in the Fleet, a Logistics Review Group (LRG) was created under the auspices of the Chief of Naval Operations (Logistics) N4.

In their 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 their readiness requirements, the reliability levels specified by contract, and their logistics resources and planning necessary to achieve the required readiness. As a result of these findings, A_o was adopted as and continues to be the primary measure of material readiness in the acquisition process. Supportability factors, such as A_o, are integral elements of program performance requirements that relate to a system's operational effectiveness, operational suitability, and life cycle cost reduction.

1.6 Definitions of Key A_o Terms, Concepts and Processes

1.6.1 How is A_o defined today? What does it mean?

Operational Availability (A_o) is defined as the probability that the system will be ready to perform its specified function, in its specified and intended operational environment, when called for at a random point in time (the textbook definition).

In practical terms, availability has been defined as the ability of a product to be ready for use when the customer wants to use it - it's available if its in the customer's possession and works whenever it needs to. If the product is 'in the shop" for repair, or it is in the customer's possession but does not work, then it is not available, and considered "down". The above definition is the classic simplified description of availability. To be useful, the equation needs qualification in order to measure and analyze either A_o requirements or demonstrate performance. Appendix 3 provides mathematical formulas and a detailed mathematical discussion of the definition above as it applies to a variety of systems types and situations.

1.6.2 Why are A_o and Cost of Ownership important?

A_o and cost both satisfy the classic definition for good Measures of Effectiveness / Figures of Merit (MOE/FOM).

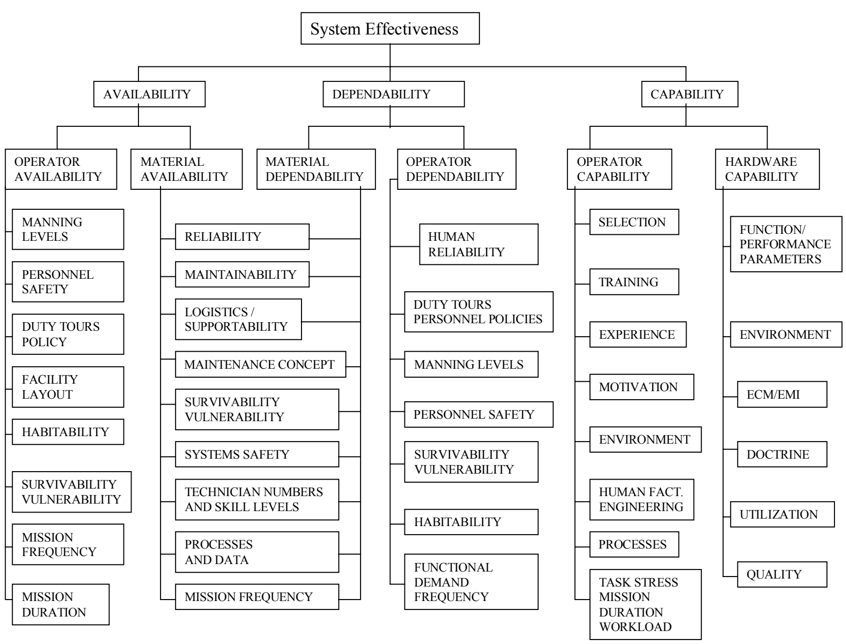
- They represent the viewpoint of the stakeholders, i.e., those who have the right and responsibility for imposing the requirements on the solution.
- They assist in making the right choice by indicating "how well' a solution meets the stakeholders need.

Dr. Benjamin Blanchard states: "The use of effectiveness FOM is particularly appropriate in the evaluation of two or more alternatives when decisions involving design and/or logistics support are necessary. Each alternative is evaluated in a consistent manner employing the same criteria for evaluation."[1]

Although the exact definition and components of Systems Effectiveness (SE) will vary from system to system, in general, A_o will be one of the major contributors. Figure 1-2 shows some of the SE variables and how they can be categorized. Careful evaluation of the design and support alternatives will be necessary to select the solution that best meets the Fleet's requirements.

Figure 1-2 shows SE components and illustrate the potential candidate trade-off parameters in the areas of capability, dependability, and availability. This handbook will show that the Fleet customer (user/operator) and the Program/Resource Sponsor will evaluate Measures of Performance (MOP) on many of the key capability/performance areas to narrow the trade-offs to workable alternatives. Once the threshold is selected, systems engineers and analysts model the alternatives to support a design decision.

Figure 1-2 also shows how these factors are interrelated. Operational Capability (C_o) refers to the system's operating characteristics (range, payload, accuracy, and the resultant ability to counter the threat). A_o refers to the probability that the system will be ready to perform its specified function, in its specified/intended operational environment, when called for at a random point in time. Operational Dependability (D_o) refers to the probability that the system, if up at the initiation of the mission, will remain up throughout the mission. Operational capability, operational availability and operational dependability must be defined relative to the specific warfare environment and operating scenario envisioned for a given system. Combined, they determine System Effectiveness (SE).



[1] Logistics Engineering And Management, Fifth Edition, Benjamin S. Blanchard

Figure 1-2: Systems Effectiveness

1.7 Descriptions of Key Models and Concepts

Effective logistics managers routinely use three related models as part of the supportability analysis process. These are the Level-Of-Repair-Analysis (LORA) model, sometimes called the Repair Level Analysis (RLA), the Life Cycle Cost (LCC) model, and the Readiness Based Sparing (RBS) model, defined in OPNAVINST 4442.5 (30 June 2000). The following three paragraphs introduce each model. Applicable terms, concepts and acronyms are fully defined in Appendix 2.

1.7.1 The Level-Of-Repair-Analysis (LORA) Model

The purpose of the LORA model is to solve for the lowest life cycle cost repair level for each of the repairable candidates in the weapon system Work Breakdown Structure (WBS). LORA is normally run at the repairable candidate level. Inputs to the model include the system hardware reliability/maintainability calculations, weight, cube, volume, etc. Data concerning logistics element resources needed to repair each of the candidates at each of the three levels of maintenance; Organizational (O), Intermediate (I), and Depot (D) are also input. The model performs the following sequence of calculations:

1. It assumes that all repairable candidates are non-repairable at the O level and are discarded. Considering failure rates and the time to obtain replenishment spares and repair parts from the source, the model calculates how many of each part must be kept at each O level site to satisfy expected failures. The model stores all costs for each repairable candidate.
2. The model next assumes that all repairable candidates are sent to the D-level for repair. The model calculates all logistics elements required for repair of each candidate. The model stores these costs by repairable candidate.
3. The model next assumes that all repairable candidates are repaired at the I-Level with only major assemblies going to the depot for repair. All of these costs are stored by repairable candidate.
4. The model then optimizes the repair level by comparing the relative costs for each repairable candidate for each of the options: (1) discard at O, (2) repair at I, (3) repair at D, and selecting the least cost option for each repairable candidate.

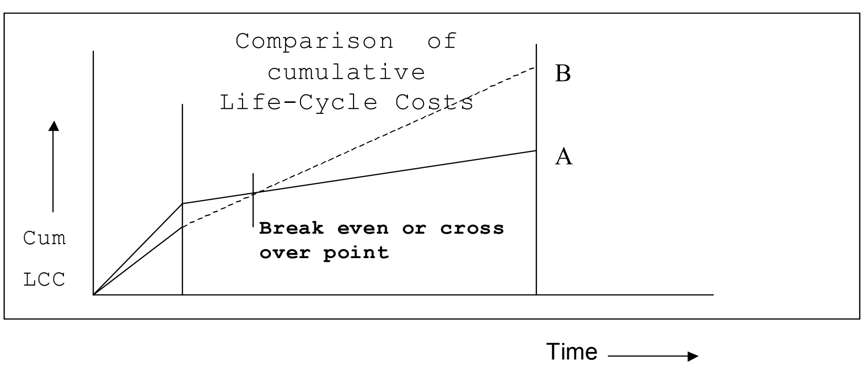
The least cost option for each candidate provides a comprehensive report for consideration. The model provides decision support information to assist in assigning a Source, Maintenance and Recoverability (SM&R) code (a code that defines whether an item is a repairable or consumable and at what level it will be repaired)

1.7.2 Life Cycle Cost (LCC) Models

The main purpose of an LCC model is to estimate the annual and total Operating and Support Costs (O&S). In order for a complete LCC report to be produced, the LCC model must have the capability to capture Research and Development (R&D), Production and O&S costs as inputs. The model performs the following sequence of calculations:

1. Operational requirement information and hardware information including failure rates and the repair level info derived with the LORA model are input to compute an annual operating hour value. This is multiplied with expected failure rate information resulting in a numbers of repair actions required per year.
2. Initial and recurring logistics factors are entered including the expected spares pipeline turnaround time and the desired supply system "effectiveness". This is the percent of requisitions filled without the need for backorder (delay). Navy supply models are normally set to optimize between the A_o requirement and cost of spares support.
3. The model will calculate initial logistics costs by logistics element and recurring logistics element costs for each year of the operational life of the system.
4. The model provides a calculation of the spare parts required at each level of maintenance as a function of failure rates, operational usage, repair times, delay for ordering out of stock repair material, and the pipeline time. Pipeline time is the time needed to get the failed part to the repair location, and to return the Ready For Issue (RFI) part back into the correct level of the supply system.
5. The LCC reports will be an estimate of the total of R&D costs, production costs and operating and support costs. Disposal costs can also be captured and included in the total. Reports will itemize each logistics element such as the specific numbers of each spare for each repairable candidate and for each level of maintenance.
6. Some LCC models include utility programs to automate time-consuming sensitivity and risk analysis. Some LCC models also include the capability to perform "Sparing to Availability" calculations (as discussed below).

Figure 1-3 shows the LCC solution to the hypothetical example of the two alternative weapon system designs discussed in paragraph 1.2. Over the 20-year lifecycle, system 'A' is $6.44B less expensive than system 'B'




```
Acquisition A= 148/.85 = 176 AC @ $30M = $5,280M
Acquisition B= 148/.80 = 185 AC @ $28M = $5,180M (B is $100M better)
LCC A = $5,280 + 176 X 5.5 X 20 = $24,640M
LCC B = $5,180 + 185 X 7.0 X 20 = $31,080M (B costs $6.44B more)
```

Initial Acquisition Costs + Recurring O&S Costs = Total Life Cycle Cost

Figure 1-3: LCC Break-Even Analysis

1.7.3 Sparing to Availability Models

Sparing to an availability models require essentially the same input data as LCC and LORA models. Operational needs, logistics infrastructure, and hardware information are input into the model. The sparing to availability model calculates the number of each type of spare part to be kept at each maintenance level site in order to satisfy an A_o target value. The model divides the spares budget target by the failure rate for each spare part candidate. This creates an index representing readiness per dollar spent for each part. The part with the highest index is selected. The calculations and selections are repeated until the A_o target is reached, constrained by the spares budget target.

Several models are currently being used and are generally known as Readiness Based Sparing (RBS) models as defined in OPNAVINST 4442.5. For aviation, the Aviation Retail Requirements Oriented to Weapons Replaceable Assemblies (ARROWS) model is used. For maritime systems, the Availability Centered Inventory Model (ACIM) model is used. In addition to the RBS models, the Navy also uses a demand-based model, the Modified Fleet Logistics Support Improvement Program (FLSIP) model to develop allowances for those maritime systems that don't qualify for readiness based sparing.

SECTION TWO

OPERATIONAL AVAILABILITY STUDIES and ANALYSES

2.1 Pre-Project R&D Studies

2.1.1 Introduction

The early phase of an acquisition is the time to create the initial A_o threshold consistent with mission requirements. To develop the initial A_o, the program team should begin as early as possible to understand and to assess the assumptions used to formulate preliminary system alternatives. In this phase, the program team should ensure that underlying components of A_o, Reliability (MTBF), Maintainability (MTTR), and Supportability (all MLDT components) are reasonable. They must be relative to the current and projected level of technology, to the current Fleet operating experience for similar systems, and to the current maintenance and logistics support procedures and delay times. The focus is on initial A_o as compared to systems in the Fleet, and the use of "the system" as a part of a larger "system" such as a weapons platform (ship, submarine, or aircraft) operating in a specified warfare environment. The program team must integrate data and analysis from a number of sources to develop and specify a Initial Capabilities Document (ICD) and an associated Analysis of Alternatives (AoA) (formerly Cost and Operational Effectiveness Analysis (COEA)) for "the system."

2.1.2 A_o Study Objectives

The A_o goal drives the selection of potential support elements, selection of model elements, and therefore model data input requirements. The PM must have budgeted sufficient funding to run iterative models and studies to show how the investment of R&D funding to evaluate new support capabilities will reduce life cycle support costs through improved systems supportability. The analysis process typically includes the following steps:

1. Define The Purpose of The Analysis
2. Identify the Baseline and Alternatives
3. Develop Ground Rules and Assumptions
4. Select Relevant Elements and Structure
5. Determine Estimating Technique
6. Select or Construct a Model
7. Identify Input Data, Sources and Collect Data
8. Estimate and Evaluate Relevant Support Factors
9. Perform Sensitivity Analysis, and Identify/Verify Major drivers
10. Perform Risk and Uncertainty Analysis
11. Develop Recommendations
12. Document a Report of the Analysis

The purpose of the analysis in this preliminary early phase is to establish an achievable initial baseline A_o based on comparable systems and to establish the A_o threshold and objective requirement for the proposed system based upon additional (not currently available) intended missions. The two competing constraints for this analysis are A_o and cost. A_o focuses on direct influences on the system at the operational location. Cost focuses on all resources at all locations, which influence or contribute to the operation and support of the system, both directly and indirectly.

2.1.2.1 Analysis Rationale and Checklist

The following checklist is recommended to ensure that the developed rationale for the analysis has been thorough, accurately stated, and provides management with the information necessary to make informed decisions. The information necessary to assess the value of the analysis will be available over time. This checklist is included here at the beginning of this discussion so that the PM understands the range of information necessary for accurate A_o assessment. This checklist should become the basis for initial and downstream iterations of the A_o development and validation process.

1. **Purpose**
   - Is the analysis objective clear?
   - Have the critical items been defined?
   - Has the analysis problem defined bounds and scope?
2. **Effectiveness Parameters**
   - Have effectiveness parameters been identified?
   - Are the metrics appropriate to the production function?
   - Have the operations and maintenance requirements been adequately defined?
   - Are objectives properly balanced (some ignored while others are over-emphasized)?
   - Have performance measures been mistaken for effectiveness measures?
   - Has effectiveness of the future system been taken into account?
   - Will the correct use of expected and average values be used to measure effectiveness?
   - Has consideration been given to proper weighting of multiple effectiveness measures?
   - Have plans been made to analyze sensitivity to changes in assumptions?
3. **Alternatives**
   - Have current capabilities been considered as baseline?
   - Were different mixtures of system components considered?
   - Have any feasible/significant alternatives been omitted or postponed?
4. **Assumptions**
   - Were the assumptions defined and documented adequately?
   - Have the quantitative uncertainties been addressed and factual position taken?
   - Were qualitative uncertainties addressed and positions stated as fact?
   - Did the assumptions pass the ‘reasonableness’ check?
5. **Cost Elements**
   - Have all relevant cost elements been identified?
   - Have the majors cost categories been identified?
   - Does the cost element structure break the costs down to the appropriate level?
6. **Techniques**
   - Have all of the parametric, engineering estimates, projections from actual and analogous system comparisons been considered?
   - Do the techniques fit the optimization problem and program phase?

7. Model

- Does the model adequately address the problem?
- Will the model provide a logical link between cost and effectiveness parameters?
- Will the model allow for timely response?
- Is the model comprehensive? Does it include all relevant cost elements?
- Does the model consider both initial and recurring costs for all relevant elements?
- Will the model be understood for the intended use?
- Is the model consistent?
- Does the model allow the proposed system to be compared to analogous systems?
- Is the model flexible?
- Is the model simple?
- Is the model useful? Does it directly support decision-makers needs for information?
- Is the model valid? Is it capable of providing logical repeatable results?

8. Data

- Has all necessary input data has been identified?
- Have all sources of data been identified?
- Has the data been normalized and scrubbed for inconsistencies and reporting system-induced problems?
- Have the sources of all costs been recorded and justified?
- Is the quality of data accurate and sufficient so that when used in a model it will provide realistic representation of the end result?

9. Calculations

- Have cost generating activities been identified and cost drivers stratified?
- Are constant dollar factors used?
- Have inflation, learning curves and price levels been properly applied?
- Have the costs per year been captured and projected into future?
- Are the element cost streams summarized into a top-level profile?

10. Sensitivity

- Have all critical parameters been analyzed for sensitivity?
- Has the impact on all costs been assessed?
- Has the impact on LCC been summarized?

11. Risk

- Has a range of A_o been developed, based on risk associated with Reliability, Maintainability, and Supportability predictions?
- Has the range of uncertainty associated with A_i components and unit costs of logistics resources such as spare parts been used to form bounds of risk concerning cost and A_o estimates?
- Have supportability risks associated with performance based logistics services and related contracts been analyzed in relation to meeting and sustaining the A_o threshold?
- Has an independent assessment agent validated the results?

12. Recommendations

- Have specific recommendations been developed based on results of analyses of model runs?
- Has an independent assessment agent validated the recommendations?
- Are recommendations backed up by summary graphs showing results of analyses?

13. Reporting

- Has the total analysis adequately been documented?
- Are the facts and necessary caveats stated correctly?
- Does the executive summary state recommendations that are backed up with descriptions of methodology, input data, and output run sheets, references and enough information for analysis replication verification?

2.1.3 Data and Modeling

In order to obtain an accurate A_o result, it is important that the model be designed and functions correctly. The DoN Validation, Verification and Accreditation (VV&A) Implementation Handbook provides guidance in the process of selecting credible models. To model the baseline operational scenario, the analysis team / agency should study the initial draft ICD and user inputs to:

- Describe the mission frequency and duration;
- Determine the number of comparison systems in operation;
- Describe the current logistics support environment; and
- Describe logistics resources numbers and costs used to support the comparison system.

From operational data on existing (baseline) systems the following information is obtainable:

- Describe the achieved A_o of current, similar operational systems, subsystems, or components including achieved reliability, maintainability and supportability values;
- Identify the costs of current operational systems, subsystems or components;
- Determine the readiness drivers of current operational system; and
- Identify any special design requirements or extraordinary support system performance requirements. As a reminder, cannibalization actions conducted on predecessor systems can have an impact on the model for future systems when data is used from those predecessor systems.

From the R&D and Engineering communities, the following is obtainable:

- Identify technologies under development, their expected maturity, and their estimated timeframe for readiness for production and risks;
- Determine the anticipated reliability of those technologies relative to current technology;
- Identify the operating environment in which the system is intended to function, together with related mission/warfare objectives;
- Establish mission effectiveness goals for the system based on the relationship of the system to its platform and the relationship of the system to other related systems on the platform; and
- Incorporate the technical operating characteristics required for the system, based on the established operating environments in which the system will perform.

Consider the following five inputs together to determine the operational requirements for the system, including the specification of a preliminary A_o threshold:

- Detailed combat scenario data required for warfare analysis and simulation based on established wartime operational scenarios.

- The Design Reference Mission Profile (DRMP) based upon an approved concept of operations. Appendix 5 highlights the vital importance of establishing the mission profile prior to the design concept selection and the specification effort.

- Technical and engineering data from the appropriate systems command, Navy laboratories, and external technical databases to establish basic engineering relationships of the system to the platform and to other systems.

- Relationships to other systems established via Reliability Block Diagrams (RBD) or other methods such as the WBS. Delineation of system redundancy, parallel or series structure, and the impact of system degradation must be a part of information provided.

- Specific technical operating characteristics of the system, drawn generally from the threat assessment documentation and program documents on existing/similar systems including the Baseline Comparison System (BCS).

In summary, the operating environmental data, the platform availability data, the system mission effectiveness data, and the system technical operating characteristics data will all contribute to determining the tentative A_o threshold for the system.

2.1.4 Studies and Analyses

For all analysis, it is imperative to select or create a Baseline Comparison System (BCS). Often this is the existing system or sub-system that is being considered for replacement. If no replacement system directly correlates to the proposed system, a notional system or composite system must be created to represent a notional comparison baseline. It is important to identify differences in the existing/similar system(s) capabilities that support the need for the replacement system. In order to commence the A_o study, consider the following:

- Ensure that the A_o of a system or subsystem is consistent with the overall platform readiness objective.

- Create a baseline Reliability Block Diagram RBD for the platform in a top-down approach by allocating the platform readiness requirement to the subsystems. (See Appendix 4). A platform RBD is complex and should be developed by the organization responsible for reliability modeling. The value of RBDs is in their ability to show reliability choke points and the need for redundant capability to compensate. Several commercial models are available to generate RBDs.

- Ensure that A_o requirements are scenario-dependent by relating them to the readiness requirements of their host platforms. To establish preliminary A_o thresholds on the basis of mission effectiveness for systems (subsystems or equipment) being acquired for a platform, the program team will distinguish between three cases:
    1. A replacement system with upgraded capability (e.g., a new radar replaces an older model on an aircraft);
    2. A new system with new capability (e.g., a new self-defense system is added to a ship currently without one); and
    3. A replacement system with improved supportability or a redundant system (e.g., an additional power unit is added to a ship to backup an emergency power supply or to reduce logistics support costs).

A structured, accurate, adaptable RBD or WBS for ships/flights/classes requires a methodology and detailed link of hardware to mission area in order to consistently baseline and measure sensitivity to system Ao. The ultimate platform metrics methodology would include defined mission area to system relations and structured models, which could simulate mission readiness given measurable/testable parameters of Ao at the system level. The following paragraphs describe the specific analysis that is to be conducted.

<table>
<tr><th>RBD Availability</th><th colspan="3">New System/Capabilities</th></tr>
<tr><td></td><td>Replaced old but upgrades warfare capability</td><td>Adds new capability to platform</td><td>Adds redundant capability to platform or replaces old system with no intent to upgrade capability</td></tr>
<tr><td>1. Block diagram or WBS available</td><td>Old Block diagram/WBS valid with substitution of new system for replaced system</td><td>Old Block diagram must be modified to incorporate this series addition. Platform readiness will decrease when system is added in series.</td><td>Old Block diagram must be modified to incorporate this parallel addition. Platform readiness will increase when system is added in parallel.</td></tr>
<tr><td>a. If platform readiness measure was just satisfied prior to adding the new system</td><td>Cannot go below replaced system's A_o</td><td rowspan="2">Must make new system's A_o as high as possible. Platform readiness will drop unless other systems are improved. Should request total platform reanalysis to reallocate A_o's to all systems.</td><td>Any system A_o will improve platform readiness.</td></tr>
<tr><td>b. If platform readiness measure was not satisfied prior to adding this new system</td><td>Should consider increasing new system's A_o to make up deficiency</td><td>Should consider using new system's A_o to make up deficiency.</td></tr>
<tr><td>2. Block diagram not available</td><td>Assume new system will replace old system in exactly the same operational availability relationship to either system on the platform. Assume new system A_o must be at least equal to old system A_o.</td><td colspan="2">Establish an operating environment and scenario for the new system in terms of required system effectiveness or performance (kill rate, acquisition time/accuracy, range, etc.); base new system A_o on costs and system effectiveness tradeoffs in intended operating environment for new systems in isolation from platform.</td></tr>
</table>

Figure 2-1: A_o and Platform Relationship

2.1.4.1 Evaluation and Approval of the Supporting Warfare Analysis

The Warfare Analysis provides necessary input into the A_o analysis process. This information should have already been prepared and available as input data. Perform the following steps - they are central to the evaluation of warfare simulation or analysis:

1. Model the combat environment in sufficient detail to clearly establish both the technical operating characteristics of the system and the mission effectiveness required of the system. Include, for example, a definition of the battle group configuration, location, threat mix, engagement probabilities, engagement duration, specific mission probabilities, platform attrition rates, response and counter-response probabilities.

2. Establish the specific mission effectiveness required for the system and its host platform(s) within the established combat environment. This mission effectiveness value, which may be specified as warfare measures of merit, must be operational in nature and may include target kills, sortie success rates, etc. Evaluate the results of the warfare analysis to ensure that the objective or goal established for a specific measure of merit is met by the system under consideration.

3. Ensure that the underlying assumptions of the simulation or other analytical methodology are consistent with current Navy tactical and strategic planning for the weapons platform(s) and the system itself. Verify that Navy deployment cycles, flying hour projections, platform availability goals, sortie rates, hours per sortie, theater utilization rates, and aircraft inventories, etc., are reasonably represented in the assumptions used to conduct the warfare analysis.

4. Evaluate alternative systems configurations, with varying operating characteristics and mission effectiveness, to determine the cost-benefit tradeoffs of the system and to relate these tradeoffs to specific tentative A_o thresholds.

2.1.4.2 Operational Availability Analysis

- Describe the mission frequency and duration, and other measures of merit.
- Describe the perceived threat, including technologically achievable threats over the planed life of the system.
- Describe the capabilities required for both mission performance and supportability.
- Identify the anticipated number of systems to be procured.
- Identify the preferred direction regarding logistics support.
- Create the initial estimates of what resources might be available to procure the system and its support.

From operational data bases (e.g., the CNO (N76) Material Readiness Data Base (MRDB)) on existing (i.e., baseline) systems:

- Identify the achievable A_o of current, similar operational systems, subsystems, or components including achieved reliability, maintainability, and supportability values.
- Obtain costs of current operational systems, subsystems, or components. This information is often available from Navy Inventory Control Point (NAVICP) item managers, ISEA agencies, or MRDB.
- Determine readiness drivers of current operational systems (the systems experiencing the most failures or consuming the most maintenance man-hours) utilizing approved data sources.
- Identify any special design requirements or extraordinary support system performance requirements.

Obtain the following information from the R&D and Engineering communities:

- Determine technologies under development, including their expected maturity, their estimated timeframe for readiness for production and any known risk areas.
- Identify anticipated reliability of the emerging technology systems, subsystems, and components.

Analyze tentative A_o thresholds and establish the baseline. The life cycle cost of a system is closely connected with A_o achieved by a system and normally the higher the A_o required of a system the higher the life cycle cost.

- Review and Validate Mission Effectiveness and A_o Relationships
- Establish Mission Effectiveness and A_o Relationships
- Review analytical results of the A_o warfare analysis.

2.1.4.3 Analyzing the Operational Scenario

- Review the Design Reference Mission Profile (DRMP).
- Identify factors in the new system pertaining to Operational Availability.
  - The number of missions per unit of time.
  - Mission duration, number of operating days, miles, hours, flights or cycles per unit of time. Minimum times between missions should also be clearly stated as system grooming can enhance operational availability.
  - Peacetime and wartime employment; operating scenario; basing concept; and operating environment.

Note: Mean Operating Time Between Failure (MOTBF) is not necessarily equivalent to Mean Time Between Failure (MTBF). Systems that are used intermittently should account for the long down times between usages when computing A_o. (Appendix 3, paragraph 3.4 discusses intermittent use.)

The program documents should further clarify the approach to satisfying the Fleet's need as expressed by the ICD by identifying the following:

- The type of system (e.g., Air Warfare (AW), Submarine Warfare (SW), Surface Warfare (SUW))
- The category of platform that employs the system (e.g., surface ship, submarine or aircraft, and the type of platform within that category: aircraft carrier, cruiser, or frigate)
- The concept of operations (e.g., Carrier Battle Group, Surface Battle Group, independent operations)
- The type of threat (e.g., stand-off air delivered missile, stand-off surface delivered missile, or submarine)
- The key capabilities required (e.g., over-the-horizon SW, AW out to 200 miles and up to 50,000 feet altitude)
- Logistics planning requirements (e.g., unique maintenance concepts; manning constraints, fifteen days continuous, independent operations isolated from re-supply; or continuous availability for a seventy-five day operating cycle.)

The existing system ORD quantifies operational data to support the A_o defined in the original acquisition, and provides the basis for deriving the new system MTBF, MTTR and MLDT. It will confirm or contradict critical assumptions about operational use, critical design considerations and support concepts. Analysis of historical data on the associated AoA provides quantifiable statistics that form the baseline for satisfying an estimation of the achievable A_o and costs.

2.1.4.4 Estimating Achievable A_o and Costs

The AoA should be obtained by the agency chartered to develop the initial system configuration. It provides the program team with the lower bound of achievable capability. On nearly all existing systems the program management office or in-service engineering agent has accomplished an assessment of the system which reports the system's performance in terms of reliability, maintainability, and supportability, as well as manpower requirements and operating costs. These reports usually identify readiness drivers within the system, provide critical parts usage/failures, system characteristics, and identify other data sources. The program team can use this data to develop baseline statistics necessary to perform the comparative analysis required to respond to the ICD.

The Program Management office of the BCS should also be able to furnish the maintenance plan, logistics support plan, and the reliability block diagrams. These provide the program team with a baseline maintenance concept, supply concept, and a diagram of the functional relationships among the major components of the baseline system. The Naval Inventory Control Point (NAVICP) can provide the dollar value of a ship-set of spares and repair parts for the comparative system and also Mean Supply Response Times (MSRT). The CNO Material Readiness Database (MRDB) and Visibility and Management of Operational and Support Costs (VAMOSC) database maintain data on the costs of operational ships, aircraft and systems, and can also provide costing factors that can be used for cost estimation purposes. The research and development community is able to furnish advances in technology that provide enhancements to the capabilities of the comparative system.

The program team selects and rejects alternatives on the basis of achievability, satisfaction of the capabilities in the ICD, acceptable risk, and cost (which will be addressed later in this chapter). In effect, the program team is conducting a marginal analysis of reliability and supportability to determine the effects on A_o by varying the two elements. The lower bound of A_o is what is currently being achieved with current reliability and supportability. The upper bound of A_o is the lower of the alternative that: (1) meets the capabilities that will be described in the ORD; (2) exceeds affordability constraints; or, (3) represents unacceptable technological risk.

2.1.4.5 Documentation, Reports and Records

In summary, understand that A_o as a value, is required in most of the required system acquisition documents. A ICD is the first document to be prepared prior to program initialization and prior to seeking the MDA's approval to proceed with early concept and technology exploration. Furthermore, policy requires operational requirements to be evolutionary in nature and become more refined as the program proceeds. The ICD and its associated AoA provide the general framework for the ORD and the Acquisition Program Baseline (APB) performance parameters and KPPs at the appropriate approval milestone. An initial Test and Evaluation Master Plan (TEMP) will be prepared to test promising concepts and technologies. Some major systems, comprised of several systems, will require a Capstone Requirements Document (CRD) to be developed before the initial milestone decision meeting.

2.2 Concept and Technology Development Activities

2.2.1 Introduction

The purpose of concept and technology development activities is to evaluate the feasibility of alternative concepts for satisfying the need in the ICD, search for opportunities to apply advanced technology, and to perform preliminary design of the material solution. The feasibility studies are performed in order to identify preferred alternatives and to support a decision by the MDA to proceed with the preferred alternative. Part of this decision support documentation is to present the A_o and cost of the baseline comparison system, other feasible alternatives along with the preferred alternative. Justification for the preferred alternative will demonstrate that it satisfies the key mission requirement and can achieve the highest A_o at the lowest life cycle cost.

Preferred alternatives are developed into the design specifications for individual equipment components. The individual components are combined to compute the A_o of the complete system. There are two primary objectives to be accomplished during these activities. 1) Develop the system design concept to a level of design detail that proves the required system technology can be achieved., and 2) Validate that the detailed system design can achieve all requirements. The validation of A_o threshold capability is accomplished through both engineering analysis and equipment test.

A balance between mission and A_o objectives must be developed. The validity of the A_o thresholds will be seen through a combination of technical analyses, cost benefit tradeoffs, and tests and evaluations. The objective of the technical effort is to identify and eliminate any problems from the system concept(s) design that can prevent achievement of the targeted A_o. Early developmental testing (DT) data is collected and used in A_o and LCC models. The following paragraphs address the use of DT data.

2.2.2 A_o / Cost Study Objectives

Cost studies and analysis will be performed to help determine the most promising solution(s) and concepts that satisfy the needs of the fleet customer at affordable cost. From a cost perspective, the first draft of the description of the functional baseline will be prepared that includes expected cost baselines. The updated AoA, and the APB also address initial costs documenting the preferred or recommended alternative along with the comparisons to other alternatives studied including the BCS. Adding cost components to the comparison requires:

- Expansion of the mission profile to define the operational and logistics requirements and environmental conditions at the system and subsystem level of indenture for each alternative studied.
- Quantify the components of A_o in a set of system design concepts in order to evaluate system feasibility against mission success and cost.
- Collect and use DT test data in A_o and cost analysis. Use the information to help influence the design in specific configuration items to improve A_o and/or reduce cost.
- Expand the A_o and cost analysis down to the sub-system levels of the WBS whenever the design progress makes this feasible.
- Refine the A_o and cost thresholds/range in program documentation.

2.2.3 Data and Cost Models

Cost estimates are derived from an underlying set of assumptions about the utilization, support concept, and financial requirements for each alternative design concept. The allocated R & M values developed by the design engineer are modeled and preliminary DT test data is also run through the models to identify candidates for attention. In addition to the operational and support data, which is derived in the mission profile definition, specific data is obtained, including:

- Definition of the elements of operating and support costs, which will be program, cost drivers.
- Identification of the elements of the WBS to which the costs are associated
- Cost factors.
- Inputs to government generated or controlled cost models such as operating personnel, labor and overhead costs of government maintenance, cost of inventory introduction and maintenance, and costs of training.
- Definition of the expected production unit cost goal along with "for analysis purposes" unit costs of systems, sub-systems, and components. Where this

information is considered competition sensitive, use **triangle function estimates**, with ranges (as low as, expected, as high as).

- Production cost elements to be considered such as recurring, non-recurring, labor, overhead, subcontracts, general and administrative, and profit.
- Anticipated production quantity, rate of production, production schedule, increments of production and provisions for accommodating changes to these factors.
- Provision for accommodation of changing economic conditions including constant dollar base year, or indices to be used to deflate out-year dollars.
- Required system reliability.
- Required system maintenance characteristics.
- Baseline maintenance concept.
- Quantitative contract support system requirements.
- Qualitative contract support system requirements (such as levels of supply support, levels of repair, spares allocation).
- Logistics element baselines.
- Requirements for Built-in-Test/Built-in-Test Equipment (BIT/BITE), Automatic Test Equipment (ATE), and other specialized support equipment.

Suggested activities include testing to verify achievement of the reliability, maintainability, and supportability values derived through technical analysis. Most testing during this period is developmental test and evaluation (DT&E). The results of DT&E are used to either verify or modify the results of technical analyses, as well as qualification and acceptance of technology and design concepts. This development test program is utilized to derive engineering information on the component of A_o and assess equipment growth towards the threshold requirements for reliability, maintainability, and supportability.

Test and evaluation (T&E) plans are established to develop a database for quantitatively assessing achievement of support-related thresholds, adequacy of support plans and resources, and impact on cost and readiness objectives. Responsibility is assigned and sufficient test assets are programmed and budgeted to provide independent assessments for both DT&E and operational testing and evaluation (OT&E). Technical thresholds (validated by DT&E) and operational thresholds (validated by OT&E) are established for R&M, inherent availability, and operational availability.

2.2.4 Concept and Technology Studies and Analyses

2.2.4.1 Expand the Mission Profile to Include Logistics and Environmental Information

A complete mission profile consists of an **operational** profile and a **logistics** profile, (including the **environmental** profile) that covers nominal, contingency, and emergency modes of utilization from factory acceptance through end of useful life. A complete mission profile is defined in the following elements:

- **Operational Profile** – describes the conditions, circumstances, and influences that affect an item during the period of time that it is on an operational mission (i.e., wartime mission). Different levels of operational stress are described and the worse case set of stresses is defined in terms of the portion of the deployed mission that this condition exists. Peacetime as well as combat scenarios must be considered when defining Mission Profiles since, depending on the platform, peacetime mission profiles may be longer in duration and hence, more stressful on portions of the equipment, than combat scenarios.

- **Logistics Profile** – describes the conditions, circumstances and influences that affect an item during the periods of time from government acceptance until issue to a user organization and from return by the user organization for storage, repair and/or overhaul until reissue to a user organization.

- **Environmental Profile** – describes the specific natural and induced nominal and worst case environments associated with the operations, events, functions, situations and parameters defined by the mission profile.

Operational Profile Issues: Specific system stress conditions need to be defined against mission objectives. Previously, the general, functional and A_o requirements to support the mission were defined and documented in the ICD. Deriving a complete mission profile requires evaluation of specific design characteristics of the system. This process continues throughout the acquisition cycle and even after deployment. Appendix 5 provides a detailed explanation of Mission Profile.

Determine the expected effect of mission stress on the predicted levels of system, sub-system and component reliability. These stress or demand factors, called "K factors", are used to normalize the predicted MTBF values. In support of the defined mission, this normalization is based on stress factors that vary between subsystems such as catapult launches hard landings, extreme vibrations and environmental factors. Document the rationale for using "K factors."

Logistics Profile Issues: Development of a wartime mission profile begins with the operational mission profile. The operational requirements are established as a series of events. The multi-mission capability of complex weapon systems often results in multiple profiles describing the complete range of mission capabilities and requirements. When a range of alternate missions is possible, each is examined as a distinct event sequence, and is separated into phases.

The logistics mission profile includes mobility requirements, deployment scenarios, mission frequency and duration, basing concepts, anticipated service life, interactions with the systems/end items, operational environment, and human capabilities and limitations. Peacetime and wartime employments are considered when identifying the supportability factors.

Environmental Profile Issues: Specific environmental conditions for the systems and subsystems must be developed in order to formulate appropriately tailored design specifications. Naval systems and subsystems are designed to survive and function in multiple operating or combat environments. Therefore, specifications governing the design must reflect environmental impacts. These specifications also provide for system survivability in the punishing transportation and storage environments encountered during the system's life.

Finally, the program team should aggregate the various systems mission profiles into a total platform level mission profile. To do so will require consistency, traceability and validation with other mission profiles under a battlefield mission scenario.

2.2.4.2 Identify the Technological Opportunities

During the initial steps of the acquisition process the program team gives consideration to all potential alternatives and opportunities that will enable them to leverage advanced technology. Alternative system design concepts are solicited from all qualified firms. Emphasis is placed on innovation and competition for achieving the best system solution at the lowest cost. The same rationale is applied to new innovative support concepts.

2.2.4.3 Quantify the Components of A_o

Each concept evaluation includes estimates of both the quantitative and qualitative parameter of the system concept for reliability, maintainability and supportability characteristics. Quantitative parameters of MTBF, MTTR and MLDT are supported by qualitative factors; such as failure mode descriptions, criticality of failures, space requirements for maintenance, and tools and repair part descriptions. These qualitative parameters are required to define the components of A_o in realistic terms for evaluation of alternate design concepts. This activity includes the definition of special logistics problems and an estimate of the potential solution. Current support capability is defined as existing procedures, repair facilities skills, and equipment that could accommodate a new requirement. Tradeoff studies are performed to evaluate alternatives to current support capabilities

2.2.4.4 Cost-Benefit Tradeoff Analysis to Support the A_o Requirement

A Cost-Benefit Analysis (CBA) is a technique to evaluate the relative worth of a plan by using a comparison of alternatives. It provides a means for picking the best solution as well as a way to look back when evaluating past decisions. There are several reasons to conduct a cost-benefit analysis:

- To make a business case involving tradeoffs
- To present a funding plan
- To sell an idea
- To align expectations
- To evaluate success or failure

The primary objective of a CBA in A_o calculations is to develop a basis for tradeoffs among all Integrated Logistic Support (ILS) elements that impact the reliability, maintainability, and supportability characteristics of each design related decision. The relationship of the components of A_o allows evaluation of both mission effectiveness and system LCC. Cost-benefit tradeoff analyses are conducted through the accomplishment of a number of key actions:

- Perform various types of cost-to-benefit curves that will be continuously refined throughout development.
- Identify preliminary thresholds for each alternative under consideration.
- Allocate key parameters to all levels in the RBD.
- Evaluate design reliability at the equipment level.
- Evaluate equipment design maintainability.
- Evaluate supportability "design-to" requirements, focusing on design features critical to A_o.
- Ensure that reliability and maintainability, and any supportability design requirements are addressed in Demonstration Testing.
- Determine the optimum design and support concepts.

The R&M supportability and cost requirements are evaluated to ensure that the thresholds are realistic. Supportability requirements, characteristics and thresholds, documented in the Integrated Logistics Support Plan, and/or other logistics plans, are updated through the refined and upgraded specifications for the system maintenance and support concepts.

The threshold values for the components of A_o must be realistic. An overly high threshold value may incur excessive cost, degrade the effectiveness of logistics planning, adversely impact program plans and schedule, or lead to compromise on a lower value later in development. A low threshold, established early in design, may later lead to unplanned support costs that require costly redesign after system delivery, thus causing O&M funding requirements.

Throughout this phase, the program team monitors development of the design concept in order to evaluate factors related to A_o. The program team must monitor system reliability, maintainability, and supportability. Monitoring is achieved through evaluating the results of technical analyses and developmental testing. An Integrated Logistics Support Management Team (Logistics IPT) may support the program team in this phase. Logistics IPT membership is tailored to the program and can include representatives from the program office, the SYSCOM functional logistics element teams, and other commands including COMNAVSUPSYSCOM, NAVICP, COMNAVFACENGCOM, the Warfighter, and independent assessment agent.

2.2.4.5 Developing Recommended Preliminary Thresholds for Alternatives

The evaluation is performed in two steps:

- First, an AoA is established for cost comparison. The most likely baseline comparison system (BCS) is an operational system having a current mission profile similar to the design concept profile and operating requirement. The AoA is usually the process used in performing the baseline comparison system analysis outlined in Supportability Analysis Guidebooks. The baseline system must have well-defined cost factors.

- The second step of the cost change evaluation is comparing each alternative system design concept with the baseline system. The program team judges the difference between the baseline and alternative system design factors and estimates the expected change resulting in the cost factors. The degree of change in cost factors in relationship to A_o is indicated in Figure 2-2.

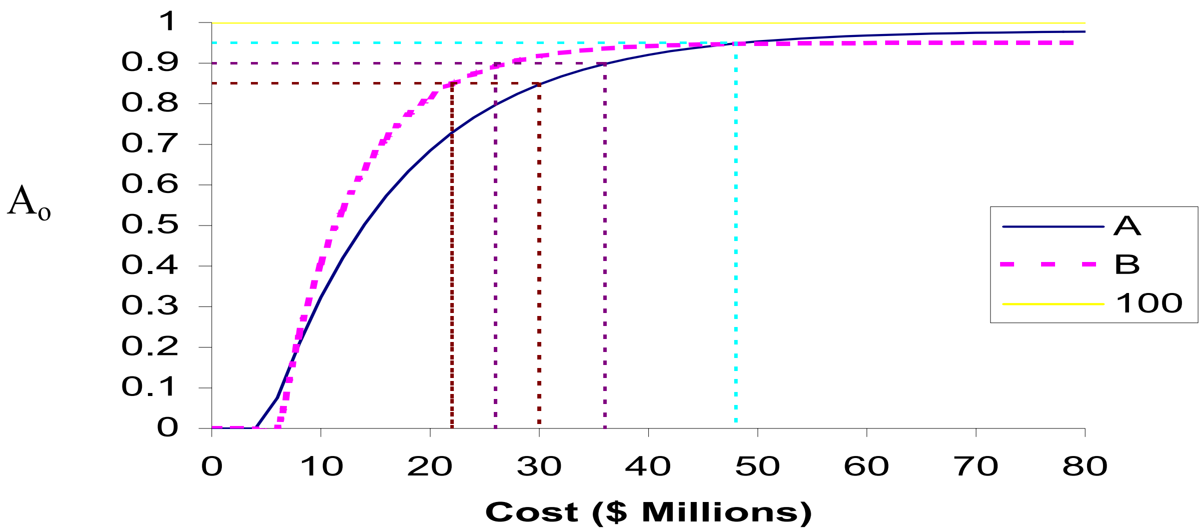


Figure 2-2: Cost To A_o Curves

2.2.4.6 **Select the Most Cost Effective Design Alternative**

The program team's key goal is to ensure performance of those analyses required to select the most cost effective design alternative that meets the documented operational and support requirements. The objective of applying Design-to-Cost (DTC) and the cost-benefit tradeoffs in this phase is not completely limited to the specific cost goals established in the previous phase. The specific cost goals established for this phase are viewed as targets by which visibility into the cost consequences of alternate design features can be measured and assessed for A_o achievement. The cost effectiveness of reliability, maintainability and supportability design characteristics are assessed in terms of DTC goals and the LCC estimate in order to arrive at an optimum mix of system effectiveness and system LCC. Cost-benefit analysis allows the program team to select the most cost-effective A_o threshold for the selected design alternative.

2.2.5 Documentation, Reports and Records

At the conclusion of concept and technology development activities, the program should have completed the following:

- Approved Design Reference Mission Profile (DRMP)
- ORD
- Initial Acquisition Program Baseline (APB)
- TEMP
- Initial Acquisition Strategy
- Draft system performance Specifications (R&M only)

- Logistics Support Planning Document
- Logistics Management Information (LMI) (formerly called Logistics Support Analysis Record (LSAR))

2.3 Development and Demonstration Activities

2.3.1 Introduction

Development and demonstration activities are to develop a system, reduce program risk, ensure operational supportability, design for producibility, ensure affordability, and demonstrate system integration, interoperability, and utility. During these activities, the system design for quantity production is completed, a "limited production" system is built and tested in the intended fleet environment, and the system requirements (established as system and equipment functions at the previous Milestone) are developed into firm product specifications (drawings, schematics, and manufacturing instructions). The logistics support system design, initiated previously, must be documented in various logistics support plan(s) and LMI, and analyses completed. Logistics support is readied for operational testing and the transition to production. Finally, the system is delivered to the Fleet representative from the Operational Test and Evaluation Force (OPTEVFOR) for operational tests supporting the production decision.

2.3.2 A_o / Cost Study Objectives

Refine the A_o requirement by analyses at the detailed sub-system level by:

- Updating / expanding design reliability, maintainability and supportability analyses.
- Verifying reliability and maintainability (R&M) specifications through testing.
- Performing maintenance planning and document maintenance concept.
- Developing and refining logistics planning documentation.

The program team updates design reliability, maintainability, and supportability analyses to include both the latest predictions and results of DT&E. This action ensures that the specified A_o threshold is achievable; and if not, appropriate actions are taken to adjust reliability, maintainability, or supportability to meet the ORD specified A_o. Engineering analyses are conducted to transform the functional specifications established at the previous Milestone into firm designs, described in product specifications. Reference NAVSO P-6071, March 1986.

Analytical activities further define the detailed logistics support concepts and resource requirements as the system/equipment design progresses. The time requirements, levels and locations of actions, and the requirements for spares and repair parts, facilities, personnel, training, training equipment, technical data, tools and test equipment are refined for established configurations. The logistics planning is expanded to reflect the activities for test support, pre-operational support, implementation of each element, and to establish performance and reporting requirements for monitoring logistics activity progress.

2.3.3 Development and Demonstration Data and Models

Refer to generally applicable information concerning models and data in section 2.1.3.

2.3.3.1 Input to Supportability Analysis Database.

The primary sources of technical data on system performance relative to A_o are results of engineering analysis and the Logistics Management Information (LMI). An analysis of A_o must be conducted using historic data from existing, similar weapon systems along with the results of developmental testing.

2.3.3.2 Development Test (DT) Results

Test and evaluation during development is an evolutionary process that becomes more detailed, controlled and specific as the item design matures. The objective of DT-I testing for A_o, performed prior to this phase, is to validate engineering analyses, develop information on a specific design or technology, and to "grow" the reliability and maintainability of a design configuration. This type of early developmental testing may continue. Test and evaluation is conducted to determine and record critical parameters of a design related to A_o. These tests must evaluate the actual functions of an item against its intended functions, established through engineering analyses.

The designer should have considerable latitude to work out and correct problems and design deficiencies so that a satisfactory design evolves. This allows the designer to design, test, modify, redesign, and retest, until the hardware design is optimized within time and resource constraints. As the equipment design progresses, development tests are performed on models, breadboard circuits, parts, or other items to establish basic design parameters and determine functional capabilities. The important element in this development or growth testing is to obtain and document the engineering data that ensures achievement of reliability, maintainability and supportability in the final product.

2.3.3.3 DT Test Data and Influencing the Design for Supportability

Data obtained during test and inspection is utilized to provide feedback for changes in design. This establishes a final design, which will achieve the A_o threshold. The information on the A_o component characteristics of the product design is established in the LMI and documented in the logistics plan. These specifications of reliability, maintainability and supportability characteristics of the system design, with past DT-I records, are the primary input to DT-II. A_o and LCC analysis using achieved reliability values from DT-I will allow the supportability engineer to help focus design improvements where they provide the best payoff.

At this stage, production costs, key support cost factors and quantity relationships are derived and compared with "available" resources. These early cost estimates are iterated as primary parameters during the formulation of minimum essential performance and A_o requirements for the new system or equipment. Such cost-benefit relationships are the primary vehicle for the supportability engineer to identify design deficiencies and areas where support cost savings are feasible. The contract must call for delivery of this valuable cost and A_o driving information to all analyses agencies.

2.3.4 Studies and Analyses

2.3.4.1 Update and Verify R&M and Supportability Analyses

At this point in the acquisition process, design trade offs are complete and actual supportability development starts. The detailed engineering analysis of the components of A_o is comprised of those analytical techniques, which cannot be performed without a detailed design description, based upon an approved DRMP, such as drawings, schematics or a description of parts and materials. This description must include updated reliability and unit cost estimates for each system, sub-system and repairable candidate. Contractors are understandably reluctant to provide preliminary cost information for a variety of legitimate reasons. The contract must call for preliminary estimates including ranges if necessary., to be used for "analysis purposes." The analyst can use these in "triangular functions" (low, probable, high) in cost risk analysis.

The program team's objective is to complete the engineering analysis for reliability, maintainability and supportability as early as possible in the development cycle to serve as a basis for design decisions. The **inherent** R&M design characteristics and requirements are now well established in the equipment level development specifications. The R&M engineering analyses now address parts selection and detailed design checks to assess design capability against "fixed" R&M specifications. Not until now are the analytical logistics effort expanded to define the supportability requirements of a specific design configuration at the sub-system level.

2.3.4.2 Complete Logistics Planning

Four major products result from the engineering analyses performed concurrently with the developmental & demonstration activities. They are:

1. A complete Acquisition or Integrated **Logistics Support Plan** (ALSP/ILSP) should be available at the conclusion of these design/development/demonstration activities. The supply support chapter of the A/ILSP is of critical importance to the achievement of A_o requirements because it is the basis of the spares budget. The planning factors along with the maintenance plan are used in pre-provisioning supply support planning. The program's logistics team is responsible for developing the logistics planning and associated documentation. The Inventory Control Point (ICP) and NAVSUPSYSCOM should also be included in the development of these plans and their review prior to publication. The production A/ILSP is to identify specific support resources to meet installation and checkout requirements and Fleet operational needs. At this same time, logistics test and evaluation criteria are developed to support the TEMP and must be consistent with the logistics test and evaluation described in the logistics plan. Developmental testing should be sufficiently rigorous to identify any logistics problems to prepare the logistics support system before Operational Test and Evaluation (OPEVAL).

2. The **Level of Repair Analysis** (LORA) is refined to include updated and detailed design information. The LORA is conducted in conjunction with the Logistics/

Supportability Analysis process. LORA is particularly important because it provides the initial basis for maintenance and supply support planning. As mentioned earlier, LORA enables economic and other maintenance considerations along with constraints, to support decisions on repair, replacements, or discard of components. LORA determines the sites and reasonable skill-categories for performing the appropriate level of maintenance. The NAVICP needs this information to complete the provisioning process for the system and equipment, to load failure rate predictions to its inventory model programs, and to determine stocking levels. Prior to the production decision, the LORA should be completed for each system and sub-system.

3. The **Maintenance Plans** should be completed. Often a major weapon system will have an entire family of maintenance plans at the sub-system and test/support equipment level. From the Maintenance Plan, supply policies and procedures are established for use during the interim (contractor) support phase, if necessary. Support concepts such as Full Service Contracting (FSC) and Contractor Logistics Support (CLS) may require new organic maintenance concepts and structures.

4. The LMI is the methodology that analyzes and integrates the major logistics support elements. Alternative support concepts and cost trade-off analyses should be performed to achieve the support system design required to meet program needs.

2.3.4.3 Monitoring and Evaluating the A_o and Related ILS Resource Requirements

The program team's key action in monitoring A_o is to ensure proper testing of the A_o components. The following two actions are essential:

- Test to ensure achievement of A_o
- Correct critical deficiencies

DT&E is conducted during this phase to validate the engineering analyses performed for the components of A_o, and to ensure that the equipment achieves the A_o threshold. DT-II is usually conducted to support the limited rate production Milestone decision. DT-II demonstrates that the design meets its performance, reliability, maintainability, and logistics supportability specifications. The testing conducted during DT-II is usually performed in discrete phases (DT-IIA, DT-IIB), comprising two types of developmental testing, which comprise a formal Technical Evaluation (TECHEVAL) of the product. This phase of testing must be conducted on hardware & software that is representative of the production model in order to identify technical deficiencies and determine whether the design meets technical specifications and requirements. TECHEVAL also provides a major source of data for certification of readiness for OPEVAL and Low Rate Initial Production (LRIP).

2.3.4.4 Monitor DT Testing to Adjust Logistics Planning Factors

Analysis, evaluation, testing and in-service management of A_o performed throughout the system life cycle. A specific approach/technique, at a given time, on a specific program depends on the phase of the program and the individual program's unique characteristics and requirements. When testing, evaluation, or assessments are viewed as 'point events' (vice continuous processes), limitations to scope are normally encountered -- just like limitations to scope are often encountered in Operational Evaluations of highly reliable systems (e.g., the available test time is not sufficient to physically prove achievement of a threshold). In such 'point events,' logistics delay time can be addressed empirically if the processes used and quality and quantity of support assets available are sufficiently representative of those planned to be available during anticipated normal Fleet operations. If they are not sufficiently representative of anticipated Fleet operations, historical averages or distributions of delay times applicable to the system/operational concept in question, and/or responsible projections of delay times can be used analytically instead. If, in the process of so doing, unreasonable or historically unsupportable delay times are encountered, logistics planning factors will require adjustment to meet the requisite A_o. Thus, reasonably accurate testing of the A_o threshold/goal must be accompanied by:

- Identification of Critical Deficiencies
- Correction of Deficiencies
- Analytical Testing, Engineering Evaluation and Reliability Qualification.

2.3.4.4.1 DT-II Test Data

DT-II tests provide data to support the continuing design effort and to provide assurance that the designed configuration meets the established specification requirements. The DT-II test program (early engineering evaluation tests and reliability qualification tests) is structured to include a reasonable assessment of A_o characteristics of the product. This is done so that the demonstration testing effort of TECHEVAL provides more assurance. Experience gained in an expanded qualification test program may justify a reduction in reliability demonstration testing.

Test data from development tests (including test conditions, significant events and problems) are meticulously recorded, analyzed and maintained in the integrated data system in order to plan logistics support based on achieved versus predicted reliability. DT-II engineering evaluation tests are conducted to assess the degree to which design configuration, components and materials meet equipment development specifications. DT-II tests also determine the effects of varying stress levels or combinations and sequences of environments; validate Failure Modes Effects and Criticality Analysis (FMECA); identify failure mode effects; and verify that reliability, maintainability, and supportability requirements have been met. DT-II tests are performed on the highest prototype and production assembly levels practicable that represent intended production items as closely as possible. Reference NAVSO P-6071, March 1986.

2.3.4.4.2 Reliability Growth Testing

Reliability growth testing is an essential element of the DT-II Program. Once design concept feasibility to achieve A_o is verified, engineering evaluation tests are planned and implemented to identify and remove significant failure modes in the design configuration. Testing exercises the product and its elements over anticipated life cycle usage conditions to increase the probability of detecting and identifying inherent failure modes. These reliability growth tests are implemented with a vigorous Test, Analyze and Fix (TAAF) program. The level of design maturity achieved and demonstrated is largely determined by the success in debugging the design during the DT-II tests.

2.3.4.4.3 Reliability Qualification Testing

Reliability qualification tests demonstrate that the design can meet or exceed A_o requirements in the operational environment. Qualification tests are conducted to the environmental extremes demanded by the design reference mission profile (DRMP). Test conditions involve the most severe levels, combinations and sequences of functional stress identified in the design specifications. The reliability qualification test program is structured so that, upon completion, the risk of failing any reliability demonstration testing is certified as very low.

Qualification testing at or above DT-II stress-levels provides maximum assurance that the product will meet reliability requirements. If failures occur during qualification testing, the failures and failure modes are analyzed and compared with qualification criteria to determine the need for corrective action and any follow-on retest.

The optimum reliability qualification test program requires qualification testing at various indenture levels (parts, components, equipment, subsystem and system levels) using a wide range of simulated mission scenarios and operational environments. Generally, these tests are performed at the highest practicable level. If a given item is to be procured from two or more contractors, samples from each source are qualified. If there is a change in the configuration of an item subsequent to its qualifications, the nature of the change is examined to determine the need for re-qualification.

2.3.4.4.4 Demonstration and Acceptance Testing

Acquisition programs with moderate to high technical risks often include the fabrication and testing of one or more Engineering Development Models (EDM). The fabrication and test of one or more pilot production models follow EDMs. For programs of lesser risk, it may involve pilot production models only. EDMs are prototypes of the complex system that are functional equivalents of the system, built for one or more iterations of the test-fix-test process to establish system attributes such as reliability, maintainability, supportability and safety. An EDM may not have the exact physical configuration of the planned production system. DT&E is performed on EDMs to reduce the design risks and uncertainties prior to fabrication of a more representative production model. It also verifies attainment of technical performance objectives in the components, subsystem, interfaces and, finally, at the total system level.

2.3.4.4.5 Reliability Demonstration

Reliability demonstration tests determine contractor compliance with the contractual requirements for system reliability. These tests are performed on the prototype configuration (EDM or pilot production unit) specified in the contract. The reliability demonstration is performed after completion of all qualification tests, and when analysis of engineering data indicates that the product can achieve the specified reliability requirements. The program team ensures that the test scoring rules, such as failure definition and test times are formalized and are representative of service use. The tests are conducted under environmental and operational conditions, including preventative maintenance, in accordance with the specified mission profile. Testing by the Navy, or by the contractor, using platforms assigned on loan from the Navy, are acceptable alternatives to factory test cell mission profile simulation. Results of the test must be documented in a written report.

The program team must be aware of the limitations of reliability demonstration tests and the resources required. Since reliability demonstration tests indicate that the product will perform reliably under service use, the environmental conditions and operational demands invoked on the product during these tests must be compatible with conditions and demands of the mission profile. Reliability demonstrations are usually conducted in the contractor's facility. Test conditions cannot exactly duplicate Fleet environments; therefore, results may be optimistic and misleading. Typical test plans require definition of four parameters: (1) the specified MTBF; (2) the minimum acceptable MTBF; (3) the consumer's risk, and, (4) the producer's risk. The program team both specifies the test plan in the contract or equipment specification or reviews and approves the contractor developed test plan.

2.3.4.4.6 Maintainability Demonstration

Maintainability demonstrations indicate that maintainability characteristics of the product meet contractual maintainability requirements. The specific approach used can range from limited controlled tests to an extensive controlled field test of the product. These tests provide quantitative estimates of maintainability parameters such as corrective maintenance downtime, fault isolation time, failed item replacement, and checkout time. The tests are witnessed and verified by the government and documented in a written test report. Reference NAVSO P-6071, March 1986.

Maintenance skills, spares provisioning, sequence of fault occurrences, and other relevant conditions must represent operational expected conditions. The validity of these demonstrations is highly dependent upon the degree to which these environmental resources and skills are representative of those in actual service use. The program team supplies operational and other constraint providing a basis for defining the test procedures. As a minimum, this information includes the maintenance philosophy, descriptions of the maintenance environments, the modes of operation for the test, and the levels of maintenance to be demonstrated.

The program team determines the type and scoring of this formal maintainability demonstration. The scoring criteria are based on mission requirements, cost of tests, and the type of equipment being developed.

2.3.4.4.7 Conducting Cost-Benefit Tradeoff Analysis at Lower levels of Detail

Two significant characteristics affect the cost-benefit analysis process:

- As the system design progresses from a description of required equipment functions to required physical characteristics, the latitude to change the design diminishes.

- As the design of the system and the logistics support becomes more definite, the ability to accurately estimate cost increases.

Therefore, the program team and contractor teams are able to more realistically estimate costs. The ability to change cost factors without an unacceptable cost burden no longer exists. Also, the system and equipment design evolves from mission operations concepts and functional descriptions into detailed engineering descriptions (drawings, materials and dimensions).

2.3.5 Documentation, Reports and Records

Documents created or updated in this phase include:

- ORD
- Acquisition Strategy
- APB
- Exit Criteria for next milestone
- TEMP
- Logistics element plans (as required) and an Integrated (or Acquisition) Logistics Support Plan (ILSP/ALSP)
- LORA(s)
- Maintenance Plan(s)
- Logistics Support Summary reports

2.3.5.1 DT Test Outputs

Data obtained during test and inspection assists in establishing a final design that will achieve the A_o threshold. The information on the A_o component characteristics of the product design is established in the LMI and in the logistics plan. These specifications of reliability, maintainability, and supportability characteristics of the system design, with past DT-I records, are the primary input to DT-II.

Results of the A_o analysis, as well as recommendations for actions necessary to exceed A_o thresholds and achieve A_o goals, are reported to the Resource Sponsor. Reports are also made to the Resource Cost/Performance team on previously unbudgeted costs and any extraordinary support requirements, indicated by the analyses. Alternative courses of action with associated A_o expectations and cost considerations are also to be provided.

If the analyses at this advanced design phase determine that A_o goals cannot be met, the program team reviews the options very carefully. Engineering and logistics analyses evaluate all alternatives such as improving reliability (MTBF), maintainability (MTTR), and supportability (MLDT) to determine what is required and what may be economically accomplished to meet A_o. They must not immediately come to the conclusion that a greater repair parts investment is required. Per OPNAVINST 4442.5, all ACAT I, II, & III and selective ACAT IV programs are to apply the Readiness Based Sparing (RBS) Model.

As the program progresses through this phase, some (production and support) cost and performance tradeoff flexibility is needed to permit development of an acceptable cost constraint. The contract must be structured to require the contractor to conduct cost-benefit tradeoffs based on A_o

The specific output of the cost-benefit analysis and tradeoff process is the cost estimate to support the production milestone. This estimate includes a DTC goal for the acquisition cost component, and a separate DTC component for operating and support (O&S) costs.

The Systems Commands / PEOs / DRPMs certify to the DCNO (Fleet Readiness and Logistics)(N4), prior to a system entering OPEVAL, that the system is ready for operational testing. The certification is made to the CNO, usually by naval message, with an information copy sent to OPTEVFOR, and other interested commands

Certification and the CNO decision to approve OPEVAL are based upon completion of the following steps related to A_o:

1. The TEMP is current and approved by CNO.
2. All TEMP-specified prerequisite DT-II has been completed and the reports are published.
3. All DT&E objectives and performance thresholds have been met.
4. System operating and maintenance documents, including 3-M and Preliminary Allowance Parts Lists, have been distributed for OPEVAL.
5. The ILS plans and necessary supporting detailed technical documentation, such as Failure Mode Effects, and Criticality Analyses (FMECA), LORA, LCC, and Supportability Analyses have been provided to OPTEVFOR.
6. Adequate logistics support (typically greater then during normal operational support requirements), including spares and repair parts, are available for OPEVAL, and the logistics support system is representative of that which will support the production system.
7. The OPEVAL manning of the system is the same (numbers, rates, ratings, and experience level) as a planned for Fleet units under normal operating conditions.
8. The test plan has been approved and provided to OPTEVFOR.
9. Required training for personnel who will operate and maintain the system during OPEVAL (including OPTEVFOR personnel) has been completed, and this training is representative of that planned for Fleet units who will operate the system.

2.4 Production and Deployment Activities

2.4.1 Introduction

At this point, research and development activities have resulted in production and deployment of the system and achievement of an operational capability that satisfies mission needs. The production period provides a key window of time for measuring, analyzing and impacting A_o requirements at the lowest possible cost. During the production years, systems are delivered to the user and empirical operational data is collected on system’s reliability, failure rates, maintenance repair times, and logistics delay time experiences. Data must be aggressively collected, analysis performed and corrective actions made with a proactive and cooperative approach. Once production contracts end, the ability to affect corrective actions in a timely fashion becomes more challenging and costly. During production there are three principal objectives with regard to A_o:

- Execute the program plans to achieve the design A_o;
- Monitor the program A_o to identify deviations from plans and determine the degree of deviation; and,
- Identify corrective actions needed to resolve issues.

2.4.2 A_o / Cost Study Objectives

Production Cost Study requirements include:

- Validate the A_o and cost estimates during early fielding with actual fleet feedback data.
- Confirm A_o with currently funded logistics resources. Identify any funding deficiencies that may adversely impact A_o.
- Approve the post-fielding A_o monitoring plan. The program A_o monitoring plan is designed to explain how actual systems performance data will be collected and analyzed to determine how performance changes over time. Critical elements of A_o, MTBF, MTTR, and MLDT must be monitored over the life of the program utilizing an approved and unbiased set of methods and procedures.
- Update the appropriate documentation to reflect demonstrated A_o:
  - ♦ LMI reports;
  - ♦ Maintenance Plan;
  - ♦ Provisioning Computation (spares model rerun); and
  - ♦ Acquisition/Integrated Logistics Support Plan and affected logistics element plans.
- Assess the impact of deviations from the logistics plans, maintenance plan, and transition plan on achievable $A_{o.}$
- Manage changes or modifications in design, configuration or support resources that impact the achievement of the A_o threshold.
- Develop plans and identify resources for A_o improvement, if the threshold is not being achieved.
- Plan for post-production support.

2.4.3 Data Inputs and Models

Refer to generally applicable information concerning models and data in paragraph 2.1.3. In previous phases, only predictions and DT test data were available to model achievement of A_o and cost objectives and thresholds. During this phase, actual operational test and Fleet feedback data is collected for model inputs, such as:

- Test and Evaluation Reports

- Casualty Reports
- Commanding Officer Narrative Reports
- 3M Data / CASREP / Tech Assist Data
- VAMOSC cost Reports
- CNO MRDB Reports
- ISEA failure rate analysis reports, including information concerning failure trends from intermediate and depot data.

2.4.4 Studies and Analyses

There are three primary areas of concern:

1. Ensure that the system production model provides the same characteristics as those to which the prototype was designed, developed and tested
2. Ensure that the configuration, installation and Fleet operation of the system is consistent with the product specifications and developmental use study
3. Manage and coordinate the execution of key Fleet introduction plans.

2.4.4.1 Operational Test and Evaluation (OT&E)

The final phase of DT&E is TECHEVAL, which is conducted in the system's intended operational environment. For shipboard systems, TECHEVAL is usually conducted in an active Fleet ship in at-sea exercises. TECHEVAL has two purposes: to verify that production systems meet technical performance requirements, and to verify that the system is ready for OPEVAL, as judged by the Operational Test Readiness Review Board. The program team has to ensure that the TECHEVAL report is available to support the Review Board approximately two weeks prior to start of OPEVAL. The operations and tests performed during TECHEVAL are to be structured to ensure that all the components of A_o are assessed in the field environment.

OPEVAL is usually conducted on the same hardware as TECHEVAL. It usually starts about a month after the completion of TECHEVAL, to allow for the analysis of TECHEVAL results and the certification to the CNO of readiness for OPEVAL. Upon completion of OPEVAL, OPTEVFOR's goal is to issue a final report within 90 days containing the OPEVAL results. These are to be presented to the MDA to support a full production decision.

During OPEVAL, logistics delay time can be addressed empirically if the processes used and quality and quantity of support assets available are sufficiently representative of those planned to be available during anticipated normal Fleet operations. If they are not sufficiently representative of anticipated Fleet operations, historical averages or distributions of delay times applicable to the system/operational concept in question, and/or responsible projections of delay times can be used analytically instead. If, in the process of so doing, unreasonable or historically unsupportable delay times are encountered, logistics planning factors will require adjustment to meet the requisite A_o. Thus, reasonably accurate testing of the A_o threshold /goal can usually be achieved.

2.4.4.2 Monitoring Achieved A_o from Early Fleet Reporting

Until now, A_o has been a threshold or objective planning factor only. The program team now begins to consider A_o as both a process and a measure of achievement. The process is the measuring of the interdependent impacts of shortfalls in reliability, maintainability, or supportability upon each other, the A_o of the components of the system, and ultimately, the material readiness of the entire system. The system can be displayed in a matrix with its major components on one axis and the components of A_o and their sub-elements on the second axis. This matrix should be viewed on three planes overlaying each other. The three planes of the matrix are threshold values, schedules, and costs. The objectives of this type of matrix are to provide continuous and consistent monitoring of production system performance in order to focus attention on those critical resources that adversely impact reliability, maintainability, and/or supportability.

The program team needs to monitor key A_o and cost driving indicators utilizing Navy approved methods and processes. The team needs to manage critical items and resource requirements that vary from the required levels of performance and to coordinate the various (contractor and government) activities contributing to the acquisition, production, deployment and support of the system. Team members must complete applicable portions of the A_o matrix and concentrate management attention on those variances from system specifications and assess the impact of a variance in one component of material readiness upon other components of A_o. The dependent relationships are important not only during production, but become keys to analyses of problems in the deployed operational system.

2.4.4.3 Update the Appropriate Documentation to Reflect Demonstrated A_o

Changes to the program and logistics plans will occur throughout production, fielding/deployment and operational support periods. These changes must continue to be reflected in the documents that are crucial to program coordination and Fleet support. Of great importance is the Users Logistics Support Summary (ULSS), or Operational Logistics Support Plan (OLSP), or Operational Logistics Support Summary (OLSS), as appropriate. Fleet supportability documents are monitored throughout the operational phase by the program team and updated as significant changes occur. The support establishment and the Fleet use these program and support documents for scheduling, budgeting, and planning.

Changes to the supportability concept described by these documents can significantly impact the achievable A_o. For example, a decision to change the maintenance concept from piece part repair to modular replacement may change the following:

- The technical manuals
- The manning levels
- The Allowance Parts List (APL)
- The Program Support Inventory Control Point (PSICP) weapon system file data
- The technical skills required of the shipboard maintenance personnel
- The intermediate maintenance activity and depot overhaul point work load schedule
- The budgets
- The packaging, handling, storage, and transportation plan
- The IOC date

The impact of a change will determine the scope of the supportability changes. The more drastic the change the more impacts to the support infrastructure and levels. What may appear on the surface to be an insignicant engineering improvements may have significant support ripples.

2.4.4.4 Assessing the Impact of Deviations, Changes and Modifications

During production, the requirements for deviations from specifications, and the need for modifications and/or engineering change proposals becomes evident. These will naturally change the allocation of the A_o driving parameters (reliability, maintainability and supportability) among the components of the system being designed. Each of the three parameters is discussed below.

Concerning **reliability**, DT&E and OT&E will have confirmed that the system design and its prototype model provide the capabilities and meet the thresholds established for this system. However, this does not guarantee the same for this production model. Reliability (MTBF) is the most intractable and most expensive factor to alter, impacting virtually all elements of material readiness when changes occur. Changes to the system design at any level of indenture must receive the program team's immediate attention. They must determine the impact of the change upon all other dependent elements, assesses the costs/benefits/risks of that change to the system configuration, and re-establish control of all elements that have changed.

Required engineering changes to system design costs time, money, and readiness in terms of:

- Modifications to technical manuals, training plans, parts allowance documents, test procedures, retrofit planning, and the other support elements;
- Cost to retrofit installations, procure new spares and purge stocks of obsolete parts, buy new test equipment, print publications, conduct retraining, and depending on the terms of the contract, possibly contend with litigation; and
- Decreased readiness until the updated support products are in place and the turmoil to the support establishment levels out.

Configuration changes require the same level of the management attention, techniques, coordination and planning that the original system configuration required without the inherent structure of the original planning.

Concerning **maintainability** and maintenance planning, the maintenance concept/plan drives all other supportability elements of the system. Second only to configuration changes, the maintenance plan impacts every ILS element. The maintenance plan is driven by the acquisition approach and is dependent upon the reliability and configuration of the system. However, all other elements of logistics are dependent upon the maintenance plan, so the support system required to maintain the system and restore it to operation, when/if it should fail, must be designed and in place when the system is first deployed.

The program team must continuously be sensitive to any changes in configuration, form, fit and function of the system, or its component parts that require maintenance personnel to take longer than the MTTR threshold to restore the system to full operation. Although the MTTR threshold is an average for all maintenance actions, the program team should review any action that substantially exceeds the threshold.

Concerning **supportability**, the program should have an experienced logistics manager and supporting team to coordinate and control the many interdependent elements of logistics support. All logistics elements are merged into the LMI through the logistics support analysis process. The logistics team orchestrates this process, reduces uncertainty in support planning, ensures the compatibility of resources and planning, diminishes the duplication of action, and coordinates the transition of support tasks from the contractor to the Navy.

During the system's production, the reliability and maintainability should be locked into the system design and the configuration frozen. As long as that stability is maintained, the consistency among the various planning documents will be maintained and the budgeted cost of each element will track as planned. This ensures that the system is properly installed, trained personnel are on-site, and resources required to sustain inherent performance of the system are simultaneously positioned.

However, no program is immune to changes that affect system reliability, maintainability, supportability or producibility. When changes occur, the support team's functions are fourfold.

1. Maintain the supportability analysis. They continue to document all parameters used to determine support resource requirements and relate those parameters to the program thresholds. They are knowledgeable of changes to the program plans and whether a change is at the system level or the piece part level.

2. Establish interdependencies among the program elements. The support team is able to identify the impact of a change in one area to any other logistics element.

3. Identify critical tasks. The start up of some tasks is dependent upon the completion of other tasks. All tasks are tied to budget cycles. Tasks requiring Operations and Maintenance funds are particularly susceptible to changes in schedule that modify the fiscal year in which the task is begun.

4. Assess and reduce risk. Risk is a function of both the probability and the consequences of failure. The logistics team cannot eliminate changes to schedules, configuration, budgets, or other deviations from the program plans. They are expected to identify the impact of those changes on other program elements and to minimize or prevent degradation to system A_o at the time of deployment caused by inconsistent or out of phase support elements.

Each element of support requires varying response times to plan, budget, and execute, and requires a lead-time. The logistics team knows when an increment of each element of support is required to be positioned to be responsive to Fleet requirements. This Fleet support date is preceded by the requisite lead-time; thus, establishing the latest date that support and documentation must be provided to the responsible activity in order for that element of support to be in place to support the operational system. Any changes subsequent to that lead-time date produce a risk of degrading A_o in the fielded system. This can only be offset by extraordinary management attention to reduce the response time. For example, 12 months before the first production model is delivered a major repairable module is changed from a remove and replace maintenance concept to a lower level of indenture circuit card remove and replace concept. The change provides reduced operation and maintenance cost to the Fleet and increased repair capability at the shipboard level of maintenance. The logistics team should immediately be aware that:

- Technical manuals do not address these new maintenance procedures.
- Maintenance courses have already graduated personnel who were trained in the former maintenance procedure.
- Test equipment to fault isolate to the circuit card level have not been bought and the procurement and production lead-time for this specialized support equipment is at least two years.

Situations similar to the above example occur frequently and cannot be precluded. The serial impact of the change upon other elements of support is not exaggerated. The program team must be aware of the multiplier effect of any variance from the program plans, schedule, or budgets. They must take immediate action to maintain consistency and coordination among the various support elements to ensure system material readiness is sustained at the threshold value.

2.4.4.5 Develop Plans to Sustain A_o

The final test of whether the program team has maintained the system design A_o through production is the A_o achieved by the system when it is deployed in the operational environment. In order to do this the program team has to establish the following:

- Development of a continuing and consistent reporting system to monitor system performance based upon Fleet feedback utilizing Navy approved methodology.
- Determine responsibility for compiling those reports and how the Program Manger can monitor the system performance utilizing an unbiased reporting process.
- Manage variance from thresholds.

The program team must maintain all of the baseline documentation back to program initiation. This establishes the evolution of the system parameters to those of the production baseline configuration. The TEMP together with the results of DT&E, OT&E and Follow-on Operational Test and Evaluation (FOT&E) form the baseline for comparing achieved A_o in the testing environment with the actual Fleet experience. The Fleet will provide Casualty Reports (CASREPs), 3-M reports, Allowance Change Requests, Commanding Officer Narratives and any other special reports specified by the program team. Also available to the program team are failure analyses compiled by CNO (N76) MRDB, the In-Service Engineering Agent (ISEA), the Designated Overhaul Point (DOP) and Shore Intermediate Maintenance Activities. Additional data as parts usage and failure rate data from the NAVICP, configuration data from the program records as well as that maintained by the ISEA and NAVICP and Not Operationally Ready Supply and CASREP data from the NAVICP are provided.

Inevitably, parts allowances will have "holes" in them and, just as inevitably, the parts required to restore systems to an operational status will be for items Not-In-Stock. The program team's immediate concerns during this initial operational period are:

- Problem Definition
- Assessment of Impact
- Feedback
- Correction

Throughout the operational cycle of the system, the program team's first and most critical task is to define the problem when the system fails to meet performance parameters. It is always preferable to monitor the applicable parameters and identify and resolve issues before they degrade A_o. When does the program team take corrective action and when do they continue to monitor the system's performance, but not take action?

As introduced in paragraph 1.2 and explained more fully in appendix 3, A_o is expressed in equations such as:

$$A_o = \frac{MTBF}{MTBF+MTTR+MLDT} = \frac{MTBF}{MTBF+MTTR+MSRT+MOADT+M_{Adm}DT}$$

Where: MTBF = Mean Time Between Failures (an index of system reliability)
MTTR = Mean Time To Repair (an index of system maintainability)
MLDT = Mean Logistics Delay Time (an collective index of system supportability)
MSRT = Mean Supply Response Time (an index of system supportability)
MOADT= Mean Outside Assistance Delay Time (an index of system supportability)
$M_{Adm}DT$= Mean Administrative Delay Time (a collective index of system supportability)

Throughout the acquisition, each component of A_o, and A_o itself, has been individually tested and validated as achievable. These threshold values are the baseline values against which the system's performance in the fleet is compared. A problem exists when any of these metrics fall below the threshold value. However, the objective of the acquisition has been to deliver a system to the Fleet that provides enhanced capability. The critical criterion by which that system is measured to the probability that it will be ready to operate when called for at a random point in time is A_o. The system A_o can be met with many combinations of MTBF, MTTR, and MLDT values. A 20% shortfall in reliability may be offset by a 25% gain in supportability, and the system A_o threshold may still be met.

Before the first system is deployed, the methodology for monitoring system performance must be in place, and functioning. The sophistication of the reporting and monitoring systems depend upon the complexity of the system and the level of detail necessary to identify and isolate problems for testing, analyzing and fixing. Some recent technological innovations in Automatic Identification Technologies such as contact memory buttons have greatly improved the ability to store maintenance and performance information for access on demand. Technology is constantly improving, so implementing most recent innovations can be very beneficial. A well-managed, complex system can have a very detailed reporting system tracking the following metrics:

- Total system A_o, MTBF, MTTR, MLDT, MSRT, MOADT, and $M_{Adm}DT$.
- The A_o, MTBF, MTTR, MLDT, MSRT, MOADT, and $M_{Adm}DT$ for all of the system's modes of operation.
- Uptime and downtime, and deployed and non-deployed periods, for each ship in which the system is installed.
- Subsystem equipment and components experiencing reliability problems.
- High usage repair parts and supply system response times to provide those parts.

The reporting system can display the data in matrix form, pie charts, time line progressions, and narrative. This requires special reporting by the ships, special compilation and drafting by the responsible shore activity, and printing and distribution costs.

The sophistication of the above tracking and monitoring system is not required for all programs. For example, A_o for a missile is computed as the number of successful launches divided by the number of attempts since the missile is a non-recoverable, go/no-go system. The disadvantage of this method of monitoring is that it does not isolate problems to the components of reliability, maintainability, or supportability. The program team knows only that the material readiness of the system/equipment is degraded and they then have to isolate the cause of the degradation through additional testing and analysis. This could be costly. The program team assesses the requirement for a given level of detail and determines whether the costs to obtain and compile data over the period of time to system maturation are worth it. The program team should minimize the reporting requirements on the Fleet and maximum the use of existing reporting system while satisfying the requirements to measure readiness.

When shortfalls in the achievement of readiness thresholds occur, the program team identifies the cause, assesses the impact, determines the fix, and executes the solution. Identification of the cause is the most difficult of these to accomplish. The more complex the system, the more difficult will be the job of isolating the problem. As a general rule, readiness problems are initially manifested as supply support problems. When individual parts fail, the system fails. When parts fail faster than the supply system can replace them, a logistics support problem exists and the thread to sustaining A_o unravels. On the surface, the Fleet is correctly reporting that the supply support is unsatisfactory. The system is non-operational due to lack of repair parts. Once the parts are provided the system will be repaired. If the problem results from the supply system buying an insufficient inventory, or the procurement lead times have increased significantly, then the degradation to the system availability is a supply support problem.

If the program team begins with the premise that readiness problems are manifested initially as supply problems, then they continue the analysis to determine if the supply support problem is masking a more serious, long-term reliability or other logistics support problem. The initial analysis should be to correlate the predicted replacement rate with the actual replacement rate in the Fleet. Given the high levels of reliability in modern designs and the lead time to implement supply changes (i.e., system stock, additional OBRPs, repair contracts etc.), a long-term replacement (modernization program) rate for support planning should be pursued.

The product specifications provide a design replacement factor or failure rate for each part in the system. The program team obtains the actual failure rates for the parts that are causing the most frequent CASREPs, have the most backorders in the supply system, or are otherwise identified by the Fleet as supply problems. This failure data is available from both the PSICP and 3M Maintenance Data System (MDS). Both sources of data are obtained and compared. The 3M data indicates actual failure rates unique to the system. The PSICP usage rates indicate total demands against the supply system and identify the activities that using those parts. Comparing the data from these sources reveals whether the lack of parts is caused by higher than predicted failures in the system; by other systems using common repair parts; or by intermediate or depot level activities that are using more parts than predicted. These two data sources will identify which parts are causing support problems and, when compared with predicted replacement rates, will focus the actions of the program team's actions toward an integrated ILS solution that include reliability, maintainability, and supply support.

Frequently, parts problems are caused by Fleet operations and maintenance practices. Repair parts with higher than predicted use can result from the following factors:

1. Poor fault isolation detection procedures or equipment can cause higher repair parts demand. If the technician can only isolate failures to an ambiguity group of three parts with available test equipment, then the only means available to identify the actual failure is to replace each of those three parts until the system is fixed. If two of those parts have very low failure rates but are experiencing very high demand, then the program team needs to assess fixes to the fault isolation procedures.

2. Unplanned usage occurs when secondary parts such as cover plates, shims, leads, gaskets, or insulators experience higher usage than predicted. Corrective maintenance procedures may require the removal or even destruction of these parts. Any time a part is removed, the chance for it to be damaged, destroyed, or lost increases. If that part is critical to safe operation of the equipment, its actual failure rate may not have been predicted and it would not have been stocked.

3. Increased system utilization occurs when the system was designed to be used "x" number of hours per month and planned maintenance cycles and parts usage per year were based upon that utilization rate. If the parts usage dramatically increases, then the program team should determine and compare the actual Fleet system utilization rate. The Fleet may have discovered new capabilities not anticipated, or the predicted utilization rate may have been grossly understated. In this situation the system is faultless, except that the failure rates require re-computation; and the supply system needs to increase inventory levels to accommodate the higher demand caused by greater system operating hours.

4. Technical data errors frequently cause a higher than normal demand for parts. When the technical manual identifies the incorrect part; the part number to National Stock Number (NSN) cross reference list misidentifies the correct NSN; or the part has been modified making it useless in older configurations of the equipment but it still has the same NSN as the obsolete configuration. The Fleet will continue to order and reorder the same item until the data problem is highlighted and corrected.

The above examples of relationships among logistics elements are indicative of difficulties confronting the program team in attempting to identify the real system-degrading problem. The point is not to be misled by the initial problem identification, but continue to analyze until satisfied that the actual root cause degradation has been identified and a fix developed.

When the real problem is determined, the program team still contends with lead-time to develop, procure, deploy the fix and, most importantly, to assess the interdependent impacts on other elements of maintainability and supportability until the fix is in place.

2.4.5 Documentation, Reports and Records

Development of a plan for post-production support begins at the full production decision and is updated throughout the production cycle. This plan provides planning for continued support for the life cycle of the system after the production line is closed. The post-production support plan should include the following:

- The schedule for the production line closing.
- Maintenance concept (total contractor logistics support, organic support, or some mixture).
- Whether or not continuing contractual coverage is required for proprietary hardware or software; and if so, who is responsible for maintaining/implementing that contract.
- Whether or not the government will buy those rights in data.
- Whether or not the government will make a "life-of-type" buy of all proprietary piece parts to support the system throughout its life cycle.
- Whether the contractor depot will support the system or transition to an organic Navy depot is required.
- Procurement of all system technical specifications in sufficient level of detail for re-procurement from capable sources in a competitive mode.
- Disposal/Demilitarization requirements, if any.
- Requirements for a transition plan that provides the schedule, responsibilities, and strategy for transitioning supply and depot level maintenance support from the contractor to the Navy. This plan accommodates budget cycles, administrative, and procurement lead times; and the orderly transfer of engineering and technical data required for Navy activities to have support in place on the date of transition.
- The Operational Supportability Document, whether it be an Operational Logistics Support Plan, Users Logistics Support Summary, or Operational Logistics Support Summary (OLSP/ULSS/OLSS), identifies the logistics products and services (and

guidance for their use) necessary to operate and maintain the system, subsystems and equipments in their operational environments. The requirement for this plan may be satisfied by a number of formats commonly known as Operational Logistics Support Plan (OLSP), Operational Logistics Support Summary (OLSS), or Users Logistics Support Summary (ULSS). Rather than discussing a planning process, as does the ALSP/ILSP, this document provides concrete, operational supportability information to the end user. Document should be provided, by the Program Team, to the end user sufficiently prior to Fleet introduction or IOC, and maintained current for the life cycle of the end product. It should address each of the logistics elements, providing specific products such as publications by title and number; parts lists by number, support equipment by nomenclature, part number and quantity, training courses by course number, length, and location, etc. (i.e., everything the end user needs to know to ensure proper system operation and maintenance). Document may need to be site specific, depending on the application.

2.5 Sustaining Operations

2.5.1 Introduction

Operational objectives are the execution of a support program that meets operational support performance requirements and sustainment of systems in the most cost-effective manner for the life cycle of the system. Three principal objectives with regard to A_o are:

1. Operate the system to achieve the design A_o;
2. Monitor the program A_o to identify deviations from plans and determine the degree of deviation; and,
3. Identify corrective actions to maintain the required A_o in deployed systems.

Mean Logistics Delay Time (MLDT), specifically MSRT, frequently has the single greatest impact on system A_o. While MTBF and MTTR are usually measured in minutes or hours; MLDT is often measured in days, weeks or months, and occasionally, years. There are several forces acting on system A_o and cost, which warrant management attention, such as:

- Configuration management in terms of repair part allowancing and stock control,
- Material availability after system modification/upgrade,
- Organic or contract supported physical distribution capability,
- Material obsolescence as systems age beyond traditional commercial lifespan,
- Material availability as Original Equipment Manufacturers (OEMs) consolidate or cease to operate,
- Material availability outside of traditional supply lanes,
- Physics of failure cause reductions in systems reliability,
- Systems aging factors cause reductions in systems reliability,
- Maintenance induced failures cause reductions in systems reliability, and
- Environmental conditions contribute to the above three.

2.5.2 A_o / Cost Study Objectives

The following strategies for improving A_o performance and/or cost savings apply:

- Validation of the A_o and cost estimates with actual fleet feedback data.
- Identify specific sub-systems and components that are driving A_o and cost problems.
- Provide decision support analysis and recommendations for system improvements.
- Confirm the achievement of A_o during early fielding. Measure the achieved A_o.
- Manage changes or modifications in design, configuration or support resources that impact the achievement of the A_o threshold.
- Identify resources to improve A_o if the A_o threshold is not being achieved.
- Identify post-production support issues.

2.5.3 Data Inputs and Models

Refer to generally applicable information concerning models and data in paragraph 2.1.3. In previous phases only predictions and test data were available to model achievement of A_o and cost objectives and thresholds. During Fleet operations, actual fleet feedback data is collected for input into the following models:

- VAMOSC cost Reports
- Casualty Reports
- Commanding Officer Narrative Reports
- 3M Data
- CNO (N76) MRDB, and ISEA failure rate analysis reports, including information concerning failure trends from intermediate and depot data.
- Engineering Change Requests
- Prime contractor analysis reports.
- ISEA Feedback Report

2.5.4 Studies and Analyses

Methodologies for improving chances of success include:

- Ensure that the fielded system continues to provide the required A_o and cost characteristics.
- Ensure that the configuration, installation and Fleet operation of the system is consistent with the product specifications and use study from which the system was developed.
- Perform A_o and cost studies and analysis to support recommendations for system upgrades, modernization, technology insertion and other engineering modifications.

2.5.4.1 Monitoring Achieved A_o from Fleet Reporting

The process includes the study of the interdependent impacts of shortfalls in reliability, maintainability, or supportability upon each other, the A_o of the system sub-units, and ultimately, the material readiness of the system. The system can be displayed in a matrix with its major components on one axis and the components of A_o and their sub-elements on the second axis.

The program team should continue to monitor key indicators including those critical path items and resource requirements that vary from the required levels of performance. The program team assesses the impact of a variance in one component upon other components of A_o. The dependent relationships are important to the program team not only during production, but become critical to analysis of problems in the deployed operational system.

2.5.4.2 Assessing the Impact of Deviations, Changes and Modifications

During operations / sustainment, the need for modifications and/or engineering changes becomes more probable. These will naturally change the allocation of the A_o driving parameters (reliability, maintainability and supportability) among the components of the system.

2.5.4.3 Execute the Plan to Sustain A_o

The final test of whether the program team has maintained the system design A_o through production is the A_o achieved by the system when it is deployed in the operational environment. In order to achieve this, the program team has to establish the following:

- Performance of a continuing and consistent reporting system to monitor system performance.
- Compile those reports and determine how the Program Manager can monitor the system performance.
- Manage variances from established thresholds.

Inevitably, the parts required to restore operations will be for items not in stock. Throughout the operational cycle of the system, the program team's first and most critical task is to define the problem when the system fails to meet performance parameters, assess the impacts and decide when, and what, corrective actions are advisable.

2.5.5 Documentation Reports and Records

Several reports should be generated during the operational phase to address potential or actual problems, alternatives, and recommendations including problem identification and alternative analysis reports and decision support trade-study reports.

2.5.5.1 Follow-On Tracking

The primary element of documentation for this phase is the plan for the follow-on tracking, monitoring and reporting system for A_o and the components of A_o in the operational environment. The following key action steps are required, on a continuing basis, to execute the production, deployment, and follow-on support aspects:

- Manage changes/modifications in design, configuration or support resources (including contractor logistics support) to maintain the A_o threshold.
- Assess the impact on system A_o due to changes in the configuration.
- Identify resources to improve A_o, if the A_o threshold is not achieved.

Appendix 1

Definitions of Applicable Terms

A

Acquisition Logistics: Technical and management activities conducted to ensure supportability implications are considered early and throughout the acquisition process to minimize support costs, optimize availability and to provide the user with the resources to sustain the system.

Acquisition Management: Management of all or any of the activities within the broad spectrum of "acquisition," as defined above. It also includes training of the defense acquisition workforce and activities in support of Planning, Programming, and Budget System (PPBS) for defense acquisition systems/programs.

Acquisition Managers: Persons responsible at different levels for some activity related to developing, producing, and/or fielding an Automated Information System (AIS) or weapon system. Includes senior level managers responsible for ultimate decisions, Program Managers, and commodity or functional area managers.

Acquisition Phase: All the tasks and activities needed to bring a program to the next major milestone occur during an acquisition phase. Phases provide a logical means of progressively translating broadly stated mission needs into well-defined system-specific requirements and ultimately into operationally effective, suitable, and survivable systems.

Acquisition Plan (AP): A formal written document reflecting the specific actions necessary to execute the approach established in the approved acquisition strategy and guiding contractual implementation. (Refer to Federal Acquisition Regulation (FAR) Subpart 7.1 and Defense Federal Acquisition Regulation Supplement (DFARS) Subpart 207.1 and Acquisition Strategy.)

Acquisition Planning: The process by which the efforts of all personnel responsible for an acquisition are coordinated and integrated through a comprehensive plan for fulfilling the procurement need in a timely manner and at a reasonable cost. It is performed throughout the life cycle and includes developing an overall acquisition strategy for managing the acquisition, including supportability, and a written acquisition plan.

Acquisition Program: A directed, funded effort that is designed to provide a new, improved or continuing weapons system or AIS capability in response to a validated operational need.

Acquisition Program Baseline (APB): A document that contains the most important cost, schedule, and performance parameters (both objectives and thresholds) for the program. It is approved by the Milestone Decision Authority (MDA), and signed by the Program Manager (PM) and their direct chain of supervision, e.g., for acquisition category (ACAT) ID programs it is signed by the PM, Program Executive Officer (PEO), Component Acquisition Executive (CAE), and Defense Acquisition Executive (DAE).

Acquisition Strategy (AS): A business and technical management approach designed to achieve program objectives within the resource constraints imposed. It is the framework for planning, directing, contracting for, and managing a program. It provides a master schedule for research, development, test, production, fielding, modification, and postproduction management and other activities essential for program success. Acquisition strategy is the basis for formulating functional plans and strategies e.g., Test and Evaluation Master Plan (TEMP), Acquisition Plan (AP), support planning, competition strategy, and prototyping; etc.

Affordability: A determination that the life cycle cost of an acquisition program is in consonance with the long-range investment and force structure plans of the DoD or individual DoD Components.

Analysis of Alternatives (AoA): An analysis intended to aid decision-making by illuminating the risk, uncertainty, and the relative advantages and disadvantages of alternatives being considered satisfying a mission need. The AoA shows the sensitivity of each alternative to possible changes in key assumptions (e.g., threat) or variables (e.g., performance capabilities). Part of the CAIV process.

Availability: A measure of the degree to which an item is in an operable and committable state at the start of a mission when the mission is called for at an unknown (random) point in time.

B

Baseline: Defined quantity or quality used as starting point for subsequent efforts and progress measurement that can be a technical cost or schedule baseline. (See APB).

Baseline Comparison System (BCS): A current operational system, or a composite of current operational subsystems, which most closely represents the design, operational, and support characteristics of the new system under development.

Benchmarking: Rating organizations practices, designs and processes against the world's best practices for purposes of seeking improvement.

Built-in-test (BIT): An integral capability designed into a product, which provides an automated test capability to detect or isolate failures.

Built-In-Test-Equipment (BITE): Any device permanently mounted in the prime equipment and used for the express purpose of testing the prime equipment, either independently or in association with external test equipment.

C

Capstone Requirements Document (CRD): A CRD captures the overarching requirements for a mission area, forming a family-of-systems (e.g., space control, theater missile defense, etc.) or system-of-systems (e.g., national missile defense). CRDs, when required, shall guide DoD components in developing ORDs for future systems and upgrading existing systems (CJCSI 3170.01C). The JROC shall be the initiation authority for CRDs.

Commercial Off-The-Shelf (COTS): Any item, other than real property, that is of a type customarily used for non-governmental purposes and that: (1) has been sold, leased or licensed to the general public; or, (2) has been offered for sale, lease, license to the general public; or any item that evolved through advances in technology or performance and that is not yet available in the commercial marketplace, but will be available in the commercial marketplace in time to satisfy the delivery requirements under a Government solicitation.

Compatibility: Capability of two or more items or components of equipment or material to exist or function in the same system or environment without mutual interference.

Contractor Logistics Support (CLS): A strategy for weapon system life cycle support where the contractor manages (and may also own (see FSC)) the inventory, determine stockage levels, typically repairs non-serviceable material, and is required to meet specific performance metrics.

Cost Benefit Analysis: The act of developing, analyzing and documenting cost estimates for two or more alternatives through various approaches and techniques. It is the process of analyzing and estimating the incremental and total resources required supporting past, present, and future systems and is an incremental step in the selection of alternatives in the decision-making process.

Cost as An Independent Variable (CAIV): Methodologies used to acquire and operate affordable DoD systems by setting aggressive, achievable life cycle cost objectives, and managing achievement of these objectives by trading off performance and schedule, as necessary. Cost objectives balance mission needs with projected out-year resources, taking into account anticipated process improvements in both DoD and industry. CAIV has brought attention to the government's responsibilities for setting/adjusting life cycle cost objectives and for evaluating requirements in terms of overall cost consequences.

Cost Effectiveness: A measure of the operational capability added by a system in terms of its life cycle costs, where the measure of effectiveness is operational availability and the cost includes the total cost of ownership.

D

Design Parameters: Qualitative, quantitative, physical, and functional value characteristics that are inputs to the design process, for use in design trade-offs, risk analyses, and development of a system that is responsive to system requirements.

Design Reference Mission Profile (DRMP): The DRMP provides a time history of events, functions (often referred to as use or operations) and environmental conditions that a system is expected to encounter during its life cycle, from manufacturing to removal from service use. See Appendix 5.

E

Economic Analysis: (a) A systematic approach to identify, analyze, and compare costs or benefits of alternative courses of action that will achieve a given set of objectives. In the broad sense, the systematic approach called "economic analysis" applies to new programs as well as the analysis of ongoing actions. (b) A complete, detailed, and fully documented analytical study in which the economic approach is used.

Escalation: Use of a price index to convert past to present prices or of converting present to future prices; increase due to inflation and outlay rates for the type of equipment being acquired and the branch or the service involved.

Exit Criteria: Program specific accomplishments that must be satisfactorily demonstrated before a program can progress further in the current acquisition phase or transition to the next acquisition phase. Exit criteria are normally selected to track progress in important technical, schedule, or management risk areas. The exit criteria shall serve as gates that, when successfully passed or exited, demonstrate that the program is on track to achieve its final program goals and should be allowed to continue with additional activities within an acquisition phase or be considered for continuation into the next acquisition phase. Exit criteria are some level of demonstrated performance outcome (e.g., level of engine thrust), the accomplishment of some process at some level of efficiency (e.g., manufacturing yield), or successful accomplishment of some event (e.g., first flight), or some other criterion (e.g., establishment of a training program or inclusion of a particular clause in the follow-on contract) that indicates that aspect of the program is progressing satisfactorily. Exit criteria are documented in the ADM.

F

Failure Rate: The total number of failures within an item population, divided by the total time expended by that population, during a particular measurement interval under stated conditions.

Figures of Merit (FOM): An evaluation method that uses performance factors such as system performance, operational performance, and support performance. Total Life Cycle Cost is the common denominator.

Force Levels: Number of aircraft, ships, troops, and other forces that are required to accomplish assigned tasks or missions. Normally identified by specified aircraft model, ship type, Army divisions, etc.

Full Service Contracting (FSC): A strategy for contracting out all facets of logistics support (ILS elements) for total weapon system life cycle support, often over the entire lifecycle of the specific system. This includes inventory management; stockage levels, locations, strategies; repair or replacement decisions; and is required to meet specific performance metrics.

Functional Analysis/Allocation: The examination of a function to identify all sub-functions necessary to the accomplishment of that function, and the identification of functional relationships and interfaces and the capturing of those relationships in a functional architecture. Requires the flow-down of upper-level performance requirements to lower-level sub-functions.

H

Human Factors: The systematic application of relevant information about human abilities, characteristics, behavior, motivation, and performance. It includes principles and applications in the areas of human engineering, anthropometrics, personnel selection, training, life support, job performance aids, and human performance evaluation.

I

Independent Cost Analysis: An analysis of program office and/or component life cycle cost estimates conducted by an impartial body disassociated from the management of the program.

Independent Cost Estimate (ICE): A life cycle cost estimate for ACAT I programs prepared by an office or other entity that is not under the supervision, direction, or control of the military department, defense agency, or other component of the DoD that is directly responsible for carrying out the development or acquisition of the program, or if the decision authority has been delegated to a Component, prepared by an office or other entity that is not directly responsible for carrying on the development or acquisition of the program.

Initial Capabilities Document: DoD 5000.2 requires development of in Initial Capabilities Document (ICD) to define broad, time-phased operational goals and the requisite capabilities required to meet to those goals. The ICD will examine multiple concepts and material approaches to optimize the way the DoD provides these capabilities. The examination will include analyses on affordability, technology maturity and responsiveness.

Inherent Availability (A_i): Availability of a system with respect only to operating time and corrective maintenance. It ignores standby and delay times associated with preventive maintenance as well as administrative and logistics down time.

Integrated Logistics Support (ILS) Elements: A traditional group of items that taken together constitute logistics support including maintenance planning; manpower and personnel; supply support; support equipment; technical data; training and training support; computer resources support; facilities; packaging, handling, storage, and transportation; and, design interface.

Integrated Product and Process Development (IPPD): A management technique that simultaneously integrates all essential acquisition activities through the use of multidisciplinary teams to optimize the design, manufacturing, and supportability processes. IPPD facilitates meeting cost and performance objectives from product concept through production, including field support. One of the key IPPD tenets is multidisciplinary teamwork through Integrated Product Teams (IPTs).

Integrated Product Team (IPT): Team composed of representatives from appropriate functional disciplines working together to build successful programs, identify and resolve issues, and make sound and timely recommendations to facilitate decision-making. There are three types of IPTs: Overarching IPTs (OIPTs) focus on strategic guidance, program assessment, and issue resolution; working level IPTs (WIPTs) identify and resolve program issues, determine program status, and seek opportunities for acquisition reform; and program level IPTs focus on program execution and may include representatives from both government and industry.

Interoperability: The ability of systems, units, or forces to provide services to and accept services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together. (Joint Pub 1-02)

K

Key Performance Parameters (KPPs): Those capabilities or characteristics so significant that failure to meet the threshold value of performance can be cause for the concept or system selected to be reevaluated or the program to be reassessed or terminated. KPP's are a critical subset of all the performance parameters found in the ORD, and are included in the performance portion of the APB. KPP's are validated by the JROC for ACAT I programs. For ACAT IA programs, the JROC or cognizant PSA validates KPP's.

L

Level of Repair Analysis (LORA): A specialized form of Life Cycle Cost (LCC) Analysis where the LCC of each alternative level of repair is studied for each repairable item candidate. LORA is the basis for repair level decisions based on the LCC of all resources required for performing the repair at each level of repair.

Life Cycle Cost (LCC): The total cost to the government of all categories of costs for the total system to include the following:

(1) **Research and Development (R&D).** The cost of all R&D activities should be estimated beginning with program initiation through development (including such efforts as redesign and test efforts necessary to install equipment or software into existing platforms). Non-recurring and recurring R&D costs for prototypes, engineering development equipment and/or test hardware (and major components thereof) should be shown separately. Contractor system test and evaluation and government support to the test program should be fully identified and estimated. Support, such as support equipment, training, data, and military construction should be estimated.

(2) **Investment.** The cost of investment (i.e., low rate production, and production and deployment) should include the total cost of procuring the prime equipment and its support (e.g., command and launch equipment; support equipment; training; data; initial spares; war reserve spares; pre-planned product improvement (P3I) program; and military construction). The cost of all related procurement (such as, modifications to existing aircraft or ship platforms) should be included. Nonrecurring and recurring costs for the production of prime equipment and major support equipment should be shown separately.

(3) **Operating and Support (O&S).** The cost of O&S activities should include all direct and indirect elements. Personnel costs should be based on estimates for officers, enlisted personnel, civilians, and contractors, expressed in terms of the Manpower Estimate Report

functional categories. The O&S estimate should include unit level consumption (consumables, including expendable training stores, and fuel), depot maintenance, sustaining investment, system and inventory management control, and indirect O&S costs. The length of time and costs associated with defense program phase-in, and the length of time and costs associated with steady state operations should be identified. Appropriate use of Visibility and Management of Operating and Support Costs (VAMOSC) program data (Chapter 4 of DoD 5000.4-M, December 1992) will be made in deriving these estimates.

Life Cycle Management (LCM): A management process, applied throughout the life of a system that bases all programmatic decisions on the anticipated mission-related and economic benefits derived over the life of the system.

Life Cycle (Weapon System): All phases of the system's life including research, development, test and evaluation (RDT&E), production, deployment (inventory), operations and support (O&S), and disposal.

Logistics Funding Profile (LFP): That portion of the program budget necessary to execute the acquisitions logistics plan.

Logistics (Maintenance/Supply) Related Reliability: A measure of reliability that addresses all incidents that require a response from the logistics system. The probability that no corrective (or unscheduled) maintenance, unscheduled removals, and/or unscheduled demands for spare parts will occur following the completion of a specific mission profile.

Logistics Management Information (LMI): The supportability analysis documentation (previously called Logistics Support Analysis Record (LSAR)) that recognizes the effects of occurrences that place a demand on the logistics support structure without regard to the effect on mission or function.

Logistics Supportability: The degree to which system design characteristics and planned logistics resources (including test, measurement, and diagnostic equipment; spares and repair parts; technical data; support facilities; transportation requirements; training; manpower; and software support) allow meeting system availability and wartime usage requirements.

M

Maintainability: The measure 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. (See Mean Time To Repair (MTTR).)

Maintenance: 1. The upkeep of property, necessitated by wear and tear, which neither adds to the permanent value of the property nor appreciably prolongs its intended life but keeps it in efficient operating condition. Normally includes "repair," but in Defense in the case of real property, is distinguished from repair by being limited to recurrent, day-to-day, periodic, or scheduled work required to preserve or restore a real-property facility to such condition that it may be effectively utilized for its designated purpose. 2. Preventive maintenance to deter something from going wrong; or corrective maintenance for restoration to proper condition.

Maintenance Concept: A brief description of maintenance considerations, constraints, and plans for operational support of the system/equipment under development. A preliminary maintenance concept is developed and submitted as part of the preliminary system operational concept for each alternative solution candidate by the operating command with the assistance of the implementing and supporting commands. A major driver in designing the system/ equipment and the support planned.

Maintenance Plan: A more detailed description of maintenance decisions on each repair-able item candidate within the system Work Breakdown Structure (WBS). There is typically a family of maintenance plans covering each major subsystem, e.g., radar subsystem, hydraulic subsystem, etc. The maintenance plan is based on the level of repair analysis and is the basis for each of the traditional elements of logistics support (LS).

Major Assembly: An operation in the construction of a section, which joins a number of subassemblies.

Material Management: Direction and control of those aspects of logistics which deal with material, including the functions of identification, cataloging, standardization, requirements determination, procurement, inspection, quality control, packaging, storage, distribution, disposal, maintenance, mobilization planning, industrial readiness planning, and item management classification; encompasses materiel control, inventory control, inventory management, and supply management.

Material Readiness Database (MRDB): The CNO (N76) MRDB was established as a single authoritative source for calculating A_o and associated reliability and maintainability parameters including, but are not limited to MTBF, MTTR, MLDT, MOAT, M_{Adm}DT, and MSRT.

Mean Down Time (MDT): The average time a system is unavailable for use due to either corrective or preventive maintenance. Time includes the **actual repair time**, including fault detection, fault isolation, removal and replacement of failed components, and verification that the fix restored proper operation (i.e., MTTR) and all **delay time(s)** associated with arrival of a qualified repairman, with necessary technical publications, support equipment, and appropriate replacement parts, etc (i.e., MLDT).

Mean Down Time for Documentation (MDTD): The average downtime per maintenance action to obtain documentation needed for fault location/isolation, maintenance and checkout.

Mean Down Time for Other Reasons (MDTOR): The average downtime per maintenance action for reasons not otherwise identified.

Mean Down Time for Training (MDTT): The average downtime per maintenance action due to lack of training.

Mean Logistics Delay Time (MLDT): The average time a system is unavailable due to logistics system delays associated with the maintenance action (i.e., obtaining required parts (MSRT) or other logistics resources (M_{Adm}DT, MOADT) and other delays) where:

- **Mean Supply Response Time (MSRT):** Is the average portion of down time awaiting receipt of a spare component (both from onboard and from off ship). MSRT is the single greatest driver in MLDT.
- **Mean Administrative Delay Time (M_{Adm}DT)**: The average period of down time awaiting logistics resources other than spare parts. It includes time awaiting qualified maintenance personnel, support equipment, technical data, training, facilities, etc. Examples are Mean Down Time for Documentation (MDTD), Mean Down Time for Training (MDTT), and Mean Down Time for Other Reasons (MDTOR).
- **Mean Outside Assistance Delay Time (MOADT):** The average time awaiting maintenance teams from other locations - depot repair teams and general support teams who travel to operating sites to perform maintenance are examples.

Mean Time Between Failures (MTBF): For a particular interval, the total functional life of a population of an item divided by the total number of failures within the population. The definition holds for time, rounds, miles, events, or other measures of life unit.

Mean Time Between Maintenance (MTBM): One of the basic measures of reliability for repairable fielded systems, it is the average time between all system maintenance actions, including both corrective and preventive maintenance actions whether scheduled or unscheduled.

Mean Time Between Critical Failure (MTBCF): A measure of system reliability, which includes the affects of any fault tolerance such as that provided by redundancy. The average time between failures, which cause a loss of a system function, considered “critical” by the customer.

Mean Time To Repair (MTTR): A basic technical measure of maintainability - the average elapsed time (clock hours) for corrective maintenance (including testing times for fault detection, isolation and verification of correction).

Measures of Effectiveness (MOE): A measure of operational success that must be closely related to the objective of the mission or operation being evaluated. For example, the number of enemy submarines sunk or enemy tanks destroyed may be satisfactory MOEs if the objective is to destroy such weapons systems. However, if the real objective is to protect shipping or an infantry battalion, then the best course of action might be one, which results in fewer friendly submarines or tanks actually killed. MOEs denoted in the Analysis of Alternatives (AoA), Operational Requirements Document (ORD) and Test and Evaluation Master Plan (TEMP) must be consistent. A meaningful MOE must be quantifiable and a measure to what degree the real objective is achieved.

Measures of Performance (MOP): Measures of a system’s technical performance expressed as speed, payload, range, time on station, frequency, or other distinctly quantifiable performance features. Several MOPs may be related to the achievement of a particular MOE.

Milestone Decision Authority (MDA): The individual designated in accordance with criteria established by the Under Secretary of Defense (Acquisition, Technology, & Logistics) (USD (AT&L)), or by the Assistant Secretary of Defense (Command, Control, Communications, and Intelligence) (ASD (C^3I)) for Automated Information systems (AIS) acquisition programs, to approve entry of an acquisition program into the next phase.

Mission Area: A segment of the defense mission as established by the Secretary of Defense (SECDEF). Each DoD component has mission areas (e.g., Navy - antisubmarine warfare, Army - ground combat, etc.) for which it must equip its forces.

Mission Critical System: A system whose operational effectiveness and operational suitability is essential to successful completion or to aggregate residual combat capability. If this system fails, the mission likely will not be completed. Such a system can be an auxiliary or supporting system, as well as a primary mission system.

Mission Element: A segment of a mission area critical to the accomplishment of the mission area objectives and corresponding to a recommendation for a major system capability as determined by a DoD Component.

Mission Need: A statement of operational capability required to perform an assigned mission or to correct a deficiency in existing capability to perform the mission.

Mission Need Analysis: Assesses alternatives in an operational context, identifying what force capabilities would be gained (or foregone) by pursuing any of a designated set of alternatives. Assesses the strengths and weaknesses of a military force when confronting a postulated threat in a specified scenario or set of circumstances (such as force structures, geographic location, and environmental conditions).

Mission Need Determination (MND): The process, that leads to a Initial Capabilities Document (ICD), by which DoD Components determine deficiencies in current capabilities and opportunities to provide new capabilities in terms of non-materiel solutions and/or materiel solutions.

Mission Reliability: A measure of the ability of an item to perform its required mission critical functions for the duration of a specified mission. Can also be stated as the probability that a system can complete its required operational mission without an operational mission failure.

Model: A physical, mathematical, or otherwise logical representation of systems, entity, phenomenon, or process. (DoD 5000.59, 4 January 1994).

O

Objectives: The performance value that is desired by the user and which the PM is attempting to obtain. The objective value represents an operationally meaningful, time critical and cost-effective increment above the performance threshold for each system performance parameter.

Operating Costs: Those program costs necessary to operate and maintain the capability. These costs include military personnel (MP) and operations and maintenance (O&M) Costs.

Operating Time: The time during which the system is operating in a manner acceptable to the operator.

Operational Assessment (OA): An evaluation of operational effectiveness and operational suitability made by an independent operational test activity, with user support as required, on other than production systems. The focus of an OA is on significant trends noted in development efforts, programmatic voids, and areas of risk, adequacy of requirements, and the ability of the program to support adequate operational testing (OT). OA may be made at any time using technology demonstrators, prototypes, mock-ups, engineering development models, or simulations but will not substitute for the independent operational test and evaluation necessary to support full production decisions.

Operational Availability (A_o): The A_o of a system is the probability that the system is capable of performing its specified function when called for at a random point in time. It is Navy policy that Ao is the primary measure of material readiness for weapon systems and equipment. It is the quantitative link between readiness objectives and supportability. (OT&E Definition: Ao is either the total uptime divided by the total calendar time (uptime plus downtime) for continuous operating systems, or the number of systems that are ready, divided by the number possessed (e.g., the number of times the system was available, divided by the number of times the system was required) for on-demand systems.)

Operational Capability (C_o): The measure of the results of the mission, given the condition of the systems during the mission (dependability).

Operational Constraints: Initially identified in the Initial Capability Document /ICD). As a minimum, these constraints will consider the expected threat and natural environments, the possible modes of transportation into and within expected areas of operation, the expected electronic warfare environment, the potential for NATO application, operational manning limitations and existing infrastructure support capabilities.

Operational Effectiveness: The overall degree of mission accomplishment of a system when used by representative personnel in the environment planned or expected (e.g., natural, electronic, threat, etc.) for operational employment of the system considering organization, doctrine, tactics, survivability, vulnerability, and threat (including counter-measures, initial nuclear weapons effects, nuclear, biological, and chemical contamination (NBCC) threats).

Operational Mission Failure: A failure that prevents the system from performing one or more mission essential functions.

Operational Requirements: User-or user representative-generated validated needs developed to address mission area deficiencies, evolving threats, emerging technologies or weapon system cost improvements. Operational requirements form the foundation for weapon system unique specifications and contract requirements.

Operational Requirements Document (ORD): Documents the user's objective (desired) and threshold (minimum acceptable) level of requirements for operational performance of a proposed concept or system. Format is contained in CJCSI 3170.01B.

Operational Suitability (OS): The degree to which a system can be placed satisfactorily in field use with consideration being given to availability, compatibility, transportability, interoperability, reliability, wartime usage rates, maintainability, safety, human factors, manpower supportability, logistics supportability, natural environmental effects and impacts documentation, and training requirements.

Operations and Support (O&S) Cost: Those resources required to operate and support a system, subsystem, or a major component during its useful life in the operational inventory.

P

Performance: Those operational and support characteristics of the system that allow it to effectively and efficiently perform its assigned mission over time. The support characteristics of the system include both supportability aspects of the design and the support elements necessary for system operation.

Preventive Maintenance: Time associated with performance of all required maintenance intended to prevent system failures. This is usually scheduled maintenance expressed in terms of hours per time period (e.g., year).

Program Decision Meeting (PDM): Navy or Marine Corps review forum to advise the Navy Acquisition Executive for decisions on acquisition programs at various levels.

Program Element (PE): The 11 major force programs are subdivided into PEs. The PE, the basic building block of the future year's defense program (FYDP), is defined as "an integrated combination of men, equipment, and facilities which together constitute an identifiable military capability or support activity." It identifies the mission to be undertaken and the organizational entities to perform the mission. Elements may consist of forces, manpower, materials, services, and/or associated costs as applicable. The PE consists of 7 digits ending with a letter indicating the appropriate service.

R

Readiness: The probability that, at any point in time, a system or equipment is either operating satisfactorily or ready to be placed in operation on demand when under stated conditions, including stated allowable warning time.

Readiness Based Sparing (RBS): A methodology, using approved models, to perform reliability, maintainability, and availability analyses and sparing determinations (OPNAVINST 4442.5 germane).

Redundancy: Repetition of parts or subsystems to assure operation if original (primary) part or subsystem fails. The existence of one or more means, not necessarily identical, for accomplishing a given function. Active redundancy has all items operating simultaneously, while standby redundancy has alternate means activated upon failure.

Reliability: The ability of a system and its parts to perform its intended function (mission) for a specified period of time under stated conditions without failure, degradation or demand on the support system. See Mean Time Between Failures (MTBF).

Reliability, Availability, and Maintainability (RAM): Requirement imposed on acquisition systems to insure they are operationally ready for use when needed will successfully perform assigned functions, and can be economically operated and maintained within the scope of logistics concepts and policies. RAM programs are applicable to materiel systems; test measurement and diagnostic equipment, training devices; and facilities developed, produced, maintained, procured, or modified for use. (See individual definitions for Reliability, Availability, and Maintainability.) Reference DON NAVSO P-6071, March 1986.

Reliability Block Diagram (RBD): A methodology to provide a graphic model of the impact failure of an item has on a system. It is oriented toward evaluating the expected operational success of elements of a system operating in parallel or in series. RBDs are used as input to simulation or analytic models that calculate system reliability and availability. This highly structured approach is used to model complex systems and may be applied to special mission requirements.

Required Operational Characteristics: System parameters that are primary indicators of the system's capability to be employed to perform the required mission functions, and to be supported.

Required Technical Characteristics: System parameters selected as primary indicators of achievement of engineering goals. These need not be direct measures of, but should always relate to the system's capability to perform the required mission functions, and to be supported.

S

Safety: Freedom from conditions that can cause death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment.

Supportability: The degree to which system design characteristics and planned logistic resources, including manpower, meet system peacetime readiness and wartime utilization requirements. For purposes of A_o, supportability is the average time needed to satisfy material and administrative requirements associated with restoring a failed system or equipment to operation using specified administrative and logistics channels. Supportability is expressed herein as Mean Logistics Delay Time (MLDT). Except for actual repair time (expressed as MTTR), all Logistics Support elements are included within supportability.

Supportability Analysis (SA): An analytical tool, conducted as part of the Systems Engineering (SE) process, to determine how to most cost-effectively support the system over its entire life cycle. It provides the basis for related design requirements that may be included in specifications.

Sustainability:
(1) **Wartime Sustainability:** The ability to maintain the necessary level and duration of operational activity to achieve military objectives. Sustainability is a function of providing for and maintaining those levels of ready forces, materiel, and consumables necessary to support military effort.
(2) **Peacetime Sustainability:** The ability to maintain the necessary levels of forces, materiel, and consumables to support the burden of ownership of the system.

System Readiness Objective: A criterion for assessing the ability of a system to under-take and sustain a specified set of missions at planned peacetime and wartime utilization rates. System readiness measures take explicit account of the effects of Reliability and Maintainability (R&M) system design, the characteristics and performance of the support system, and the quantity and location of support resources. Examples of system readiness measures are combat sortie rate over time, peacetime mission capable rate, operational availability, and asset ready rate.

Systems Effectiveness: The measure of the extent to which a system may be expected to achieve a set of specific mission requirements. It is a function of availability, reliability, dependability, and capability.

Systems Engineering: A comprehensive, iterative technical management process that includes translating operational requirements into configured systems, integrating the technical inputs of the entire design team, managing interfaces, characterizing and managing technical risk, transitioning technology from the technology base into program specific efforts and verifying those designs meet operational needs. It is a life cycle activity that demands a concurrent approach to both product and process development.

T

Test Analyze and Fix (TAAF): An iterative, closed loop reliability growth methodology. TAAF is accomplished primarily during engineering and manufacturing development activities. The process includes testing, analyzing test failures to determine the cause(s) of failure, redesigning to remove the cause(s), implementing the new design and retesting to verify that the failure cause(s) have been removed. Reference DON NAVSO P-6071, March 1986.

Test and Evaluation Master Plan (TEMP): Documents the overall structure and objectives of the test and evaluation program. It provides a framework within which to generate detailed T&E plans and it documents schedule and resource implications associated with the T&E program. The TEMP identifies the necessary developmental test and evaluation, operational test and evaluation and live fire test and evaluation activities. It relates program schedule, test management strategy and structure, and required resources to critical operational issues (COIs);

critical technical parameters; objectives and thresholds documented in the Operational Requirements Document (ORD); evaluation criteria; and milestone decision points.

Total Ownership Cost (TOC): An emerging concept designed to determine the true cost of design, development, ownership and support of DoD weapons systems. At the DoD level, Total Ownership Cost is comprised of the costs to research, develop, acquire, own, operate and dispose of defense systems, other equipment and real property, the costs to recruit, retain, separate, and otherwise support military and civilian personnel, and all other costs of the business operations of the DoD. At the individual program level, Total Ownership Cost is synonymous with the life cycle cost of the system.

Transportability: The capability of materiel to be moved by towing, self-propulsion, or carrier via any means, such as railways, highways, waterways, pipelines, waterways, and airways.

U

Uncertainty: A condition, event, outcome, or circumstance of which the extent, value, or consequence is not predictable. State of knowledge about outcomes in a decision, which are such that it is not possible to assign probabilities in advance. Some techniques for coping with this problem is *a fortiori* analysis (making use of conclusions inferred from another reasoned conclusion or recognized fact), contingency analysis, and sensitivity analysis.

Usage Rates:

(1) **Wartime Usage Rates**: The quantitative statement of the projected manner in which the system is to be used in its intended wartime environment.

(2) **Peacetime Usage Rates**: The quantitative statement of the projected manner in which the system is to be used in its intended peacetime environment.

User: There may be more than one user for a system. The Services are seen as users for systems required to organize, equip, and train forces for the CINCs of the unified command.

W

Work Breakdown Structure (WBS): An organized method to break down a project into logical subdivisions or subprojects at lower and lower levels of details. It is very useful in organizing a project. See MIL-HDBK 881 for examples of WBSs.

Working-Level Integrated Product Team (WIPT): Team of representatives from all appropriate functional disciplines working together to build successful and balanced programs, identify and resolve issues, and make sound and timely decisions. WIPTs may include members from both government and industry, including program contractors and sub-contractors. A committee, which includes non-government representatives, to provide an industry view, would be an advisory committee covered by Federal Advisory Committee Act (FACA) and must follow the procedures of that Act.

Appendix 2

Glossary of Acronyms

A_o	Operational Availability
ABC	Activity Based Costing
AAW	Anti-Air Warfare
ACAT	Acquisition Category
ACIM	Availability Centered Inventory Model
ADM	Acquisition Decision Memorandum
AIS	Automated Information System
APB	Acquisition Program Baseline
APL	Allowance Parts List
AoA	Analysis of Alternatives
ARROWS	Aviation Retail Requirements Oriented to Weapons Replaceable Assemblies
ASUW	Anti-Surface Warfare
ASW	Anti-Submarine Warfare
ATE	Automatic Test Equipment
AW	Air Warfare
BCA	Business Case Analysis
BCS	Baseline Comparison System
BIT	Built-in Test
BITE	Built-in Test Equipment
CA	Criticality Analysis
CAIV	Cost as an Independent Variable
CASREP	Casualty Report
CEB	Chief of Naval Operations Executive Board
CINC	Commander in Chief
CLS	Contractor Logistics Support
CNO	Chief of Naval Operations
COMOPTEVFOR	Commander, Operational Test and Evaluation Force
COTS	Commercial Off The Shelf
CRD	Capstone Requirements Document
DAB	Defense Acquisition Board
DID	Data Item Description
DOD	Department Of Defense
DON	Department Of Navy
DRMP	Design Reference Mission Profile
DT	Developmental Testing
DTC	Design to Cost
DT&E	Developmental Test and Evaluation
EDM	Engineering Development Model
FMECA	Failure Modes Effects and Criticality Analysis
FLSIP	Fleet Logistics Support Improvement Program
FOC	Full Operational Capability
FOM	Figure of Merit

FSC	Full Service Contracting
GAO	Government Accounting Office
GFE	Government Furnished Equipment
ICD	Initial Capabilities Document
IDE	Integrated Digital Environment
ILS	Integrated Logistics Support
ILSP	Integrated Logistics Support Plan
IMA	Intermediate Maintenance Activity
IOC	Initial Operational Capability
IOT&E	Initial Operational Test and Evaluation
ISEA	In-Service Engineering Agent
JCS	Joint Chiefs of Staff
JROC	Joint Required Operational Capability
KPP	Key Performance Parameter
LCC	Life Cycle Cost
LORA	Level of Repair Analysis
LSAR	Logistics Support Analysis Record
LRG	Logistics Review Group
LRIP	Low Rate Initial Production
$M_{Adm}DT$	Mean Administrative Delay Time
MAM	Maintenance Assistance Modules
MDA	Milestone Decision Authority
MDT	Mean Down Time
MDTD	Mean Down Time for Documentation
MDTOR	Mean Down Time for Other Reasons
MDTT	Mean Down Time for Training
MEC	Military Essentiality Code
MLDT	Mean Logistics Delay Time
MOADT	Mean Outside Assistance Delay Time
MOD-FSLIP	Modified Fleet Logistics Support Improvement Program
MOE	Measure of Effectiveness
MOP	Measures of Performance
MRDB	Material Readiness Database
MRTT	Mean Requisition Response Time
MSRT	Mean Supply Response Time
MTBF	Mean Time Between Failures
MTBM	Mean Time Between Maintenance
MTTR	Mean Time To Repair
NAVICP	Navy Inventory Control Point
NAVSUP	Naval Supply Systems Command
NSN	National Stock Number
OLSP	Operational Logistics Support Plan
OLSS	Operational Logistics Support Summary
O&M	Operations and Maintenance
OPEVAL	Operational Evaluation
OPTEMPO	Operations Tempo (pace of operations)

OPTEVFOR	Operational Test and Evaluation Force
ORD	Operational Requirements Document
O&S	Operating and Support
OT	Operational Testing
OT&E	Operational Test and Evaluation
PBL	Performance Based Logistics
POM	Program Objectives Memorandum
PPBS	Planning, Programming, and Budgeting System
PPS	Post Production Support
PRS	Provisioning Requirements Statement
PSICP	Program Support Inventory Control Point
PTD	Provisioning Technical Documentation
RBD	Reliability Block Diagram
RBS	Readiness Based Sparing
RCM	Reliability Centered Maintenance
RFI	Ready For Issue
RFP	Request for Proposal
RLA	Repair Level Analysis
R&M	Reliability and Maintainability
RM&A	Reliability, Maintainability and Availability
SAS	Supportability Analysis Summary
SMA	Supply Material Availability
SM&R	Source, Maintenance and Recoverability
SOW	Statement of Work
SRA	Shop Replaceable Assemblies
SYSCOM	Systems Command
SUW	Surface Warfare
SW	Submarine Warfare
TAAF	Test, Analyze and Fix
TAT	Turn Around Time
TECHEVAL	Technical Evaluation
T&E	Test and Evaluation
TEMP	Test and Evaluation Master Plan
ULSS	Users Logistics Support Summary
VAMOSC	Visibility and Management of Support Cost
VV&A	Validation, Verification & Accreditation
WBS	Work Breakdown Structure
WRA	Weapon Replaceable Assemblies

Appendix 3
Mathematical Description(s) of A_o

Paragraph 1.5.1 defined A_o in terms of a probability statement. This Appendix will develop that definition into specific equations that are commonly used in the analysis of A_o and its individual elements. These equations will provide analysts and decision makers with the necessary tools and common logic for determining if A_o estimates are accurate and how each of the controllable components of A_o contribute to, or limit, a system's A_o.

The objective of supportability design is to ensure that all logistic support elements are consistent with the maintenance plan and support the achievable A_o in the operational environment. A_o is broken down into the components of reliability, maintainability, and supportability to focus management attention on finite segments of uptime and downtime that can be managed. Supportability can also be broken down into finite segments of downtime that can be managed. The goal is for all logistic support elements to be coordinated, compatible, and consistent with the system's operational concepts.

3.1 Basic Concepts

Generally, A_o is interpreted as the percentage of time that the system will be ready to perform satisfactorily in its intended operational environment. The sum of uptime and downtime, referred to as total time, is a period of time specified for potential system use. Therefore, the following equations are those most frequently used when discussing A_o:

Equation 1: Operational Availability

$$A_o = \text{Up Time} / (\text{Up Time} + \text{Down Time})$$

Uptime is defined as the element of active time during which an item is in condition to perform its required functions. Downtime is the element of active time during which an item is not in condition to perform its required functions. If it is not capable of functioning it must be down, either for maintenance or for logistics-related delays.

Although the above equations provide an accurate expression of A_o, they have two major deficiencies:

- Uptime and downtime can only be measured for a system in an operational inventory and are not measurable for a system in development.
- If the A_o measured using this equation is less than the threshold required, the equation does not assist an analyst in determining what to do to increase the A_o.

To determine the causes and potential solutions of inadequate A_o, the components of uptime and downtime must also be defined and quantified. In particular, the effects on uptime and downtime of the following controllable factors must be determined:

- **Reliability**: The probability that an item can perform its specified function for a specified time interval under stated conditions without failure or demand on the support system. Reliability is controllable primarily by design decisions and secondarily by ensuring that a system is used in the manner for which it was designed.

- **Maintainability**: The measure of the ability of an item to be retained in, or restored to, operable condition. Maintainability is controllable primarily by the repair actions being performed by personnel having appropriate skill levels, using prescribed procedures and resources, at each prescribed level of maintenance and repair.

- **Supportability**: The measure to satisfy material and administrative requirements associated with restoring a failed system or equipment to operation using specified administrative and logistics channels. Supportability is controllable primarily by the various logistics delay times.

Inherent Availability A_i	$A_i = \frac{MTBF}{(MTBF+MTTR)}$	• Assures operation under stated conditions in an ideal customer service environment (no delays experienced while maintenance is being performed). It excludes: o Preventive or scheduled maintenance (i.e., battery replacement, oil change, etc. o Logistics delay times (i.e., filling out paperwork). • A_i is usually not specified as a field-measured requirement, since the customer service environment is rarely due to: o Insufficient number of spare parts o Long delays to obtain repair parts o Inadequate training of repair personnel o Excessive administrative requirements
Achieved Availability A_a	$A_a = \frac{MTBM}{(MTBM+ MTTRactive)}$	• Similar to A_i, except that preventive and scheduled maintenance actions are factored into the uptime variable (MTBM). The corresponding preventive and scheduled maintenance times are included in the $MTTR_{active}$ parameter. • A_a is usually not specified as a field-measured requirement, since the downtime factor does not consider the routine logistics and administrative delays that occur during normal field conditions.
Operational Availability A_o	$A_o = \frac{MTBM}{(MTBM + MDT)}$	• Extends the definition of A_i to include delays due to waiting for parts or processing paperwork in the mean downtime parameter (MDT). • A_o reflects the real-world operating environment, thereby making it the preferred and most readily available metric for assessing quantitative performance. • A_o is usually not specified as a manufacturer-controllable requirement without being accompanied by estimates of the logistics resources and administrative delays, induced failures, etc. which are government driven and beyond the manufacturers control.

MTBF = Mean Time Between Failure
MTTR = Mean Time To Repair

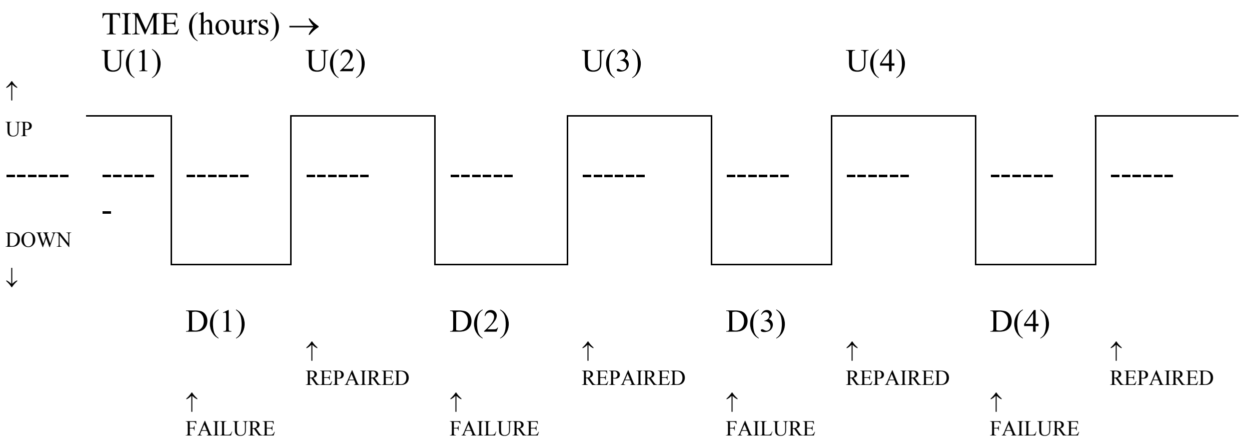
MTBM = Mean Time Between Maintenance
$MTTR_{active}$ = Mean Time To Repair for corrective and preventive maintenance

MDT = Mean Down Time includes Mean Logistics Delay Time (MLDT) (Mean Admin Delay Time ($M_{Adm}DT$) and other delays) and Mean Time To Repair (MTTR)

Table A3-1: Common Variations of the Basic Equation

The following illustration represents the operation of a system in terms of its uptimes and downtimes. The measured A_o for this system is derived as follows:

Figure A3-2: System Uptime and Downtime



UPTIME = U(1) + U(2) + U(3) + U(4)
= 2 hrs + 2 hrs + 3 hrs + 3 hrs = 10 hrs

DOWNTIME = D(1) + D(2) + D(3) + D(4)
= 2 hrs + 2 hrs + 1 hr + 1 hr = 6 hrs

$$\text{AVERAGE UPTIME} = \frac{\text{10 hours}}{\text{4 failures}} = \text{2.5 hours} \qquad \text{UPTIME / FAILURE} = \text{MEAN TIME BETWEEN FAILURES (MTBF)}$$

$$\text{AVERAGE DOWNTIME} = \frac{\text{6 hours}}{\text{4 failures}} = \text{1.5 hrs} \qquad \text{DOWNTIME / FAILURE} = \text{MEAN DOWNTIME (MDT)}$$

$$A_o = \frac{\text{Uptime}}{\text{Total Time}} = \frac{\text{Uptime}}{\text{Uptime + Downtime}} = \frac{10}{10 + 6} = .625$$

Equation 2: Operational Availability (Measured)

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

Where MTBF is the mean operating time between (successive) failures and MDT is the mean downtime per failure.

MTBF is the quantitative measure of system reliability (i.e., the duration of failure free performance under stated conditions). MDT is the quantitative measure of system downtime.

MDT is broken down into two separate increments of time: (1) the time necessary to repair a failed system at the organizational level when all the resources (manpower and spare parts, for example) are available and, (2) the additional delay(s) caused by the logistics support for the system (for example, the time required to obtain a replacement part from the supply room, the time awaiting trained personnel, or the time necessary to repair failed systems at the intermediate or depot level). The average time required to repair a system in its operating environment (when necessary resources are available) is called "mean time to repair" (MTTR). The average time delay caused by the logistics support system is called "mean logistics delay time" (MLDT).

MTTR is a quantification of inherent "designed in" system maintainability, and MLDT is a quantification of supportability which is defined to include personnel, repair at other levels, supply support, transportation, and other logistics delays not attributable to actual hands-on maintenance time (i.e., MTTR). These quantifications can be made by various methods during various phases of development (and with varying degrees of accuracy). These quantifications allow prediction of the A_o for a system in development.

Equation 3: Operational Availability (Predicted)

$$A_o = \frac{MTBF}{(MTBF + MTTR + MLDT)}$$

This general equation can be used to relate to the determining elements: reliability (MTBF), maintainability (MTTR), and supportability (MLDT). The result of this equation (predicted A_o) is not as accurate as the result of the previous equation (measured A_o). Measuring A_o usually foils predictions. However, this equation does have advantages:

- The use of MTBF to approximate uptime and the use of MTTR and MLDT to approximate downtime provide both the analyst and decision-makers with discrete variables that can individually managed and modified, regardless of the developmental stage of the system.
- Using MTBF, MTTR, and MLDT provides a sufficiently accurate approximation of A_o to use for certain purposes, throughout the system's life cycle.

MLDT, for purposes of A_o, is generally broken down into the following:

1. **Mean Supply Response Time (MSRT)** – The average down time per maintenance action to obtain spare and repair parts from both onboard and from off ship. MSRT is the single greatest driver in MLDT.

2. **Mean Administrative Delay Time ($M_{Adm}DT$)** – The average period of down time awaiting logistics resources other than spare parts and includes such considerations as:

   - **Mean Down Time for Training (MDTT)** – The average down time per maintenance action due to lack of training. This is rarely a factor in the achievement of the A_O threshold and normally occurs when trained maintenance personnel have been transferred or are otherwise unavailable. The principal requirements for the Program Manager are to ensure consistency between the planned and corrective maintenance actions required at the user level and the curriculum of the technical training courses. The first graduates of the operator and maintenance schools must be available in the fleet before the deployment of the first operational systems.

- **Mean Down Time for Documentation (MDTD)** – The average downtime per maintenance action to obtain documentation needed for fault isolation, maintenance and checkout. This is normally an insignificant portion of MLDT, but it occurs each time the system/equipment fails and is therefore inversely proportional to the reliability of the system. High MDTD normally is caused by technical publications that are not applicable to the configuration of the system/equipment installed or by errors in the technical documentation. The Program Manager should be sensitive to consistency between configuration, maintenance procedures, and parts identification in the Illustrated Parts Breakdown and the Allowance Parts Lists (APLs).

- **Mean Down Time for Other Reasons (MDTOR)** – The average downtime per maintenance action for reasons not otherwise identified. Such reasons may be varied and complex depending on the type of system and its maintenance concept.

3. Mean Outside Assistance Delay Time (MOADT) – The average downtime per maintenance action waiting outside assistance. This is normally caused by the lack of test equipment, tools, or skills beyond those available at the shipboard level. This also occurs when repairs require the use of facilities such as a dry-dock or floating crane. Every system/equipment experiences some MOADT. The Program Manager should be particularly sensitive during the maintainability / supportability analyses to the requirements of the Maintenance Plan and the requirements to replace any readiness-driving parts that fail. The objective of the Program Manager is to eliminate any requirement for outside assistance, except for catastrophic failure. The Maintenance Plan is reviewed for consistency with the number and skill levels of both operating and maintenance personnel. As soon as values are assigned to A_o, MTBF and MTTR, the value for a cumulative MLDT can be computed with the equation:

$$MLDT = \frac{MTBF}{A_O} - (MTBF + MTTR)$$

Since MSRT is the largest component of MLDT, the Program Manager can compute the MLDT required to achieve the A_o threshold, given that the values for reliability and maintainability are known. The MLDT requirement can be compared to normal supply response times to determine if it is reasonably attainable with the standard supply system.

Repair Parts Essentiality Coding – The Program Manager should review the Maintenance Code (3^{rd} position of the Source, Maintenance and Recoverability Code) of any spare or repair part that is Military Essentiality Coded (MEC) 1. A MEC 1 assigned to a part designates that part as a readiness-driver (i.e., if that part fails, its next higher assembly fails). If the loss of the next higher assembly causes failure of the system or equipment, then the part that initiated the chain of failures is a critical readiness-driving repair part and the maintenance level at which that part can be replaced and the skills, tools, test equipment and accessibility of that part become critical factors to eliminating the need for outside assistance to repair a system failure. A MEC 5 means that part is required for safe operation of the equipment, or prevents a personnel hazard. For purposes of sparing, a MEC 5 repair part is treated like a MEC 1 repair part. The Program Manager needs to ensure that any MEC 1 item that will cause total system failure is capable of being replaced at the shipboard level. If that part is not capable of being replaced at the shipboard level, then a major deterrent to A_o exists when the system is deployed.

Source, Maintenance and Recoverability Codes (SM&R) – This is a five position code that reflects supply and maintenance decisions made during the logistic planning process. The first two positions are the source code that indicates the means of acquiring the item for replacement purposes. The third position is a maintenance code that indicates the lowest level of maintenance authorized by the maintenance plan to remove, replace, or use the item. The fourth position is a maintenance code that indicates whether the item is to be repaired, and identifies the lowest level of maintenance authorized by the maintenance plan to return the item to serviceable condition from some or all failure modes. The fifth position is the recoverability code that indicates the approved condemnation level.

The third position of the SM&R Code is the code that the Program Manager reviews for all MEC 1 items to ensure that critical readiness driver repair parts are replaceable at the shipboard level, and that the supply system considers that item as a candidate onboard allowance item when an APL is computed.

Replacement Rates – All repair parts have a reliability factor that must be known or estimated at the time of provisioning. This may initially be expressed as mean cycles between failure, failures per million operating hours, mean time between failure or some other measure of reliability. At the time of provisioning, this is converted to an annual replacement rate so that all parts in the supply system use a common replacement factor. Replacement rates are important to the Program Manager because they determine what parts compute for onboard allowances and they identify potential supply support problems.

Alternatives Other Than Standard Sparing – What alternatives does the Program Manager have if the computed optimum mean response times are not sufficient to achieve the A_o threshold, given the reliability of the system/equipment? Since reliability and MLDT, specifically MSRT, are the two major drivers in the attainment of the A_o threshold, these two variables are the focus of action.

Before the design has been frozen, the Program Manager has many alternatives for increasing the system's reliability and supportability to achieve the A_o threshold. After design freeze, the options available for increasing the system's reliability and supportability significantly decrease and the costs significantly increase.

MSRT can be improved when it has been determined that standard Navy sparing will not provide the response time required to achieve the A_o threshold. The Program Manager must obtain CNO approval to use an allowance computation model that optimizes the supply support required to achieve A_o. When this situation exists, OPNAVINST 4442.5 (NOTAL) provides the procedures to be followed by the Program Manager for sparing to availability models and for obtaining approval to optimize the APLs that will provide the required onboard stocks to support the system in the Fleet.

3.2 Specific Equations

Because different systems are used different ways, the measurement and interpretation of A_o vary from system to system. For purposes of A_o measurement and analysis, systems are divided into three classes (defined in terms of the way system is used):

- Continuous-use systems: Systems that are (nearly) always in use during operations of their host platforms. Examples are search radars, radio receivers, and propulsion gas turbines.
- Intermittent-use (non-continuous or on-demand) systems: Systems that have relatively long periods of standby or inactivity between uses. Examples are fire control radars and radio transmitters.
- Impulse (single-shot) systems: Expendables that are generally used once and not recovered (and so not returned to an operable condition through repair when not recovered).

It may be difficult to classify systems according to continuous, intermittent, or impulse use, but this classification is required if A_o is to be computed consistently.

3.3 Continuous-Use Systems

For continuous-use systems, mean calendar time between failure is identical to mean operating time between failure, and use of MTBF in the A_o equation is consistent with the notion of measuring uptime in terms of calendar time. This notion is critical since all downtime is measured in calendar time. Therefore, the following equation provides an acceptable approximation of A_o in terms of reliability, maintainability and supportability.

Equation 4: A_o in Continuous Use Systems

$$A_o = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR} + \text{MLDT (MSRT} + \text{MAdmDT} + \text{MOADT)}}$$

3.4 Intermittent-Use Systems

For intermittent-use system, mean operating time between failure is not equivalent to mean calendar time between failure. Thus, MTBF must be adjusted. Two ways of displaying the A_o equation with this adjustment are now in use as shown as Equation 5 and 6. For aircraft systems, it is common to use equation 5:

Equation 5: A_o for Intermittent Use (Aircraft) Systems

$$A_o = 1 - \frac{MTTR + MLDT}{K'(MTBF)}$$

Where K' is defined as total calendar time over total operating time. It is the inverse of the proposed utilization rate.

For ship systems Equation 6 has been constructed. Where, K' is redefined to exclude downtime from calendar time. This term, defined as K", is

$$K'' = K' - \frac{MTTR + MLDT}{MTBF}$$

Equation 6 can now be written for intermittent-use systems as

Equation 6: A_o for Intermittent Use (Ship) Systems

$$A_o = \frac{K''(MTBF)}{K''(MTBF) + MTTR + MLDT}$$

Both K' and K" have been termed "K-factors," and this has led to confusion. The user should check this factor before using the equations to make sure that the correct "K-factor" is used. K' is only valid in equation 5; K" is only valid in equation 6.

3.5 Impulse System

The above equations are not appropriate for impulse systems. Since these systems are generally not recoverable once they are used, the concept of downtime has little significance. As a result, the A_o of impulse systems is quantified as the fraction of attempts at usage (firings, turn-ons, and actuations) that succeed. The equation is:

Equation 7: A_o for Impulse Systems

$$A_o = \frac{\text{Number of successes}}{\text{Number of attempts}}$$

While there is some parallel between this case and those associated with continuous-use and intermittent-use systems, the distinction is that an impulse system spends most of its time in standby, alert, or secured mode, is called upon to function for a relatively short time, and is generally not restored to operable condition once it is used.

Appendix 4

Requirements Questions / Checklist

4.1 Introduction

The intent of this checklist is to provide a one-stop reference source for a wide range of potential considerations faced by the acquisition community. Many times simply asking a question can cause the right things to get done. This is one of the purposes of publishing GAO and other audit agency reports. This is the benefit of checklists, and this is one of the reasons these questions are published here.

4.2 Guiding Analysis by Asking Questions

This section contains questions for the users, MDA staffs, Program Sponsors and/or Program Managers regarding the following:

Analysis Requirements,
Analysis Capabilities,
Analysis Methods and Tools,
Analysis Ground Rules and Assumptions,
Analysis Data and Data Sources,
Phase Related A_o Analysis, and
Analysis Documentation.

The questions apply to the phases of the acquisition program:

Phase	**Description of Phase**
A	Concept and Technology Development
B	System Development and Demonstration
C	Production and Deployment
Later Phases	Operations & Support (O&S), or Operations & Maintenance (O&M) or Sustainment.

Section two and the appendixes will describe analytical processes and tools for making sure that the answers to these questions will support Navy programs.

Questions users, MDA staffs, Program Sponsors and/or Program Managers should ask (by phase):	**A**	**B**	**C**	**Later Phases**
(1) Analysis Requirements:				
1-1 What is/are the primary requirement(s) and objectives for A_o?				
1-2 How has the customer (user) of this system documented their requirements in terms of A_o? Are these requirements clear to the Resource Sponsor / program office?				

1-3 Has the user defined an existing fleet system that forms the "Baseline" reference for the new capability needed?				
1-4 Has the user identified any A_o related constraints? How do these relate to the existing (baseline) system? How do these relate to "ground rules and assumptions" for the new system? How will all analysis agencies be informed of these constraints?				
1-5 Have the objectives and thresholds for this program been defined for: (a) A_o? (b) CAIV parameters? If so, Where? (c) Have A_o goals been allocated to major sub-systems and significant WBS items appropriate for this phase of the program?				
(2) Analysis Capability:				
2-1 What A_o estimating capability has the program established: (a) To directly support the government Program Office? (b) To support the contractor capability?				
2-2 Has the program team established a consolidated or separate analysis capabilities for supporting the three levels of program decision support; (a) Navy Enterprise level decisions? (b) Navy program (Weapon System) level decisions? (c) Detailed Engineering Trade-Study decisions?				
2-3 Have adequate resources for conducting A_o analyses been planned and programmed in program planning documents and in the POM? Are they fully funded?				
(3) Analysis Methods and Tools:				
3-1 Has the program identified and documented a standard methodology for conducting A_o analyses? Is the methodology consistent with DoD/DoN guidelines? Is the methodology consistent with best commercial practices and within the budget and programmatic limitations?				
3-2 What is/are the definitive reference(s) for the program methodology for A_o? Where is method described?				
3-3 Has the program team identified a single or a family of models for conducting A_o analysis? (a) What parametric (top-down) model(s) have been selected? (b) What engineering estimate (bottoms-up) model(s) have been selected? (c) Where is this information documented?				
3-4 Are the same methods and models used by all (contractor and government) agencies that perform/conduct decision support analysis for A_o for this program?				

3-5 If "No" on 3-4, How has the program insured that consistent results are being achieved and that analysis can be replicated?				
3-6 Have analysis methods and tools selected for use on this program been evaluated by an outside agency? Where is this documented?				
(4) Analysis Ground Rules and Assumptions:				
4-1 Has the program identified standard ground rules and assumptions for use by all agencies supporting program analysis? (a) Are man-hour rates for operators and maintainers defined? (b) Are operating hour's per/system/per/year defined? (c) Are production, deployment schedules defined? (d) Are site "stand-up" schedules defined? (e) Are the phase-in and phase-out for (new/old) systems defined? (f) Are technology refreshment schedules defined? (g) Has the economic life (for analysis purposes) been defined? (h) Has the Design Reference Mission Profile (DRMP) been defined? (i) Where are the ground rules and assumptions documented and how do all analysis agencies obtain this information?				
4-2 Have all initial production and recurring support costs been included in the analysis capability? Are ALL future costs covered to include customer costs, contractor costs, supplier costs, third-party provider costs, direct/indirect costs, variable/fixed costs, design and development costs, production/construction costs, operation and support costs, retirement and material recycling/disposal costs? Have any costs or logistics elements been identified for elimination from any specific analysis? Has the rational been documented, and if so, where?				
4-3 Has the Baseline Comparison System (BCS) been documented to the Work Breakdown Structure (WBS) level adequate for establishing the point of reference for the alternatives being considered?				
4-4 What rate of "cannibalization" will be allowed in analyzing A_o for this program? Has the effect of cannibalization on equipment reliability (accelerated wear-out), maintenance-induced failures, and manpower turnover been included in the analysis? Has the rate(s) of cannibalization versus spares costs been documented? Has the user been briefed and agreed to this aspect of analysis?				
4-5 Has the full set of ground rules, assumptions and analyses planning factors been reviewed and approved by applicable agencies such as DoD, CNO and relevant others?				

4-6 Has the full set of ground rules, assumptions and related analysis factors been provided to all analysis agencies (including the contractor)?				
(5) Analysis Data and Data Sources:				
5-1 Has the program made sure that all program analysis agencies have data access, accounts and passwords registered with the Navy VAMOSC program office?				
5-2 Has the program obtained all standard Navy planning factors from the appropriate agencies (i.e., Naval Center for Cost Analysis (NCCA), ISEA, SYSCOM financial planning offices)? Where is this documented?				
5-3 How has "Activity Based Costing/Management (ABC/M)" been used in the development of program analysis and data?				
5-4 Have all three specific categories of analysis data been obtained and shared with all program analysis agencies? (a) Program/Project data: procurement, deployment, OPTEMPO? (b) Hardware data: all hardware specific data and parameters? (c) User Op scenario data: Factors from users operations (labor rates, turn-around-times (TAT), pipeline times, attrition/discard rates, etc.)?				
5-5 Does the program/project plan to obtain and/or publish "default data guides" for use by analysis agencies? Where will analysis-planning factors be published and referenced in program planning documents such as logistics plans, test plans, acquisition program plans, etc.?				
5-6 How will DT and OT test data be used in modeling A_o? What program plans and contracts discuss this aspect of analysis?				
5-7 How will fleet data (3M, VAMOSC, ISEA feedback) be incorporated into A_o analysis activities? How will access to this data by all analysis agencies be accomplished?				
(6) Phase Related A_o Analyses:				
6-1 Has the BCS been fully defined, modeled, and have the A_o estimates been documented appropriately for this program phase?				
6-2 Have program level design alternatives been identified, and modeled and A_o analyses performed at a WBS level appropriate for this phase of the program?				
6-3 Have support concepts been defined for each design alternative, and have all initial and recurring logistics resources been included in the analysis of alternatives for this phase? Is there any need to re-baseline the objectives and thresholds using CAIV guidelines?				
6-4 Have the A_o related objectives and thresholds been defined? (a) Has analysis been updated for this phase of the program? (b) Has A_o tracking been analyzed appropriately for this phase?				

(c) Is there any need to re-baseline the program objectives and thresholds using CAIV guidelines?				
6-5 Are detailed design related A_o drivers being identified at the appropriate level of the WBS for this phase?				
6-6 Is DT and OT test data being modeled to identify and track issues with respect to reliability growth of sub-systems &systems?				
6-7 Are design influencing recommendations being provided to design engineers concerning A_o "bad actors" which most affect achievement of A_o objectives?				
6-8 How has sensitivity analysis been performed in the A_o analysis? Have sensitivity curves been developed for reliability, maintainability and other factors? Which parameters were studied? What are the drivers and what are the sub-systems parts most sensitive to these? Where were the sensitivity analysis documented? What actions have been taken to reduce the effect of A_o drivers?				
6-9 Is there a record of A_o analyses used as design related decision (trade-study) support? Where is the record maintained?				
6-10 Have sparing to availability curves been developed for the program, using an approved RBS model? Have organizational level spares been identified based on approved RBS models?				
6-11 Are all spares required to support the users readiness requirement budgeted? If not, what is the percent funded? What A_o will the budget support?				
6-12 How has risk analysis been incorporated into A_o analysis? How were risks in terms of equipment level reliability, maintainability and unit cost handled? How was a range of A_o targets developed?				
6-13 Is documentation in place describing plans for follow-on tracking, monitoring analysis and reporting for A_o and the components of A_o in the operational environment? Do plans describe decision support analysis concerning system modernization, technology insertion, block upgrades, etc.?				
6-14 Is there any way to make A_o analysis more accurate for this program at this time?				
6-15 Are all traditional logistics elements estimated for both initial logistics (procurement dollars) and recurring logistics (O&M dollars) estimated in the analysis?				
6-16 Is there any missing data or cost elements that can improve the confidence in the completeness of the A_o analysis?				

(7) **Analysis Documentation**:				
7-1 Have A_o reqmts or constraints been documented in the ICD?				
7-2 Have AoAs been prepared at the appropriate level of detail for this phase of the program?				
7-3 Has the A_o related portions of the ORD been defined or updated for this phase of the program?				
7-4 Is A_o a KPP? If not, has a waiver been submitted or obtained?				
7-5 Has the A_o portion of test plans been defined or updated for this phase of the program?				
7-6 Has the A_o portion of the Acquisition Program Baseline (APB) been defined or updated for this phase of the program?				
7-7 Has the A_o related portion of exit criteria (in terms of CAIV objectives) for the next phase been documented?				
7-8 Have other program planning documents been updated to include A_o related information appropriate for this phase? What are they: (a) Logistics support plans? (b) Systems Engineering plans? (c) Supportability Analysis plans? (d) Acquisition Strategy (mandatory requirement)? (e) Master Acquisition Program Plan? (f) Others?				
7-9 How is documentation of design related trade-studies maintained in contractor databases? Does the government have documented plans to review this data?				
7-10 Has the project set up an Integrated Digital Environment (IDE) to allow every activity involved with the program to cost effectively create, store, access, manipulate and/or exchange A_o, systems engineering and supportability analysis data?				

Table A4-1: Analysis Checklist Questions

Appendix 5

Mission Profile Definitions

5.1 Mission Profile Definitions

Mission profile definition is addressed in detail in this appendix to highlight the importance of the mission profile in the Program Manager's design concept selection and the specification effort. ASN(RD&A)(ABM) has published a technical brief entitled *Design Reference Mission Profile – Development Guidelines* (TB # ABM 1002-03 of October 2002) to assist Navy managers, designers and testers with the best possible information regarding the concept of the Design Reference Mission Profile.

Sometimes the terms "mission profile" and "environment profile" are used interchangeably or synonymously while at other times an actual or implied distinction is made between the two terms. For the purpose of this handbook, "mission profile" and "environmental profile" are considered as two separate steps in the generation of a single, integrated mission and environmental profile. This separation aids in an orderly and methodical profile derivation. A mission profile, as derived in this appendix, chronologically addresses all the significant operations, events, functions, situations, and non-environmental parameters expected to occur and to have a bearing in the course of equipment's useful life. The mission profile provides a time history or profile of events, functions (often referred to as use or operations) and environmental conditions that a system is expected to encounter during its life cycle, from manufacturing to removal from service use. The mission may be simplified to provide a hypothetical composite profile for a system with multiple or variable missions or life cycle profiles. The composite mission reflects a sequence of system operations/events and associated environments in which the various stresses occur in approximately the same proportions as in the individual multiple mission profiles, weighted according to their relative frequencies. It is a time line which describes the planned use of the system. It is a means to convey the conceptual use and the environment in which the system is intended to operate. It is a mean to identify system mode of operation, to help identify mission critical block and potential redundancy. This includes "wartime mission profile" which addresses only the factors expected during actual wartime. The environmental profile, as derived in this appendix, then addresses the specific natural and induced environments associated with the operations, events, functions, situations, repair, and parameters defined by the mission profile, in the appropriate time sequence

Another confusing aspect of mission profile is the tendency to only consider the active mission phase of a system's life profile. For example, in the case of a missile, the "mission profile" is usually just the flight portions of the system's life cycle. However, the non-flight periods of a missile's life are just as meaningful, in terms of degradation stresses impacting reliability and readiness as flight periods. Consequently, there is a need to consider the "mission" of a missile (or any system) from the time of factory acceptance of the completed item to the end of its useful life, especially the wartime phases of the mission. Figure A5-1 describes the various phases of the life cycle profile of a missile. In order to limit confusions with "mission" connotations, this appendix divides "mission profile" into two elements: an "operational mission profile" to address the operational phases of equipment utilization, and a "logistics mission profile" to address the non-operational (storage, handling, maintenance and transportation) phases of equipment's life cycle. The relationship of thee components of a mission profile are described in Figure A5-2. The following definitions are provided for the mission profile components:

- **Mission Profile** – a chronological description of the significant operations, events, functions, situations and non-environmental parameters expected to occur in an item's useful life having a bearing on the item's life and performance capabilities. A complete mission profile consists of an operational profile including a wartime profile and a logistics profile covering nominal, contingency and emergency modes of utilization from factory acceptance through end of useful life.

- **Operational Profile** – a delineation of the conditions, circumstances, and influences that affect an item during the period of time from issue to a user organization until expenditure or disposal. A wartime mission profile is included.

- **Logistics Profile** – a delineation of the conditions, circumstances and influences that affect an item from factory acceptance until issue to a user organization and return by the user organization for storage, repair and/or overhaul until reissue to a user organization.

- **Environmental Profile** – a description of the specific natural and induced nominal and worst case environments associated with the operations, events, functions, situations, and parameters defined by the mission profile.

Ultimately, the program team must aggregate the various systems mission profiles into a total platform level mission profile.

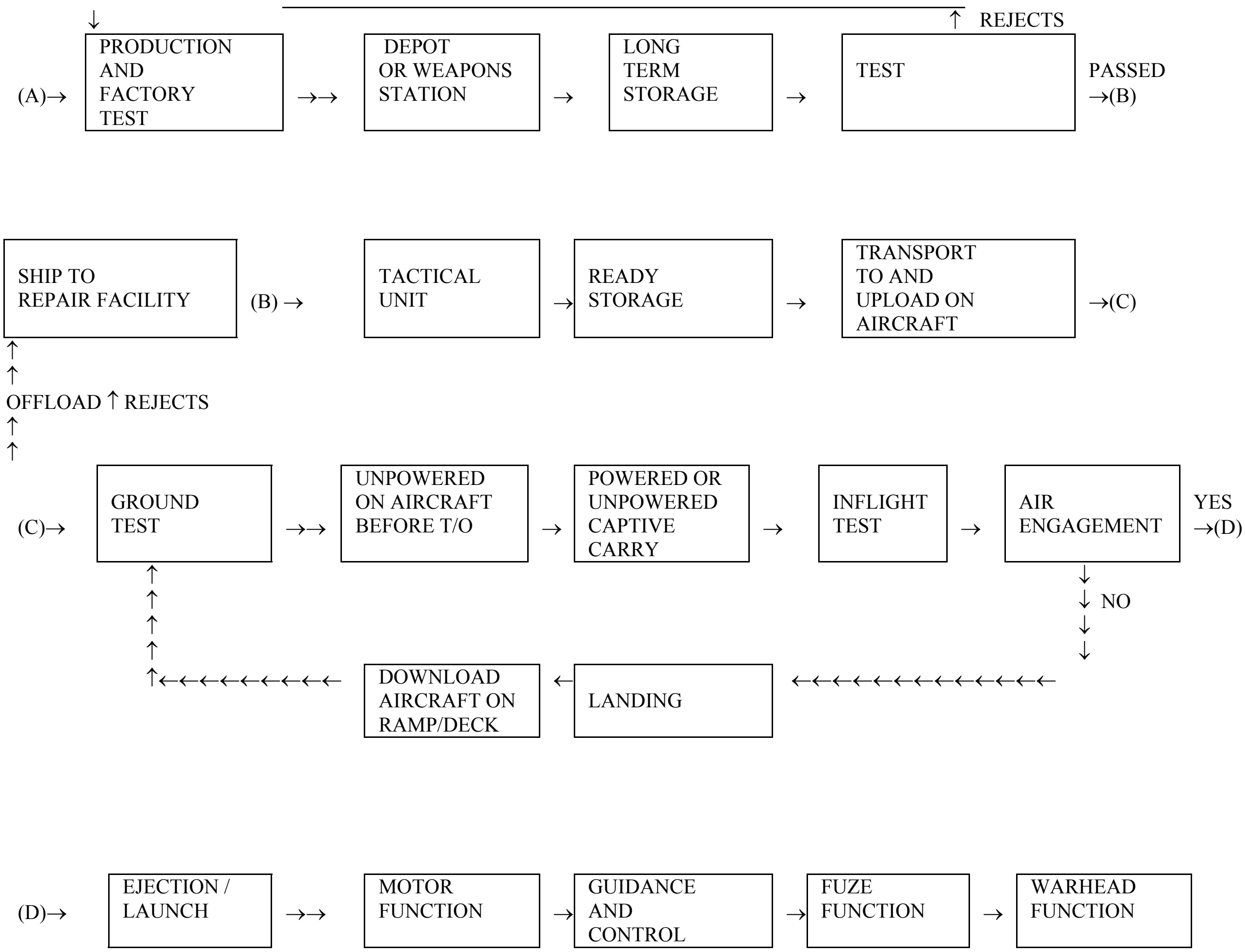


Figure A5-1: System Life Cycle Profile

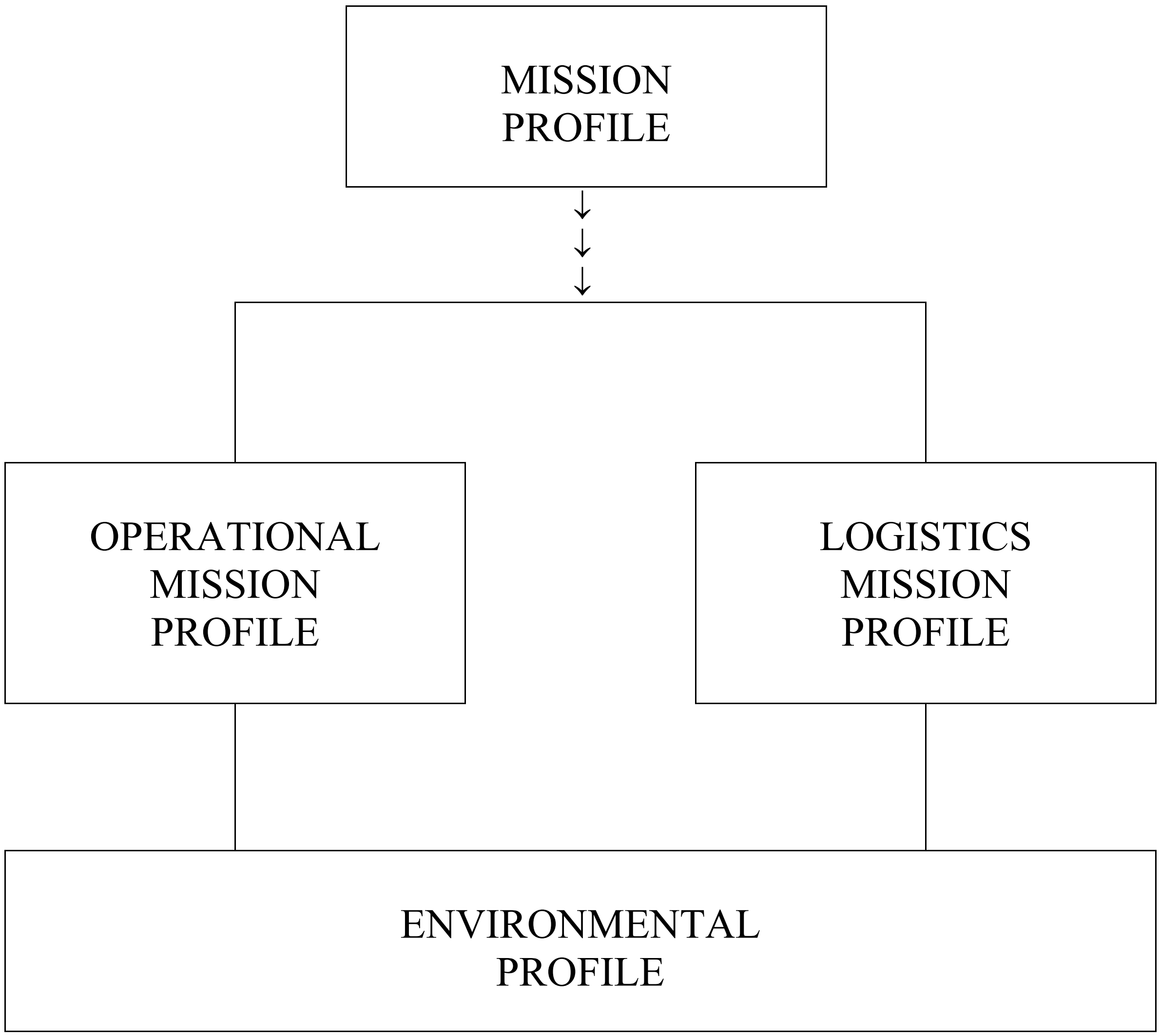


Figure A5-2: Mission Profile Components

5.2 Operational Mission Profile.

Development of a mission profile begins with the operational mission profile. The operational requirements are established as a series of events. The multi-mission capability of complex weapon systems often results in a number of wartime profiles to describe the complete range of mission capabilities and requirements. When a range of alternative missions is possible, each is examined as a distinct event sequence. Each total mission is then separated into phases.

A general example of mission phases is shown In Figure A5-3 the weapon system's mission is defined over a patrol period (t_p), which in the absence of a demand for offensive action by the weapon system is of nominal duration (T). For such a mission the entire patrol is the "availability phase". There is no launch phase or flight phase. The weapon system remains on alert status, requiring a designated reaction time to commence firing. Should a demand be made on the weapon system, that demand terminates the availability phase and initiates the ensuing launch phase and flight phase. During the launch phase the weapon system assumes a preparatory status, holds that status for a period of time up to a designated maximum, then initiates firing. The missile flight phase extends from launch through warhead fusing over the target area. The availability and launched phases constitute the mission of the missile subsystem. Principal variables influencing mission length are the demand time and hold time associated with each phase.

When the mission phases have been defined the subsystem operation modes in each phase and the performance functions in each mode are listed and related to the relevant mission requirements. It may be desirable to omit from the analysis any modes that are not significant with respect to primary mission objectives, such as the training mode. Each mode is tabulated against the mission phase(s) to which it applies. Performance functions required of the subsystem in each mode and phase are then listed and associated with the constituent equipment's necessary for their accomplishment. A form having the general information content of that illustrated in Figure A5-4 is helpful in organizing this portion of the mission analysis. In general, not all of the subsystem's functions will be equally essential to the mission. It is necessary to define the minimum limits of successful performance, that is, of "up" status, for purposes of availability analysis. This is accomplished by listing that subset of the performance functions that are deemed essential to the primary mission.

5.3 Logistics Mission Profile.

The logistics mission profile unitizes the operational mission description to identify and document the pertinent supportability factors related to the intended use of the new system/equipment. Factors to be considered include mobility requirements, deployment scenarios, mission frequency and duration, basing concepts, anticipated service life, interactions with other systems/end items, operational environment, and human capabilities and limitations. Both peacetime and wartime employment are considered in identifying the supportability factor.

The results of the logistics mission profile include, as a minimum:

- Detailed maintenance concept;
- Number of systems supported;
- Transportation factors (e.g., mode, type, quantity to be transported, destinations, transport time and schedule);
- Allowable maintenance periods; and
- Resources required for all scheduled and unscheduled maintenance.

A logistics mission profile for the missile described in Figure A5-3 would define such factors as:

- Proposed logistics cycle;
- Means of transportation (such as truck, railroad, and/or dolly) of the missile from one location to the next;
- Range of time spent at each location and the environment encountered there
- Anticipated locations in or on the carrying or launching vehicle, were the missile will be carried or launched from, and the mix of stores carried by that vehicle; and
- Required life span of the candidate missile component (such as storage life, service life, or number of flights).

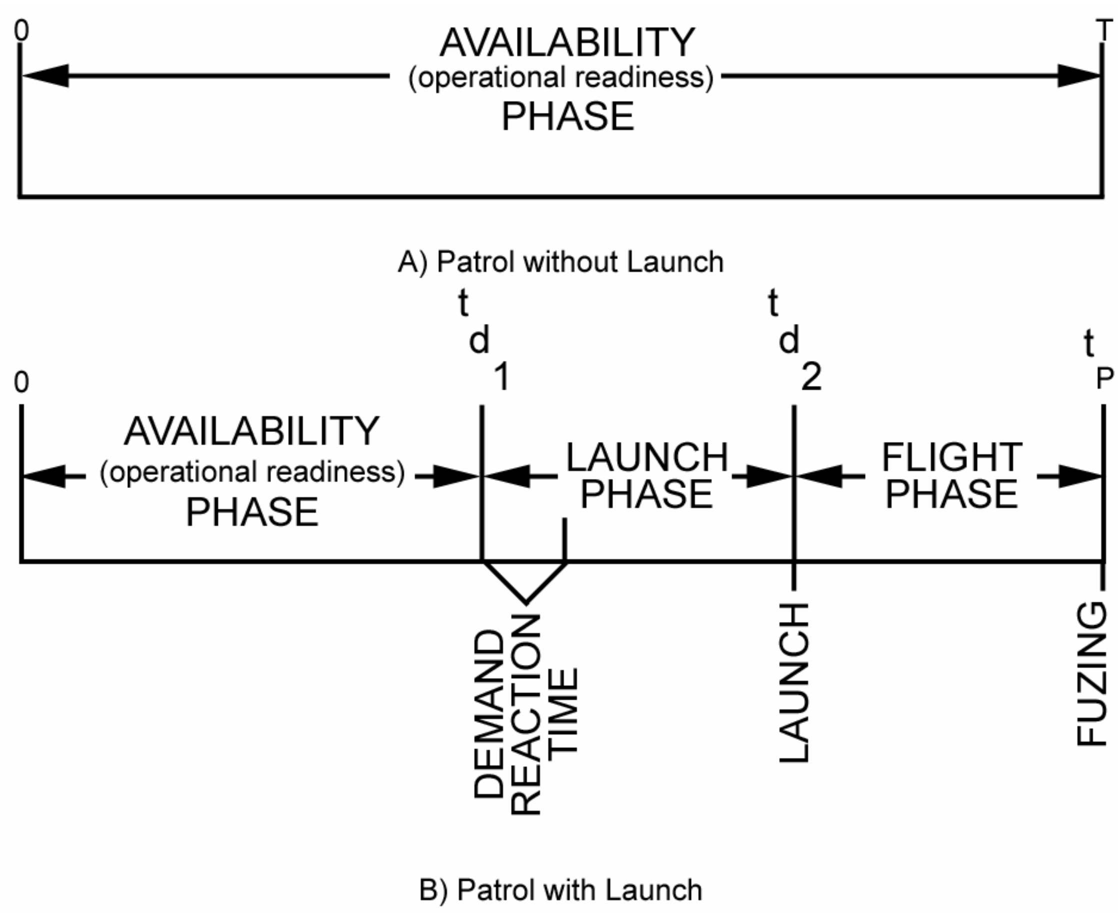


Figure A5-3: Definition Tactical Mission Phases

Subsystem Mode	Function	Related Equipment	Success Criteria	Function Time	Environment	Environment Time	Maintenance Constraints

Figure A5-4: Development of Mission Profile

5.4 Environmental Profile

Naval systems and subsystems must be designed to survive and function in the operating or combat environment. Specifications governing the design must reflect this need. The specifications must also provide for system survivability in the worst-case transportation and storage environments that are likely to be encountered during the system's life. The formulation of detailed specifications cannot be undertaken until the specific environment conditions for the systems and subsystems have been developed in detail.

During concept exploration, the Program Manager will be able to define environmental conditions only in general terms related to similar systems. Environmental parameters must be defined to the level required to assess feasibility of a design concept, such as the effects of humidity or vibration on a specific technology. Eventually, the environmental profile must be defined in both quantitative and qualitative terms to establish specification requirements which affect the Ao components, Environmental conditions and their induced stresses have significant impact on equipment reliability.

The definition of an environmental profile is often a difficult task during concept exploration. The Program Manager should be aware that the environmental conditions likely to be encountered by a new system might be considerably different from those encountered by similar systems or the system it replaces. The altitude, speed, and acceleration forces for aircraft systems and associated weapons have changed with each new generation of aircraft. Similarly, a subsystem's location on an aircraft or ship will greatly influence its environment, as will new materials used for construction, the increased density and diversity of electromagnetic fluxes renewed emphasis on arctic warfare, and many other factors.

Although difficult, the environmental profile definition is an essential element during concept exploration, and establishes much needed criteria that affect all other acquisition phases. Unfortunately, environmental specifications for ships and aircraft systems have traditionally been covered by general specifications. These are often out of date and lack the detailed information required by the systems designers, logisticians, and others involved in the system acquisition process. Outmoded or insufficiently detailed specifications have resulted in both over and under-design of system and substantial delays in the development program.