NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA

THESIS

A COMPARATIVE EFFICIENCY ANALYSIS
OF THE POINT FIVE FLSIP PLUS COSAL
INVENTORY MODEL

by

Michael D. Pawley

December, 1995

Thesis Co-Advisors: William R. Gates
David G. Brown

Approved for public release; distribution is unlimited.

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE December 1995	3. REPORT TYPE AND DATES COVERED Master's Thesis

4. TITLE AND SUBTITLE: A COMPARATIVE EFFICIENCY ANALYSIS OF THE POINT FIVE FLSIP PLUS COSAL INVENTORY MODEL	5. FUNDING NUMBERS
6. AUTHOR(S): Michael D. Pawley	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey CA 93943-5000	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.	12b. DISTRIBUTION CODE

13. ABSTRACT *(maximum 200 words)*

As the Department of Defense continues to downsize as a result of various budget reduction initiatives, new, efficient methods must be devised and implemented to increase fleet customer service without degrading readiness. The Navy's Inventory Control Point -Mechanicsburg, PA, (NAVICP-M), Point Five FLSIP Plus (.5F+) COSAL inventory model was designed to meet that challenge. This thesis describes the .5F+ model and its impact on readiness. It then compares that model to a private-sector, not-for-profit, inventory control point, the Materials Management Department of the Salinas Valley Memorial Hospital (SVMH). The techniques that each organization uses to distribute scarce resources, maximizing both effectiveness and customer service levels while minimizing costs were analyzed to identify potential crossover defense-related applications. This thesis also analyzes someof the required trade-offs for each inventory management program. The research shows that SVMH has a more efficienct inventory management program because of their customer-oriented strategic ploanning. DOD could increase their customer effectiveness, efficiency, and readiness by adopting a similar approach.

14. SUBJECT TERMS: COSAL, FLSIP, POINT FIVE PLUS, efficiency, allocative efficiency, inventory, Salinas Valley Memorial Hospital	15. NUMBER OF PAGES 207
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18 298-102

A COMPARATIVE EFFICIENCY ANALYSIS OF THE POINT FIVE FLSIP PLUS COSAL INVENTORY MODEL

Michael D. Pawley
Lieutenant Commander, United States Navy
B.A., University of South Carolina, 1971

Submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

## NAVAL POSTGRADUATE SCHOOL
December 1995

Author: _____
Michael D. Pawley
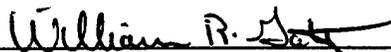
Approved by: _____
William R. Gates, Thesis Co-Advisor
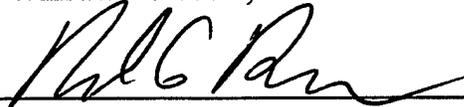
_____
David G. Brown, Thesis Co-Advisor
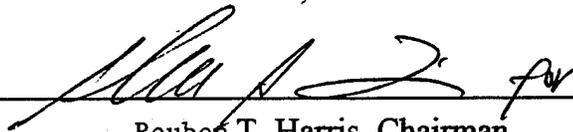
_____
Reuben T. Harris, Chairman
Department of Systems Management

iv

ABSTRACT

As the Department of Defense continues to downsize as a result of various budget reduction initiatives, new, efficient methods must be devised and implemented to increase fleet customer service without degrading readiness. The Navy's Inventory Control Point-Mechanicsburg (NAVICP-M) Point Five FLSIP Plus (.5F+) COSAL inventory model was designed to meet that challenge. This thesis describes the .5F+ model and its impact on readiness. It then compares that model to a private-sector, not-for-profit, inventory control point, the Materials Management Department of the Salinas Valley Memorial Hospital (SVMH). The techniques that each organization uses to efficiently distribute scarce resources, maximizing both effectiveness and customer service levels while minimizing costs, were analyzed to identify potential crossover defense-related applications. This thesis also analyzes some of the required trade-offs for each inventory management program. The research shows that SVMH has a more efficient inventory management program because of their customer-oriented strategic planning. DOD could increase their customer effectiveness, efficiency, and readiness by adopting a similar approach.

TABLE OF CONTENTS

I. INTRODUCTION

A. BACKGROUND

As the Congress and President continue to "downsize" or "right size" the Department of Defense (**DOD**) through budget reductions, DOD still must provide the maximum amount of national defense possible in an evolving, tense geopolitical environment, fulfilling all the goals and objectives of the national security strategy.

For a business to become a world-class performer capable of successfully competing in the global economy, that business must develop various strategies to maintain its competitive advantage. A competitive advantage is the superior strength or skill any organization possesses, such as its production, marketing, managerial, organizational, functional or leadership capabilities, which provide that organization with a unique advantage over its competitors. Strategies which maintain that competitive advantage range from designing and continuously improving product quality (product strategy) to open communication, employee cross-training and participation (human resources strategy), to the minimization of inventory investment (inventory strategy). To remain a world-class performer, the organization must continue to improve in meeting their customers' three major needs: product quality, low cost (price) and rapid delivery (Heizer, 1993).

Likewise, DOD must embrace many of these same concepts to maintain its lead position in providing national security to the nation and its allies.

Having a competitive advantage is of little value if that competitive advantage can not be sustained. Rosabeth Moss Kanter of Harvard lists four bases for sustaining the organization's competitive advantage: core competence, time compression, focus on continuous improvement, and relationships (Kanter, 1990).

1. **Core competence** is that which the organization does best. For example, Salinas Valley Memorial Hospital's (**SVMH**) core competence is providing quality health care; for DOD, it is developing and maintaining superior military capabilities.

2. **Time compression** is the ability to be first in marketing a new product, or reducing production lead time, or responding quickly to changing environment. Examples include new Wellness clinics established by SVMH, and a rapid, worldwide, deployment force being developed by DOD.

3. **Focus on continuous improvement** means reviewing processes and procedures to better meet the customers' requirements. SVMH reviews policies, guidelines, methods and operating procedures continually; for DOD, the Total Quality Leadership (TQL) program focuses these same efforts on both DOD's internal and external customers.

4. **Relationships** refer to associations and alliances with differing organizations to achieve a common goal or objective. SVMH has established relationships with its vendors to rapidly deliver its medical supplies; DOD has established relationships with various NATO allies for the common defense of the European theater.

Through these four bases, business and organizations sustain their competitive advantages. To maintain its competitive advantage, DOD should, to the maximum extent possible, operate

"business-like." DOD does this by developing and implementing strategies which are designed to continuously improve the manner in which DOD meets the demands of national security. Those demands require DOD to achieve and maintain sufficient and necessary readiness to counter any national security threat at the lowest cost possible. DOD can only accomplish those goals by efficiently optimizing all available resources - resources which include technology, personnel and finances. While financial resources are the most visible and easiest to direct of all resources, measuring their relative effectiveness towards achieving and maintaining appropriate levels of national security are the most difficult.

In an environment of declining budgets, DOD in general, and the Department of the Navy (DON) in particular, should try to obtain maximum efficiency from every budgeted dollar. Procurements of major weapons systems are seldom based on cost-benefit analysis or efficiency alone, but rather on current military strategies, topological concerns and even the procuring branch of the armed service (Goure, 1993). Moreover, DOD's external customers (ultimately, the American taxpayers) expect wise investments in their national security. The results of the efficiency of those investments in national defense can not be tested directly without a major conflagration. Instead, highly accurate, surrogate methods of measurement should be developed and utilized.

With limited financial resources, trade-offs regarding resource investments are also necessary. These trade-offs should be analyzed in light of their contribution to achieving the desired level of national security, not their cost savings or cost avoidance potential alone. Using only accounting ratios and return-on-investment measurements, without regard to meeting internal and external customer service levels, obscures DOD's goal, maximizing national security interests while minimizing resources.

Businesses in the private sector face similar challenges. Finite resources mandate that they operate as efficiently as their competitors. The primary objective of any organization, private or public, "profit" or "not-for-profit," is survival. Only after a organization has met all its operating expenses can it accomplish its secondary objective - to make a profit. Profit is defined as the reason an industry, firm or enterprise is in business (Fields, 1995). Broadly defined, profit may include returning dividends to stockholders, providing a sense of community wellness or providing for national security. In all cases, to make a profit, an organization must be as efficient as its competition. Relative success in achieving profits can be measured by an organization's relative efficiency and the level of customer service provided.

Comparing the efficiency methodologies of successful private sector business organizations to public sector methodologies will expose public organizations to different efficiency measurement

tools. By studying the inventory stocking criteria used by efficient private businesses, public organizations will have an opportunity to obtain similar efficient results in their inventory programs.

B. THESIS OBJECTIVE

1. Focus on Efficiency

This paper will focus on the efficiencies, cost savings and trade-offs generated as a result of the Navy's Inventory Control Point, Mechanicsburg, PA's (**NAVICP-M**) research into developing a COSAL inventory model to reduce shipboard inventories. It will contrast that model's approach to shipboard inventory levels with that of a private industry's approach.

2. Methodology

This thesis will begin by discussing both technical and allocative efficiencies and the conditions that characterize efficient outcomes. By measuring the economic efficiencies in regard to budgetary limitations, DOD and DON can ascertain whether their discretionary spending programs have effectively maximized the appropriate levels of national defense for the minimum expenditures. DOD and DON generally determine the effectiveness of their expenditures by measuring the overall contribution of defense to national security. A national defense program that is not "ready" to meet any and all threats to that nation's security is

5

ineffective in maximizing national defense. DOD and DON use "Readiness Indicators" to measure effectiveness in meeting potential threats.

3. The Navy Focus

This thesis will then center on one facet of those indicators, fleet readiness. For overall fleet readiness to be high each ship must be in its highest possible condition of material readiness. To accomplish this, ships have always carried an assortment of spare parts for emergent repairs. In 1956 the Navy implemented the Coordinated Shipboard Allowance List (**COSAL**) program to standardize procurement and storage of repair parts onboard naval ships. The COSAL lists all reported equipments and weapons systems onboard an individual ship, all the maintenance significant repair parts embodied in those equipments and weapons systems, and an inventory allowance listing of authorized repair parts to be stocked onboard. The Navy's supporting COSAL inventory model is the Fleet Logistics Support Improvement Program (**FLSIP**). The COSAL consolidated independent shipboard work center storerooms into a centrally managed storeroom location.

4. Point Five FLSIP Plus (.5F+) COSAL Inventory Model

The .5F+ inventory model was developed at NAVICP-M in response to the Packard Commission's 1986 report. The Packard Commission was a Presidential commission formed to investigate defense management and recommend improvements in DOD's operation,

organization and management. The commission's report recommended that a variety of improvements be made in DOD's management practices and organizational structure. In February of 1989, the President charged the Secretary of Defense to devise a plan to implement the Packard Commissions' report.

The Secretary's mission was to reduce the overall cost of operating and maintaining the armed services without adversely impacting national security or national defense. His plan, the Defense Management Report or DMR was approved by the President in July 1989. Among other things, it initiated the current "downsizing" philosophy and began the base-closure process. The preliminary goal of the DMR was to reduce or "save" $70 billion through 1995.

Initial reduction initiatives were known as Defense Management Review Decisions or DMRDs. One DMRD, DMRD 981, called for reducing spare parts inventories at all stocking levels. This savings initiative involved consolidating supply depots, disposing of slow-moving, high-value inventory items (range) and buying to lower inventory levels (depth). Not only would the initial capital outlay be reduced, but lower inventory levels would generate savings in all logistic areas associated with maintaining that inventory. Lower inventory levels would reduce holding costs (including costs of safety stock, warehousing costs, and costs of

goods-in-transit or "pipe-line" inventory), transportation costs, ordering costs, initial procurement costs, and stock out costs.

In 1991 NAVICP-M supported that initiative by investigating the feasibility of reducing first echelon inventory levels maintained on board ships. To accomplish this objective, NAVICP-M changed both the allowance model and the method of computing onboard inventory storeroom allowances.

The new model, .5F+, assists in that regard, refining the range and depth of shipboard storeroom inventories, and weighing customer demand-based and insurance-based criteria to determine sparing levels. Not only should shipboard storeroom inventories optimize the physical constraints of piece, weight and cube, they should also optimize expenditures based on budget constraints and customer service levels. One objective of the .5F+ COSAL model is to efficiently maximize the shipboard storeroom inventory based on budget constraints while meeting customer demands. This thesis will describe the methodology and decision-making criteria involved in constructing this customer-oriented model.

5.   The Salinas Valley Memorial Hospital (SVMH) Model

This thesis will also examine a private sector, not-for-profit organization, the Salinas Valley Memorial Hospital (SVMH). In establishing their inventory levels and policies, SVMH also uses customer demand-based and insurance-based criteria like the .5F+ model. This thesis will investigate the methodologies,

8

measurements and results that SVMH achieves relative to its overall effectiveness and efficiency. Both the .5F+ model and the SVMH model were designed to satisfy their internal customers' demands for service; specifically, by providing the right part at the right time at the right place in the right quantity for the lowest cost.

One measurement of customer satisfaction is the level of customer service that an organization provides. Improvements in efficiency not only increase an organization's profit, they also increase that organization's level of customer satisfaction. The efficiencies and effectiveness of both organizations will also be compared. The comparisons will be measured by their output results - the manner and degree to which each organization meets and satisfies its respective customers' needs. Comparing inventory programs and the results of their respective inventory decisions should provide a closer evaluation of the efficiencies of both organizations.

6. Trade-Off Analysis

Finally, this thesis will discuss the measurement tools that both DON and SVMH use to calibrate efficiency as well as the resultant trade-offs necessary to achieve that efficiency. Trade-off discussions will range from the initial trade-offs used in determining candidate selection through the impact of reduced shipboard inventories on future readiness.

If more efficient storeroom inventory construction procedures can be developed then the potential exists for both DOD and DON inventory logistics activities to increase their contributions to overall national security by optimizing their budget dollars. Should analysis also determine that SVMH has greater efficiency than DON's shipboard inventory, then SVMH's approach to inventory determinations should be adopted to increase the relative efficiency of DOD's inventory operation and improve customer service. By identifying procedures which enable inventory managers to optimize the mixture of spare parts carried onboard, not only will scarce budget dollars be efficiently allocated, but the overall military readiness posture will also be enhanced. Improved identification of internal customer requirements can also generate long-range, downstream procurement savings.

While this study will not definitively optimize resource-dollars, it will attempt to quantify applicable measurement tools to more accurately determine overall allocative efficiency. It will also suggest methods of improving product mix for shipboard inventories closely attuned to the internal customers' requirements.

C. SCOPE

This thesis will discuss, analyze and evaluate efficiency and readiness indicators relative to the .5F+ COSAL model and contrast

10

them with the demand-based, private-sector model used by SVMH. Discussions relative to readiness and readiness indicators will be based on both official DOD and DON publications as well as congressional reports. The appropriateness of using readiness indicators as measurement tools, as well as any alternative applicable measurement tools, will also be discussed.

Information regarding the development, results and implementation of the Navy's **.5F+** COSAL model will be based on interviews, literature and limited unpublished supporting documentation obtained while the author was assigned to NAVICP-M from 1990 - 1992 and helped to develop the **.5F+** model.

Comparisons and contrasts regarding the impact of the customer-oriented model with previous models in terms of reliability, effectiveness (as a measure of customer service) and cost savings will also be made.

All data relative to Salinas Valley Memorial Hospital's **(SVMH)** inventory management policies, procedures and inventory model utilization was obtained by personal interviews and discussions with the Material Management Director of Salinas Valley Memorial Hospital in May and October 1995. Efficiency in both the COSAL model and the SVMH model will also be compared. DOD's efficiency will be measured by the contribution to readiness and national defense that the **.5F+** COSAL model produces in terms of

11

effectiveness; SVMH's efficiency will be measured by the ability of the inventory management program to satisfy its customers' demands.

Finally, trade-offs and the impact of those trade-offs relative to DOD's and DON's budget constraints and limitations, storeroom inventories and overall impact on readiness will be investigated. This discussion will include the impact of those trade-offs towards improving efficiency.

D.   THESIS ORGANIZATION

To facilitate comparison and contrast of efficiency and associated trade-offs in both models, this thesis is organized into the following chapters.

Chapter II is an overview and discussion of efficiency, efficient allocation of resources and readiness.

Chapter III illustrates how the basic COSAL model for shipboard inventory allowances of repair parts was developed. It shows how that basic computational model was expanded to meet current readiness concerns and provides historical background information on the development of the Navy's shipboard inventory models through the current model, the .5F+ COSAL model. It also discusses the relative effectiveness of that inventory model.

Chapter IV likewise provides an introduction and discussion of SVMH's inventory management model/program and the overall effectiveness of that model/program.

Chapter V draws a comparative analysis between each organization and their respective models with recommendations for improvement where appropriate.

Chapter VI discusses the various trade-off analyses and implications of those trade-offs to overall readiness.

Chapter VII summarizes the findings and provides recommendations for further research.

II.   OVERVIEW OF EFFICIENCY AND READINESS

This chapter will begin with an introduction to the economic similarities between public organizations, e.g., the Department of Defense **(DOD)**, and private organizations, Salinas Valley Memorial Hospital **(SVMH)**, and the role that efficiency plays in decision making. A brief discussion of efficiency and some of the problems management encounters trying to measure efficiency will follow. Concepts addressed will be those of technical efficiency, allocative efficiency and "forced efficiency." The chapter will conclude by describing the methods which both DOD and SVMH use to measure their levels of efficiency.

A.   ECONOMIC SIMILARITIES OF PUBLIC AND PRIVATE INDUSTRIES

The public sector of the economy uses the same philosophical approach to economic decision making as the private sector, maximizing productivity (output) while minimizing resources (input). Success for any industry, firm or organization is measured in terms of profit. Additionally, organizations that have achieved the status of a world-class performer maintain their competitive advantage by continuously improving the way they meet their customers' needs and requirements. A "for-profit" business measures "profit" as financial return to partners, owners, and stockholders. The "not-for-profit" **(NFP)**

organization measures "profit" as contributions to corporate or foundation goals. DOD and the Department of the Navy (**DON**) measure profit or success in terms of "Readiness Indicators." Readiness indicators, which measure military preparedness and customer service levels, were designed to help measure the military's overall contribution to satisfying the national military strategy.

The national military strategy is the military's strategic plan for implementing the President's National Security Strategy. The National Security Strategy has three major objectives:

1. Enhancing national security through maintenance of a strong defense capability,

2. Promoting national economic prosperity through opening and expanding foreign markets,

3. Promoting international democracy (White House, 1995).

DOD and the military have only one purpose – to secure and defend the national security interests of the United States. "Our forces must be sufficiently ready – manned, equipped, trained and sustainable – to meet (the) deployment requirements our (national security) strategy demands" (Joint Chiefs of Staff, 1995).

From a economic perspective, the laws of Supply and Demand apply equally to both private and public sector organizations. As Figure 1 illustrates, Supply and Demand curves establish a market equilibrium price (**EP**) for all goods and services.

Supply and Demand Curves

AD₁ = Initial Aggregate Demand Curve   AD₂ = New Aggregate Demand Curve
Y₁ = Initial Weapon Systems Demanded   Y₂ = New Weapon Systems Demanded
P₁ = Price when Y₁ is demanded   P₂ = Price when Y₂ is demanded
EP₁ = Equilibrium Price   EP₂ = New Equilibrium Price
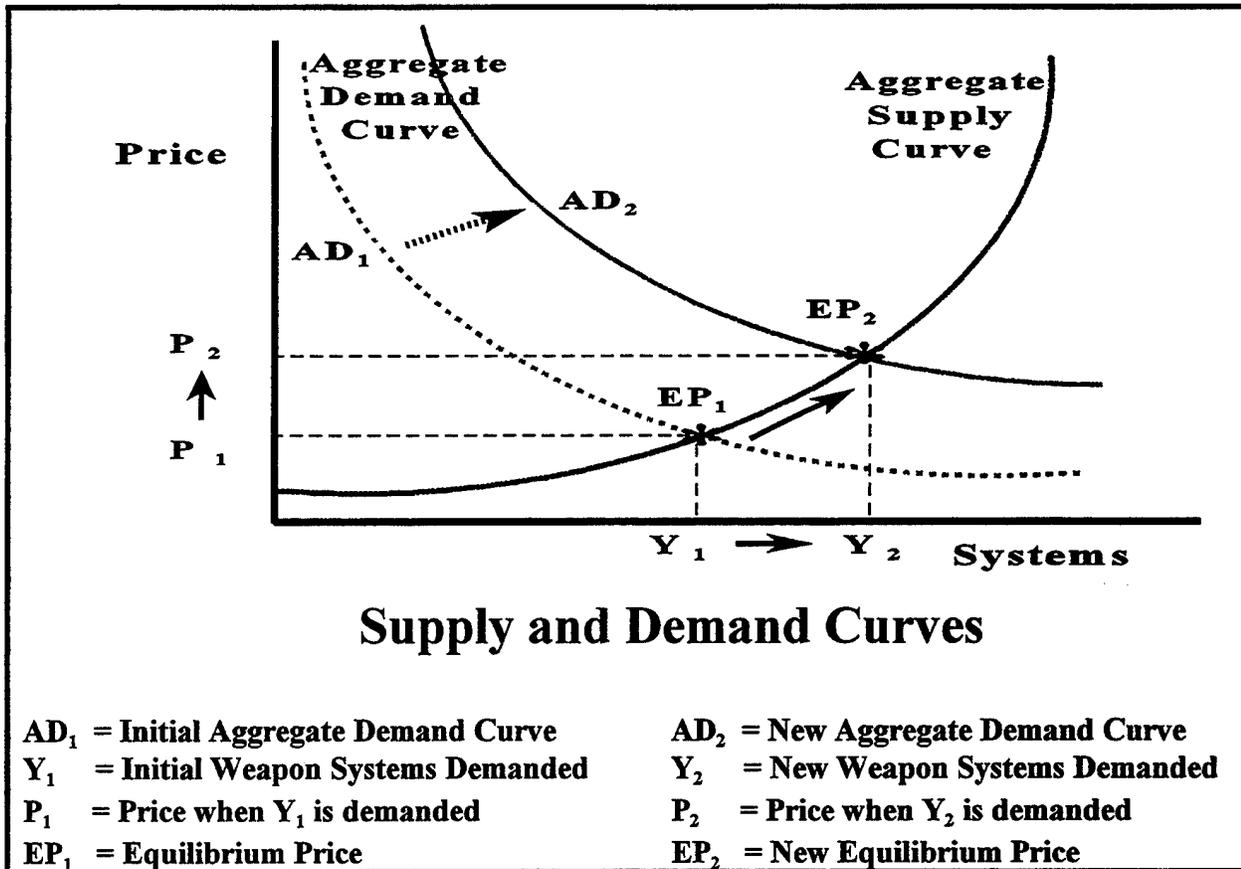
Figure 1. Supply and Demand Curves

Assuming a downward-sloping demand curve, when aggregate demand increases as a result of a change in resource availability or priorities, the aggregate demand curve will shift upward and to the right from AD₁ to AD₂. For example, DOD, anticipating that the budget would decrease, would begin demanding more weapons systems and platforms, trading off spares inventory and readiness to finance their procurement.

During the late 1980's such a scenario occurred. Faced with the challenge of financing, constructing and outfitting a 600-

17

ship navy with finite resources, DON began shifting budget dollars away from spares inventory and into procurement. Additionally, DON accepted lower material readiness rates, deferring both maintenance and upgrades to fund procurements. Readiness degradation projected an annual savings of $1.6 billion dollars; spares contributed an additional one billion dollars a year (Greeley, 1988). Figure 1 shows that both the short-run production of weapons systems and associated prices would rise from Y_1 to Y_2 and P_1 to P_2 respectively. The equilibrium price for those weapons systems shifts from EP_1 to EP_2, redistributing scarce resources to procurement at the cost of readiness (Gwartney, 1992).

In 1994-95, the movement is from procurement to readiness, delaying fleet modernization by increasing operations and maintenance funding by 6%, and to quality-of-life issues such as housing upgrades (Readiness, 1994). As DOD anticipates these budget constraints and begins to shift funding priorities, the aggregate demand curve for spares and services will shift upward and to the right. In the short-run, market prices will also rise to a new, higher equilibrium level. With limited resources, unless DOD counteracts the effect of rising prices, DOD's weapons systems purchasing power will be reduced again. One possible alternative to offset the higher prices would be developing and implementing improvements in efficiency.

In the public sector, the price that DOD pays for the goods and services it consumes and the price that DOD charges its customers for the services it provides is influenced by Public Law through congressional budget action. DOD's customer base consists of both internal and external customers. DOD's internal customers are the immediate members of the armed forces, staff and families as well as the supporting infrastructure and employees. DOD's external customers include not only U.S. taxpayers and citizens, but the nations' friends and allies as well. Both the national security strategy and the national military strategy stress the United States' role in peacetime deterrence and prevention of conflict as well as war fighting. For example, the military's overseas bases and temporary deployments of both air, ground, and afloat forces, extend DOD's customer base beyond the United States.

Demand by the military for goods and services is both finite and stochastic. The challenges facing both DOD and DON are:

1. How to increase value to the customer while reducing overall costs,

2. How to provide an acceptable level of customer service,

3. How to maximize contributions to readiness and national security while minimizing costs.

For DON one method used to meet these challenges is through the Navy's Coordinated Shipboard Allowance List (COSAL) inventory

model. The COSAL was designed to help maximize shipboard readiness while minimizing inventory requirements.

B.   NEED FOR EFFICIENCY IN BUDGET DECISION MAKING

National defense, like health care, is a public good. This thesis will compare how DOD and a private sector, not-for-profit hospital, Salinas Valley Memorial Hospital (**SVMH**), meet the same inventory management challenges for their internal and external customers. The structure and mission of SVMH impose budget constraints similar to those faced by DOD. SVMH, like DOD, must be ready to respond to emergency situations or crises. To maximize readiness while providing high levels of customer service subject to budget constraints, both SVMH and DOD must operate as efficiently as possible. To discover what types of efficiencies are operating at SVMH, investigative research focused on the kinds of inventory that SVMH manages and the inventory model/program that SVMH uses to manage that inventory.

Inventory selection criteria and the associated tradeoff decisions were investigated as well as some of the limitations involved in implementing SVMH's inventory management program. This data was used to gauge the overall efficiency of SVMH's program. Analysis of the efficiencies of SVMH's inventory program form the basis for comparison with the Navy's COSAL inventory management model/program.

However, before any comparisons can be made between DON and SVMH regarding their efficiencies, efficiency and the conditions that characterize efficient outcomes must be discussed. It is only by comparing the efficiencies of DOD's and SVMH's inventory program that recommendations can be made to improve the efficiencies of both organizations. Secondly, methods of measuring each organization's efficiency must also be addressed.

C.   DEFINITION OF EFFICIENCY

1.   Unconstrained and Constrained Optimization

When an economy with a limited quantity of competing resources is viewed from a macro perspective, efficiencies occur at those intersections of supply and demand curves for goods and services. Those equilibrium points maximize the total values of those goods and services, where value is defined in terms of consumers' incomes and preferences, subject to any given constraints (Gates, 1995).

Once a business organization has chosen a particular range of goods and services to produce, it then selects the best strategic plan to maximize its profit. Profit maximization decisions may be based on the availability of capital to the business. A business with unlimited access is considered unconstrained; one with limited access is constrained. A business may also be constrained with respect to limitations on

21

their customers' budget. For the unconstrained business, optimization occurs at maximum efficiency. Efficiency results when Marginal Cost **(MC)**, the cost of producing an additional unit at the current production rate, equals the customer's Marginal Benefit **(MB)**, usually depicted by the demand curve.

For the constrained organization such as DOD, the objective is to maximize output subject to various resource constraints such as infrastructure, personnel, and budget to name a few. For constrained optimization efficiency can be defined as that combination of goods and services such that the ratio of the Marginal Cost of producing that next unit of the good or service to the Marginal Benefit derived from that unit exactly equals the ratio of the Marginal Costs of producing all other goods and services to the Marginal Benefits derived from all other goods and services. Efficiency can be represented as follows:

$$\frac{MB_X}{MC_X} = \frac{MB_Y}{MC_Y} = \frac{MB_Z}{MC_Z}$$

In this formula X represents a good or service, Y a different good or service and Z another good or service (Gates, 1995).

2. **Technical and Allocative Efficiency**

A Production Possibilities Frontier curve **(PPFc)** is a representation of all possible combinations of the total output that could be produced, assuming (1) a fixed amount or quantity

of resources, (2) resources are being used efficiently, and (3) technology is not changing but is constant (Gwartney, 1992). Graphically the **PPFc** illustrates the optimal mix of goods and services that could be produced from limited resources. Any point along the **PPFc** is a technically efficient utilization of those resources, assuming that all resources are being used wisely with minimal waste. In essence, the **PPFc** is an aggregate composite of many Technically Efficient **(TE)** points. To obtain Allocative Efficiency **(AE)**, i.e., that allocation of resources which produces the mix of goods and services desired most by consumers, goods and services must be produced in the mix that maximizes consumers' utility (Gwartney, 1992). The relationship between these two types of efficiencies – Technical Efficiency **(TE)** and Allocative Efficiency **(AE)** and the Production Possibilities Frontier curve **(PPFc)** is illustrated by Figure 2. In it consumers demands or requirements are shown by a second curve, the Consumers' Utility curve **(CUc)**. This curve represents the aggregate sum of the consumer's preferences for all goods and services produced. While **TE** can be any point along the **PPFc, AE** is located only at that point of tangency between the two curves. To determine when **AE** has been achieved, there must be some method of measuring movement towards or away from that tangency point.

23

Technical and Allocative Efficiencies

G/S 1 = Goods and Services 1	G/S 2 = Goods and Services 2
TE = Technical Efficiency	AE = Allocative Efficiency
PPFc = Production Possibility Frontier Curve	CUc = Consumers' Utility Curve
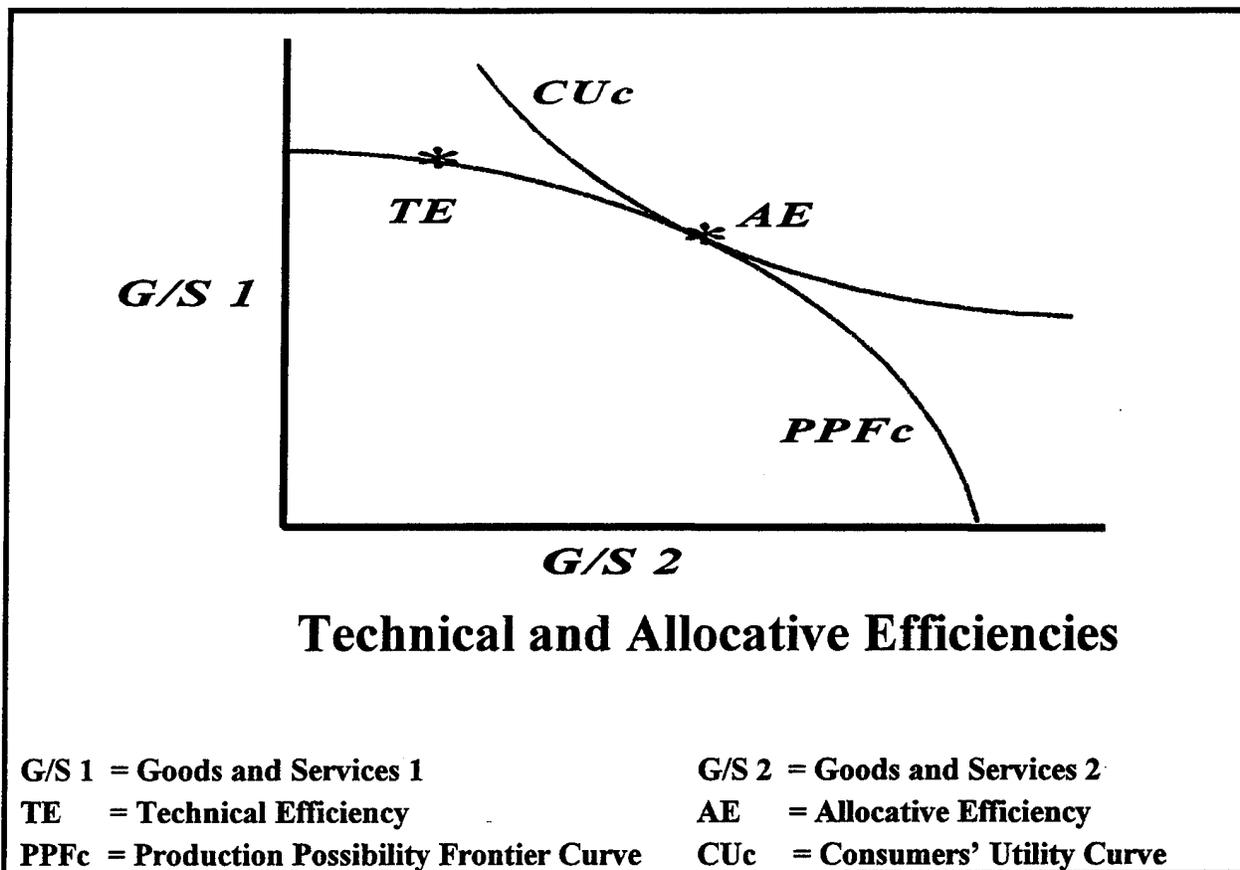
Figure 2. Efficiency Tangency Points

For DOD, **G/S 1** and **G/S 2** represent all possible goods and services that DOD can produce to ensure the highest level of national security based on fixed amount of financial resources. Examples of typical goods and services that DOD produces range from power projection through forward deployed battle groups to the Adriatic, bilateral and multilateral joint training exercises with NATO allies, drug interdiction in the Caribbean to inventory and logistic supply support. To achieve technical efficiency **(TE)** DOD must optimize the production of those goods and services

by fully utilizing all available resources with minimal waste. To achieve allocative efficiency **(AE)** DOD's optimal mix of those goods and services must maximize DOD's customers' utility, their demands and expectations.

3.   Movement Towards Allocative Efficiency

An organization is "inefficient" if its operating point (**OP**) either does not lie along the PPFc (is not technically efficient) or its **OP** is on the PPFc (is technically efficient) but is not located reasonably close to its allocative efficiency point.   In such a scenario, what options are available to move that organization closer to first technical efficiency and second allocative efficiency?   The decision makers in this scenario must decide why the organization has not achieved allocative efficiency.   If management is not incompetent or untrustworthy, then the assumption must be that management either believes it is at its **AE** point or believes that it has achieved a **TE** point that is reasonably close to its **AE** point and the necessary investment to achieve allocative efficiency is not cost effective.   If management knew it had not achieved allocative efficiency, then it would institute policies and procedures to move closer to that tangency point.   In a free market economy, competition, as reflected in the market price, tends to move businesses towards allocative efficiency.   However, there may be barriers unrelated

to competition which prevent management from achieving technical and allocative efficiency such as:

1. Ineffective policies and procedures (both internally and externally imposed) which hinder management from moving towards allocative efficiency,

2. Management using the wrong tools to accurately measure its movement towards allocative efficiency,

3. Management using its existing tools improperly, and

4. Lack of incentive programs or disincentive forces which inhibit efficiencies.

Decision makers must remove all policy and procedural barriers which hinder or prevent management from realizing their full potential in achieving technical and allocative efficiency.

4. Forced Efficiency

In a NFP organization decision makers could undertake a more coercive action and attempt to force the organization to become more efficient - "Forced Efficiency."

An organization whose procurement budget is tightly controlled must make investment decisions - balancing and trading off acquisitions of new equipment for inventory. If a business invests heavily in slow moving inventory, then inventory levels will rise while new equipment purchases decline. Since technical efficiency is any mix of goods and services which can be produced by using all available resources without waste, a high inventory

to new equipment procurement ratio could be technically efficient. However, allocative efficiency is that tangency point between technical efficiency and maximization of consumers' utility. A low stock turnover rate caused by high inventory levels would indicate that allocative efficiency probably had not been achieved. With technical efficiency, slightly lower inventory levels can reduce overall national security. However, this impact will be small because of the low inventory turnover rate. If the savings realized by reducing inventory levels are invested in other "products" that produce a higher state of readiness such as weapons systems, personnel or training, then the net impact on national security would be positive. In this example, consumer utility is defined as national security.

If an organization lacked accountability over its inventory; if it was subject to fraud, waste, theft and mismanagement, then it would be technically inefficient. Its efficiency position would no longer be on the PPFc. Decision makers should undertake action to return that organization to the PPFc and move it along the PPFc towards allocative efficiency. For a not-for-profit organization such as DOD, the leverage most readily available to force efficiency is budget reductions.

In 1992, the United States General Accounting Office (GAO) concluded from their investigations that DOD's inventory of spares had grown too large to be efficient. GAO's studies showed

27

that DOD's inventory grew from $43 billion in 1980 to $100 billion in 1990. DOD's unrequired or excess inventory also increased. GAO reported that in 1991 DOD held $40 billion of inventory beyond their needs. That inventory included spares (repairable items and consumable items) as well as clothing, medical/dental supplies, construction and industrial supplies. Either DOD was at some operating point (**OP**) no longer on the **PPFc** or their **TE** point was too far from their **AE** point. GAO also concluded that DOD's managers were subject to fraud, waste and incompetence. Based on GAO's recommendation, Congress reduced DOD's spares' budget by four billion dollars (GAO/HR-93-12).

Figure 3 represents what GAO was attempting to accomplish through those budget reduction recommendations. GAO believed that DOD's **OP** was neither at TE_1 or AE_1 but somewhere below PPF_1. By reducing the spares budget, GAO hoped to force DOD to change its organizational culture and eliminate its inventory management problems by becoming a more efficient, cost-effective operation. DOD would no longer have "sufficient funds to support its long-standing business inefficiencies" (GAO/HR-93-12). A reduced spares budget would cause a downward shift of the PPF curve from PPF curve from PPF_1 to PPF_2. Although not implicitly stated, GAO's intent would not have been to reduce national security interests, i.e., impact readiness, but rather to shift the **PPFc** such that it coincided with or passed through

28

Efficiency through Spares Reduction

BEFORE SPARES REDUCTIONS	AFTER SPARES REDUCTIONS
PPF_1 = Production Possibility Frontier	PPF_2 = Production Possibility Frontier
TE_1 = Technical Efficiency	TE_2 = Technical Efficiency
AE_1 = Allocative Efficiency	AE_2 = Allocative Efficiency
CU_1 = Consumers' Utility Curve	CU_2 = Consumers' Utility Curve
OP = DOD's Operating Point	

Figure 3. Spares Budget Reduction

DOD's previous **OP**. Since the old OP would now be located beyond PPF_2, DOD could not afford the previous OP and must move it downward. GAO intended for DOD to move its **OP** first to TE_2 on PPF_2 and then to move its TE_2 along PPF_2 towards the new allocative efficiency point, AE_2.

However, as Figure 4 suggests, this attempt at "Forced Efficiency" could fail to achieve either technical efficiency or allocative efficiency. DOD might believe that the optimal mix of
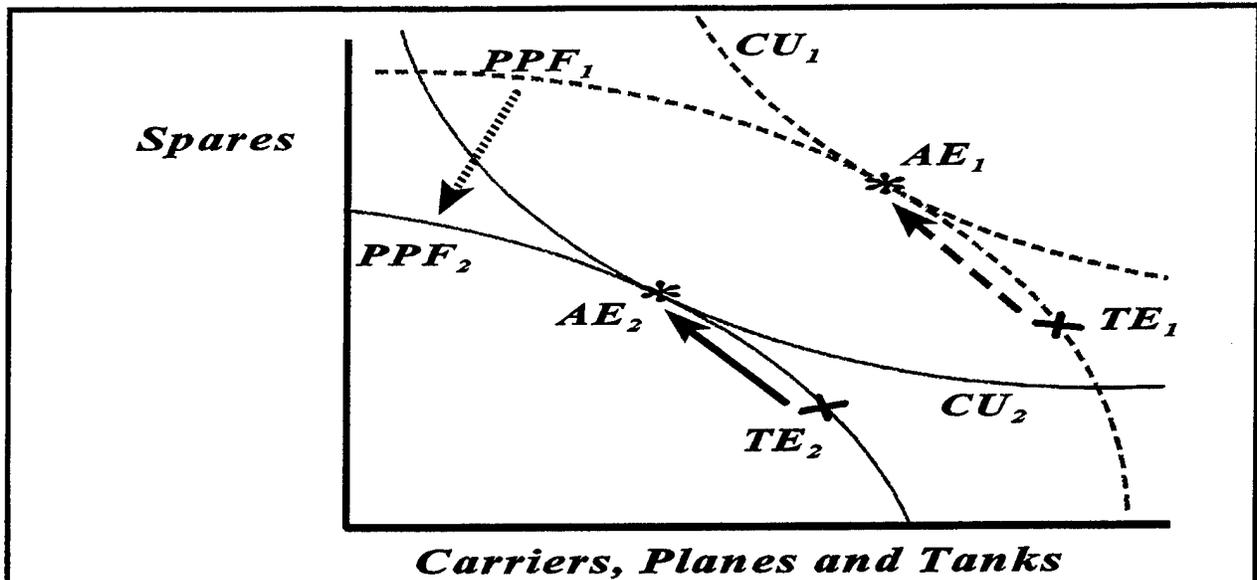
Forced Efficiency through Budget Reductions

BEFORE BUDGET REDUCTIONS	AFTER BUDGET REDUCTIONS
PPF$_1$ = Production Possibility Frontier	PPF$_2$ = Production Possibility Frontier
TE$_1$ = Technical Efficiency	TE$_2$ = Technical Efficiency
AE$_1$ = Allocative Efficiency	AE$_2$ = Allocative Efficiency
CU$_1$ = Consumers' Utility Curve	CU$_2$ = Consumers' Utility Curve

Figure 4. Forced Efficiency

defense supplies necessary to meet all national security interests was a particular ratio of aircraft carriers, long range bombers, tanks and spares. If DOD believed it was at technical efficiency point **TE$_1$** along **PPF$_1$**, then DOD could attempt to maintain that same ratio of carriers, planes, tanks and spares regardless of budget constraints.

Faced with an overall percentage reduction of DOD's budget, which would also cause the same downward shift of the PPF curve from **PPF$_1$** to **PPF$_2$**, DOD could proportionally reduce the number of

carriers, planes, tanks and spares procured to maintain its philosophical optimal mix ratios, establishing, for DOD, a new technical efficiency point, TE_2. This new point, TE_2, would be the same relative distance from the new allocative efficiency point AE_2, i.e. (AE_2 to TE_2), after the budget reduction as the previous technical to allocative efficiency points (AE_1 to TE_1) were before the budget reduction.

On the other hand, DOD could choose to alter the ratio of spares and weapons systems. Facing a reduction of spares budget alone, DOD could re-program weapons systems procurement dollars into spares procurement, trading off weapons systems upgrades for spares maintenance. If this avenue was prohibited by congressional action, then DOD could choose to do nothing.

GAO acknowledged that the primary cause of the Navy's excess inventory was the result of ship deactivations, predicted demand for spares exceeding actual demand, and equipment replacements without prior notification to inventory managers (GAO/HR-93-12). If DOD believed that GAO was correct, that part of DOD's inventory was excessive, then doing nothing, coupled with an aggressive disposal action, would reduce the DOD's investment in spares inventories. Postponing investment in spares for new weapons systems (spares previously acquired for older weapons systems are a "sunk cost" and have no impact on future procurements, excluding substitutability and holding costs) does

31

not necessarily correct the problem. If postponing buying spares until demand has been recorded does not satisfy consumers utility, i.e., does not contribute to meeting readiness goals, then such action would move DOD along the PPFc away from allocative efficiency.

In its annual report to Congress, the Congressional Budget Office (**CBO**) acknowledged that reducing funding and manpower, two major DOD resources, greatly reduces readiness (CBO, 1994). DOD would not be doing "more with less" but rather doing "less with less."

D.   **MEASURING EFFICIENCY**

Since allocative efficiency is that tangency point between the optimal mix of goods and services that can be produced and the consumers' utility function, some method of measurement must be devised to determine where an organization's technical efficiency point lies along the PPFc relative to its allocative efficiency point.

DOD can measure its movement towards or away from allocative efficiency as a level of contribution to military readiness by measuring its effectiveness in achieving its readiness goals. DOD must maximize readiness, subject to budget constraints, while establishing efficient outcomes.

SVMH, on the other hand, achieves allocative efficiency when its inventory management program maximizes customers' utility (customers' demands and expectations) within budget constrained resources. By measuring the level of customer satisfaction or level of customer service, SVMH can determine whether it is moving towards or away from its point of allocative efficiency.

E. DOD'S METHOD OF MEASURING EFFICIENCY

1. Definition of Readiness

The goal of any DON inventory allowance model should be to maintain or improve both fleet readiness and effectiveness while keeping the shipboard inventory levels and associated costs at a minimum. Requirements for increasing efficiency become more critical as a result of reduced near-term funding and continued reductions in the long term. Increasing efficiency allows DOD to absorb budget cuts without compromising national security. To ensure that national security is maintained, DOD uses readiness indicators to measure efficiency. Before discussing efficiency measurements, an understanding of readiness itself is necessary.

Readiness has been defined in a variety of ways. In January 1976, during testimony before the Committee on Armed Services (CAS), House of Representatives, Admiral Holloway, Chief of Naval Operations, defined readiness as "the ability of the fleet to successfully carry out those responsibilities for which we are

33

charged in support of our national security plans" (CAS, 1976).
Fleet readiness is comprised of personnel and material readiness.
Admiral Holloway went on to define material readiness as the
ships being in "good operating condition" (CAS, 1976). Measuring
readiness can also vary based on political agenda. In 1988 the
Navy was committed to a 600-ship fleet. The Navy traded off
maintenance operations, spare-parts procurement and aircraft
readiness rates to finance the build up (Greeley, 1988).

Since readiness rates are reported as averages, by
maintaining a higher degree of readiness for deployed units and a
much lower rate for stateside assets, overall readiness levels
have remained high. Even in today's environment of reduced
defense budgets, readiness remains the Pentagon's top priority.
The FY95 defense budget increases funding for operations and
maintenance by again trading off procurement dollars. Secretary
of Defense William Perry has indicated that the FY96 budget will
likely continue this trend - trading off fleet modernization
procurement funding for readiness (Readiness, 1994).

2. Reporting of Readiness

DOD reports readiness to the Joint Chiefs of Staff **(JCS)**
using the Status of Resources and Training System **(SORTS)**. JCS
uses this data along with other indicators to evaluate the
overall military readiness posture and their ability to meet all
national military strategy goals and missions. SORTS provides a

snapshot view of how adequately prepared a unit is to perform its assigned missions with both material and personnel resources.

The Navy measures the degree of material readiness capability of its ships based on casualty reports, or **CASREPs**, sent by individual ships. The **Naval Warfare Publication 10-1-10** (NWP 10) describes a C-3 CASREP as a major degradation of a mission area capability; a C-4 CASREP is a loss of the ability to perform a mission. For example, if one of two missile launchers on a cruiser is inoperative, that ship would report a C-3 CASREP. If the second missile launcher became inoperative as well, that would be a C-4 CASREP (NWP 10).

A recent General and Accounting Office (**GAO**) report commented on the limitations of SORTS. While SORTS does report personnel, equipment and training deficiencies, it only measures individual service readiness. SORTS neither addresses the issue of joint readiness nor does it provide a method of forecasting changes in readiness posture (GAO/NSIAD-95-29).

3. Changes to Readiness Reporting

GAO has attempted to identify "critical readiness indicators" which, together with SORTS, can provide a fuller readiness assessment (GAO/T-NSIAD-95-117). Through field level research GAO refined a listing of over 650 indicators to six critical indices: personnel deployability status, unit readiness and proficiency, operational tempo, weapon systems proficiency,

funding, and unit and intermediate maintenance performance. Several corrective initiatives have been undertaken to improve the readiness assessment picture. These initiatives include forming the Office of the Under secretary of Defense for Personnel and Readiness, establishing the JCS's Senior Readiness Oversight Council and creating the Joint Readiness System. The three service branches have begun developing and implementing readiness improvement assessments (GAO/T-NSIAD-95-117).

This thesis, however, will focus on the material aspects of readiness. One factor which impacts shipboard material readiness is the ability of the ship to repair its own weapon system casualties by drawing needed repair parts from its own storerooms. Those shipboard storerooms represent the ship's allowance of repair parts, the first echelon of DOD inventory.

4. Measuring the Contribution of Shipboard Inventory to Readiness

Effective management of shipboard storeroom inventories reduces stockouts, contributing directly to the ship's material readiness condition. Measuring the fill rate of customer demands for authorized allowance-based repair parts from shipboard inventories is one indication of the ship's contribution to material readiness. This measurement, called the **Net Effectiveness** of the ship, is calculated as follows:

$$\text{Net Effectiveness} = \frac{\text{Total Issues From Stock}}{\text{Total Demands For Stocked Items}}$$

36

Another measurement of the effectiveness of inventory management is **Gross Effectiveness,** the filling of a customer's demand for any item, whether or not that item is authorized to be carried onboard. Gross Effectiveness is calculated by the following formula:

$$\text{Gross Effectiveness} = \frac{\text{Total Issues From Stock}}{\text{Total Demands For Any Item}}$$

Net Effectiveness goals have been established at 85 percent, Gross Effectiveness at 65 percent (OPNAVINST 4441.12B). As a ship's effectiveness approaches, meets or exceeds these effectiveness goals, the overall contribution of individual storeroom inventories to material readiness increases while the percent of stock outs deceases.

F.   SVMH METHOD OF MEASURING EFFICIENCY

1.   Definition of Customer Service Level

Successfully determining a business's movement towards or away from allocative efficiency requires developing and utilizing appropriate measurement tools. While DOD uses readiness indicators, many private sector industries, such as SVMH, measure efficiency based on the quality of customer service provided. Quality of customer service indicators can be measured either as

a probability of not "stocking out" (not running out) or as a service level percentage (fill rate).

The difference in choice of measurement tools depends upon the organization's management strategy - customer orientation or product orientation. By measuring the probability of not stocking out, management directs its attention to such issues as resupply, product availability, restocking criteria, etc. In doing so, management neglects its company's most important and valuable asset - the customer. By focusing on customer service levels attention is also drawn to similar issues such as not stocking out measurements. However, meeting the needs and demands of the customer is paramount. A 95 percent probability of not stocking out is unimportant to the customer if the part is not available when the customer needs it.

2. Methods of Measuring Efficiency for SVMH

Unlike DOD, SVMH does not have a mathematically precise method of directly measuring customer satisfaction. SVMH's Material Management Department (MMD) is responsible for all aspects of inventory management. Like DOD, MMD's technical efficiency also depends on budget constraints. MMD has achieved technical efficiency when it also optimizes the procurement of those necessary goods and services required by its internal and external customers, fully utilizing its limited fiscal resources with minimal waste. To achieve allocative efficiency, MMD's

38

inventory management program must satisfy its customers' demands (customers' utility) by providing them quality, low cost products and rapidly responding to their demands within their budget constraints. As the level of customer service increases, SVMH is moving closer to achieving allocative efficiency. Once SVMH has achieved technical efficiency, by measuring and comparing that level of customer service or customer satisfaction to previous measurements, SVMH can determine whether it is moving towards or away from its point of allocative efficiency.

Since MMD measures success (its profit) by the level of customer service quality or customer service satisfaction, MMD can not measure its movement towards allocative efficiency solely on how well MMD achieved budgeted performance goals or the size of MMD's contribution to organizational solvency. However, there are customer service indicators with which MMD can measure its level of customer satisfaction. Some of these indicators are (a) Inventory stockpiling by customers and (b) Vendor resupply fill-rate, and (c) Stock turn.

a.   Inventory Stockpiling

Whenever customers lack confidence in their supplier's ability to fill their requirements in a timely fashion, customers seek alternative methods to insure that their needs are met. One form of this insurance is "stockpiling", the ordering and storing of inventory on-site in excess of anticipated normal usage. Not

only does "stockpiling" increase inventory costs, it also masks poor management practices. An absence of stockpiling would indicate customer confidence that the supplier can satisfy all the customer's requirements quickly and accurately.

b. *Vendor Resupply Fill-Rate*

Another indicator to measure customer service level could be the resupply fill-rate that MMD receives from its vendors. Fill-rate is the probability that a vendor will be able to fill an order with the requested items from its current stock (Ballou, 1992). Fill-rate or service level can be expressed by the following formula:

$$\text{Fill-Rate/Service Level} = 1 - \frac{\text{Expected number of items out of stock annually}}{\text{Total Annual Demand}}$$

An item with a demand for 300 units and an expected out of stock quantity of 15 units would have a fill-rate of .95 or 95 percent. If MMD receives a high vendor resupply fill-rate, then MMD can pass those high fill-rate benefits directly to their customers in the form of lower inventory holding costs and rapid response time. Since MMD's mission is to provide the highest possible level of customer service to its internal customers (the doctors, the nurses, etc.) and to its external customers - the patients, customer satisfaction can be measured as their ability to provide those customers with resupply service.

40

c.   Stock Turn

A third indicator that SVMH can use to measure MMD's level of customer service is stock turn. Stock turn measures how quickly or how slowly items are being issued from the warehouse relative to the average on-hand inventory, i.e., the stock usage rate. Stock turn primarily measures the efficiencies of inventory investment. As such it was originally designed to provide management with a quick ratio of inventory to sales or issues. Stock turn is usually calculated as a dollar value ratio of total issues made from stock for a given period of time to the average of the beginning and ending inventories for that same period of time. For example, if MMD began the year with $450,000 in inventory, issued $5,000,000 in stock, and ended the year with $550,000 in inventory, then the stock turn ratio was 10 to 1, a monthly stock turn of .83. In this example, all of MMD's inventory (based on dollar value) "turns over" or is issued once every five weeks. A high stock turnover rate could indicate that MMD has not made a sufficiently large investment in their inventory levels and must continually reorder to meet customer demands.

However, with a fixed level of investment, such as MMD's eight million dollar annual budget for demand-based medical supplies, stock turn could be used as a quasi-service indicator. In this case, a high stock turn would indicate that MMD is

41

stocking the appropriate mix of parts for its customers. A low stock turnover rate could indicate that MMD's inventory investment is too large relative to its sales (issues) or MMD's inventory mix is not appropriate for all its customers' requirements from stock. The customer is not "buying" the stocked inventory, either because MMD is stocking the wrong parts, MMD is stocking the right mix of parts but ordering an insufficient quantity to satisfy their customers' demands, or MMD is not reordering the demanded inventory in a timely fashion.

Any of these three indicators viewed in isolation could lead to imprecise and contradictory conclusions. By monitoring all three of these customer service indicators together, SVMH should have a fairly accurate snapshot of the level of customer satisfaction that MMD is providing.

III. THE COSAL INVENTORY MODEL

This chapter will discuss possible methods which the Department of the Navy (**DON**) can employ to meet the Department of Defense's (**DOD**) readiness goals. It will also portray an historical perspective of the Navy's shipboard inventory management program and related measures of effectiveness. The thesis will then discuss the development of the Coordinated Shipboard Allowance List (**COSAL**), its inventory model, called the Point Five FLSIP Plus (**.5F+**), and the model's relative effectiveness towards meeting DOD's readiness goals.

A. BACKGROUND

1. Methods for DOD to Increase Efficiency

DOD can more effectively meet its readiness goals, maintain or achieve higher levels of readiness and increase efficiency despite its declining budget authority by either improving weapons systems reliability, increasing shipboard inventory effectiveness, or pursuing a combination of these two efforts.

a. *Reliability and Maintainability*

Reliability is defined as the probability that a particular weapons system will operate satisfactorily within given parameters when used for a specified period of time in the environment and operating conditions under which it was designed

43

to function (Blanchard, 1992). As the reliability of a weapons system increases, overall readiness increases.

Maintainability refers to those characteristics of a system or product design pertaining to the ability to perform maintenance actions - both preventative and corrective. The design should allow maintenance actions to be preformed easily, safely, accurately and economically. Maintainability can be measured in terms of maintenance cost and maintenance time (time required to perform the maintenance, time between maintenance actions,etc). Maintainability concepts and definitions used are as follows: (Blanchard, 1992)

1. **MTBF**: mean time between failure, which measures the average elapsed time between component or system failures.

2. **MTBM**: mean time between all maintenance actions, which includes both corrective and preventive maintenance.

3. **$\bar{M}ct$**: mean corrective maintenance time. Whenever a system fails, a variety of actions are required to restore that system to full operational status. Those actions include detection, preparation, disassembly, maintenance, reassembly and final testing. A corrective maintenance cycle consists of all these steps. The mean corrective maintenance time is an average time required to complete an entire corrective maintenance cycle.

4. **$\bar{M}pt$**: mean preventive maintenance time. $\bar{M}pt$ is a similar concept as $\bar{M}ct$, but measures the time required to keep a system at its required level of performance. $\bar{M}pt$ is the average time required to complete an entire preventive or scheduled maintenance cycle. During this time the item is not available for operation.

5. **$\bar{M}$**: mean active maintenance time, the mean or average time to perform both corrective and preventive maintenance actions per operating cycle, excluding logistics and

44

administrative delay time. It is a function of both $\overline{\text{Mpt}}$ and $\overline{\text{Mct}}$.

6. **MDT**: maintenance downtime, the total time a system is "down" for both preventive and corrective maintenance actions including any applicable logistics and administrative delay time. "The mean value is calculated from the elapsed times for each function and the associated frequencies (similar to the approach used in determining $\overline{\text{M}}$)" (Blanchard, 1992).

b.   *Weapons System Redesign*

To maximize the reliability of current weapons systems, DOD could invest its shrinking procurement dollars in system redesigns of those weapons systems with low reliability and maintainability ratios. The goal of any weapons system redesign is to improve the reliability of the system by improving the reliability of the individual component parts. These improved component parts would then be retrofitted to the current system, improving the overall reliability of that system. This would increase the probability that the system would be available when needed.

There are three measurements which can be used to determine this probability: Achieved Availability (A_a), Inherent Availability (A_i), and Operational Availability (A_o). Both A_a and A_i measure probabilities under ideal circumstances, assuming that all necessary support equipment (parts and tools) and maintenance personnel are readily available. Both measurements exclude logistics and administrative delay time from their calculations. A_a measures **MTBM** relative to $\overline{\text{M}}$, which includes preventive

45

maintenance. A_i measures **MTBF** relative to $\overline{\text{Mct}}$, which excludes preventive maintenance.

A_o measures the probability that a particular weapons system, when used in its actual intended environment, will operate as designed. A_o measures **MTBM** relative to **MDT**. A_a and A_i measure the probability of operational availability of a weapons system in a perfect support environment and are used to evaluate the weapons system's designed capability. A_o measures the weapons system's probability of success under realistic conditions in the actual support environment and is used to measure actual capability.

2. Weapons Systems Reliability Improvements

One option that DOD can use to meet their readiness goals and increase efficiency is to maximize the overall effectiveness of their weapons system's reliability. To measure the effectiveness of component reliability improvements (and overall system reliability improvement), DOD could measure the A_i of the weapons system. Inherent Availability (A_i) is the ratio of **MTBF** to **MTBF** plus $\overline{\text{Mct}}$ as represented by the following formula:

$$A_i = \frac{MTBF}{MTBF + \overline{Mct}}$$

By lengthening the **MTBF** of individual component parts of a weapons system through enhancing or improving the reliability of

46

those individual components, the A_i of that system also increases (Blanchard, 1992). The longer the time between failures of a weapons system (the greater the "uptime"), the greater the availability, reliability and efficiency of that weapons system. By measuring the overall reliability of a weapons system before any financial investment had been made in increasing component reliability, and measuring the overall reliability of that same weapons system after the investment, an investment-to-reliability ratio could be evaluated from a cost-benefit perspective. The goal would be to determine the actual cost of reliability improvements relative to the net increase in system reliability. The dollar value would then be evaluated against other alternative reliability improvement investments which yielded similar changes in system reliability, choosing the most cost effective alternative. This option assumes that reliability improvements can be successfully integrated into current weapons systems and their components.

3. Shipboard Inventory Effectiveness Improvement

A second option that DOD can use to meet readiness goals is to maximize the effectiveness of current shipboard inventory used to repair and minimize weapons system "downtime." By investing in an optimal mix of repair parts for shipboard inventory, a greater number of the needed repair parts will be available (stocked) and readily accessible.

When a system is not operational, the total time required to repair that system and return it to a fully functional status is the maintenance downtime or **MDT** of that system. **MDT** is the mean active maintenance time $(\bar{M})$, or average elapsed time needed to complete both preventive and corrective maintenance of the system, plus the sum of any logistics delay time **(LDT)** and administrative delay time **(ADT)** required to obtain all necessary repair parts. Thus:

$$MDT = \bar{M} + LDT + ADT.$$

When the necessary repair parts are available onboard ship, **LDT** and **ADT** are virtually eliminated. Whenever **LDT** and **ADT** are eliminated, **MDT** equals $\bar{M}$. **MDT** becomes the time spent preforming the actual maintenance on the system.

Operational Availability **(A$_o$)** is the probability that a system will operate in its intended operational environment when required. As such it is considered a major readiness indicator. A$_o$ consists of uptime divided by uptime plus maintenance downtime or **(MDT)**. A$_o$ can be represented by the following formula:

$$A_o = \frac{MTBM}{MTBM + MDT}$$

Whenever **MDT** is decreased by reducing or eliminating **LDT** and **ADT**, Operational Availability **(A$_o$)** is increased (Blanchard, 1992). As

48

A_o increases, readiness increases. By measuring the shipboard inventory effectiveness before and after the financial investment, the investment-to-gain/loss of effectiveness ratio can be evaluated to ensure an efficient utilization of resources. The Navy's newest COSAL inventory model, the .5F+, addresses this second option. It is this inventory management program model which will be compared to SVMH's inventory management program.

4. Combination of Options

DOD could finance a combination of both options. Choosing the first option – improving reliability – would imply that either (1) the selected weapons systems had not achieved a sufficiently high degree of reliability during the design phase or (2) new and innovative technologies had been developed after introducing the weapons system which will improve their overall reliability. Equipment or system upgrades should not be considered as reliability improvements. Upgrades enhance, change or improve the performance capabilities of the weapons system, usually expanding their original mission. As such, the upgraded system can be materially and functionally different than the original system.

When designing weapons systems, a variety of factors and tradeoffs are considered and evaluated. DOD's policy regarding reliability and maintainability emphasizes system readiness, mission performance requirements, prevention of design

49

deficiencies and "developing robust systems, insensitive to the environments experienced throughout the system's life cycle and easily repaired under adverse conditions (DODINST 5000.2, 1991)."

Reliability must be designed into the system to support readiness goals and objectives. The predicted and actual failure rates of the weapons system are critical evaluative factors in selecting that weapons system. If the system has an inherent "critical single point failure mode" which cannot be eliminated, then reliability requires that redundancies be built-in or the system is made "insensitive to the cause of the failure (DODINST 5000.2, 1991)."

All component parts of the weapons system are subject to reliability testing. The overall reliability of any weapons system is a function of the reliability of each component part. By conducting a configuration breakdown analysis of all the assemblies, subassemblies and component parts, an overall reliability factor for the weapons system can be determined.

Reliability design tests and demonstrations continue throughout the weapon system's design phase until the production approval phase or Milestone III of the System Acquisition Phases. At that point the design is somewhat "frozen." Before entering the next phase of the weapon system's life cycle all customer or user requirements for reliability must have either been satisfied or waived during Initial Operational Test and Evaluation **(IOT&E)**

(Dillard, 1995). Before the weapon system is approved for production, all test results and design corrections from **IOT&E** are reviewed and verified. Any previous failures due to defective or faulty component parts should have been corrected through quality control. During the weapon system's initial deployment, the reliability objectives are again verified. These extensive testing procedures are necessary to ensure the highest reliability prior to deployment.

DOD's policies and procedures are designed to obtain the greatest system reliability at the lowest cost. Improvements to reliability during the design phase are generally less costly than those initiated after the system has matured. Figure 5 illustrates this point. A reliability-to-cost ratio can be developed by comparing an increase in reliability to its associated investment costs. Tracking the reliability-to-cost ratio during the weapons system's initial design phases and its mature phases will show when the most cost effective investment should be made.

An increase in the overall reliability of a weapon system made during its design phase is represented by movement from R_1 to R_2 along the Reliability axis. This change in the absolute value of the Reliability is **delta r**. A similar increase in the absolute value of the Reliability is also made during the mature phase, shown by moving from R_3 to R_4. However, the associated

Reliability to Cost Ratios

$R_2 - R_1$ = r increase in Reliability Percent $R_4 - R_3$ = r increase in Reliability Percent
$C_2 - C_1$ = x Dollars -- Cost of Investment $C_4 - C_3$ = y Dollars -- Cost of Investment
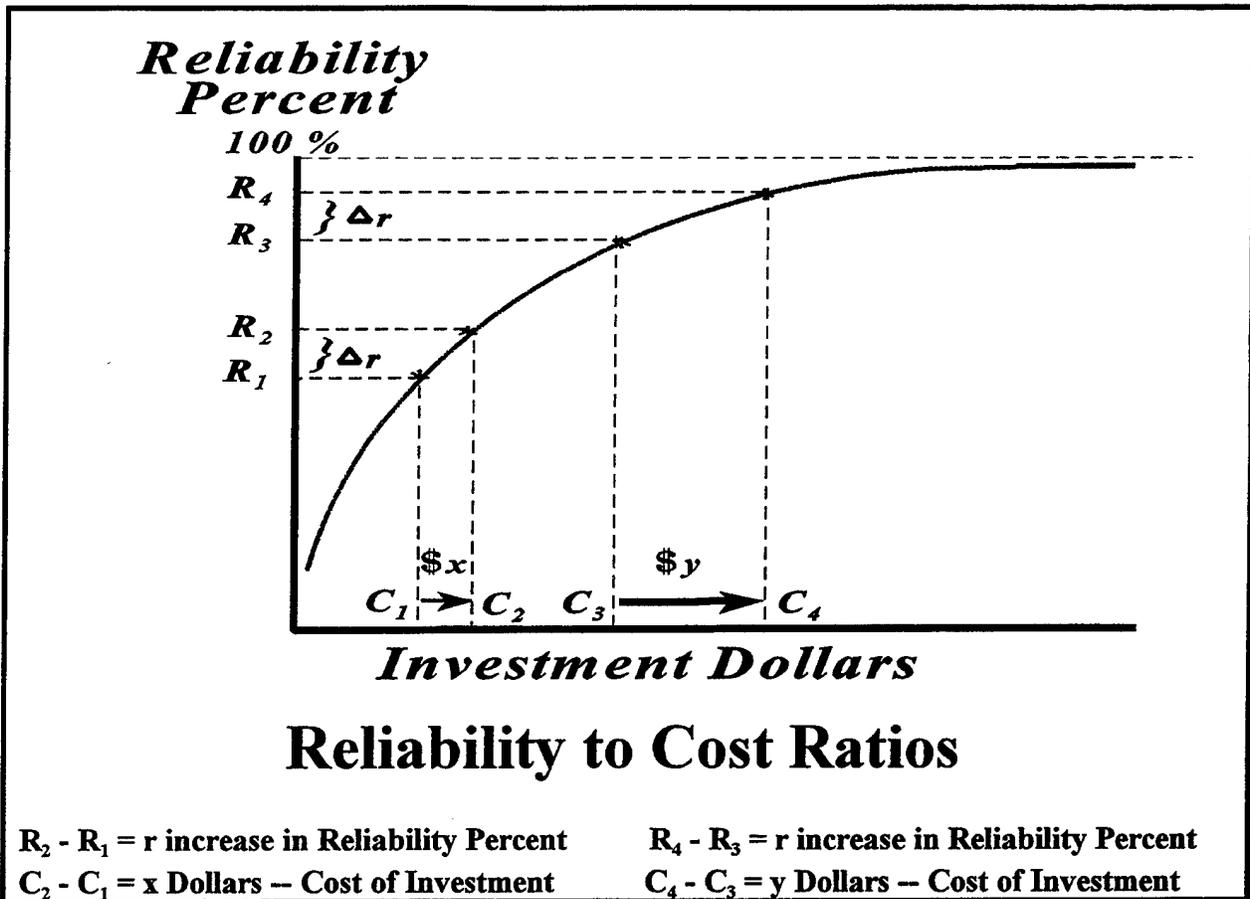
Figure 5. Reliability Increase to Investment Cost Ratio

investment costs necessary to obtain the same increase in system reliability is not the same. The investment cost of C_3 to C_4 (shown as **y dollars**) is greater than the investment costs from C_1 to C_2 (shown as **x dollars**). Reliability improvements are less expensive in the design phase than the mature phase.

Option one addresses reliability improvements for weapons systems after deployment. When a weapon system is deployed, it has met all customer required reliability factors. It is close

to its reliability design limits. Additional investment in reliability at this stage is usually not cost effective.

Option two addresses the issue of co-locating the necessary repair parts close to the equipment they support. Repair parts are required for both preventative and corrective maintenance actions. Option two does not propose increasing the quantity of repair parts in inventory, but rather altering the mix of those parts. The greater the reliability of the weapon system, the greater the MTBF of that weapon system and the smaller the overall usage rate of those repair parts. But maintenance actions, whether scheduled or not, will still be required. If the weapon system is currently at sub-optimal reliability or new and innovative technologies have been developed permitting the retrofitting of reliability improvements, reliability gains after deployment are generally more expensive than co-locating required repair parts. With limited resources and declining budgets, DOD would likely have to trade-off gains in reliability against stock piling spares. DOD could not fully fund either option.

5. COSAL Model Development

Navies have always needed a method for rationally trading off bullets, butter and black oil for sustainability. Since a ship can not carry, nor can a country afford, all possible repair parts for all ships, some type of mathematical model is needed to determine the mix of parts and the quantities that should be

procured, warehoused, transported and placed on board. The goal of any inventory allowance model should be to maintain or improve both fleet readiness and effectiveness while minimizing the shipboard inventory levels and associated costs.

a.   *Needs and Benefits of the COSAL*

In December 1956, the Coordinated Shipboard Allowance List (**COSAL**) Program was implemented to standardize qualification criteria for procuring and stowing spare parts onboard ships. The COSAL is a publication containing all the reported weapons systems and equipment installed onboard individual ships and their maintenance significant components or piece parts. All equipment and piece part items are assigned an item identification number for ease of reordering and repair. National Item Identification Numbers (**NIINs**) are also assigned to all repair and consumable items. The COSAL lists all storeroom repair parts stocked onboard to support and maintain weapons systems and equipment by NIIN.

Prior to implementing the COSAL concept, each work center on the ship maintained its own inventory and storeroom of repair parts to support its equipment and weapons systems. As a result, there was little information regarding availability of individual parts across work centers. Technicians spent an inordinate amount of time requisitioning, tracking, receiving, storing and maintaining their individual supplies (Neelley,

1965). Inventory consolidation eliminated unnecessary duplications of repair parts. This enhanced overall efficiency and lowered costs. COSALs are hull-tailored to individual ships, based on the ship's reported equipment configurations. Since the COSAL lists all repair parts authorized to be carried onboard the ship, a COSAL inventory model was required to maximize the inventory's effectiveness based on actual demand and predicted failures while satisfying both budget and onboard space constraints.

b. Initial COSAL Inventory Requirements

In addition to considering both money and storage constraints, the inventory model should identify those parts most commonly needed to repair the ship's weapons systems and supporting equipment. By analyzing preliminary statistical data, the Allowance List of the original COSAL inventory model included any repair part predicted to be needed one or more times within a ninety-day period. If a repair part did not have a minimum usage rate of one demand in ninety days, it could be carried as an insurance item. Insurance items are repair parts for equipment considered vital to the ship's primary mission or vital to the safety or welfare of the crew. However, insurance items were not stocked unless they were needed at least once during the past eight quarters (Neelley, 1965). The goal of the COSAL model was to provide a storeroom inventory management system capable of

satisfying ninety percent of a ship's demands for repair parts during a ninety-day endurance period (OPNAVINST 4441.12B).

c.   Value of an Effective COSAL Inventory

To significantly contribute to fleet readiness, a ship must be able to quickly repair its degraded or inoperative weapons systems. The most expeditious method to complete these repairs would be placing both the technical expertise and an inventory of repair parts onboard individual ships. Identifying and stocking those repair parts must be the mission of any inventory management program. The COSAL identifies those weapon systems which the ship is capable of maintaining and repairing onboard, and lists all the component parts of those weapon systems. The inventory model determines which repair parts should be stocked in the ship's storerooms, the most readily accessible level of DOD inventory.

By accurately identifying and stocking those repair parts, the ship's maintenance and repair capabilities increase, stock outs decrease, and overall material readiness improves.

d.   COSAL's Measures of Effectiveness

To determine whether the COSAL's inventory model accurately predicts which repair parts should be stocked for shipboard use, DON uses three methods to measure the model's effectiveness: **Net Effectiveness, Gross Effectiveness** and **COSAL Effectiveness.** The first two methods, Net and Gross

Effectiveness, measure the ability of the ship to provide previously identified, stocked parts to its internal customers. The third method measures the model's ability to predict overall customer demand.

(1) Net Effectiveness. Net Effectiveness measures the ship's fill rate in satisfying customers' demands for authorized repair parts relative to the storeroom inventory availability of those same authorized repair parts. The formula for Net Effectiveness is:

Net Effectiveness = $\dfrac{\textbf{Total Issues From Stock}}{\textbf{Total Demands for Stocked Items}}$

Net Effectiveness was designed to directly measure a ship's ability to issue and reorder authorized inventory parts.

(2) Gross Effectiveness. Gross Effectiveness measures the relationship between the ship's ability to issue and reorder authorized parts and the inventory model's ability to predict customer needs. Gross Effectiveness measures the fill rate of the customers' demands relative to any repair part, whether authorized for stock or not. The Gross Effectiveness formula is:

Gross Effectiveness = $\dfrac{\textbf{Total Issues From Stock}}{\textbf{Total Demands for Any Item}}$

57

Net and Gross Effectiveness goals have been established at 85 percent and 65 percent respectively (OPNAVINST 4441.12B).

(3) Need for unique measurements. While Net and Gross Effectiveness goals are important, both are dependent upon influences external to the model itself. For example, failure of a ship to expeditiously reorder a part upon issue lowers Net and Gross Effectiveness if that part is needed again. However, reordering that same part when issued does not guarantee a higher Net or Gross Effectiveness; the part may not be needed again. Other externalities which impact effectiveness percentages include system stock availability, long lead times associated with some routine stock replenishment actions, and transportation time for reordered parts to the ship.

(4) COSAL Effectiveness. DON recognized the the shortcomings of using only Net and Gross Effectiveness to accurately measure and predict inventory effectivness. A measurement was needed which determined the responsiveness of the model itself to actual demands. Both Net and Gross Effectiveness formulas use issues from stock as a criterion. By factoring out issues from stock, their influence would be negated, leaving only demands for any item relative to demands for model identified stock items. This third DON tool directly measures the effectiveness of the COSAL's inventory model in identifying and stocking repair parts for individual ships. That measurement is

COSAL Effectiveness, the ratio of the number of demands for an item identified by the model to the number of demands for any item, independent of inventory qualification criteria. The formula is derived by dividing Gross Effectiveness by Net Effectiveness as follows:

$$\text{COSAL Effectiveness} = \frac{\text{Gross Effectiveness}}{\text{Net Effectiveness}}$$

substituting for Gross and Net Effectiveness,

$$\text{COSAL Effectiveness} = \frac{\frac{\text{Stock Issues}}{\text{Demand for Any Item}}}{\frac{\text{Stock Issues}}{\text{Demand for Stock Item}}}$$

Factoring Stock Issues, the resulting formula measures how well the model predicts customers' demands (OPNAVINST 4441.12B).

$$\text{COSAL Effectiveness} = \frac{\text{Total Demands For Stocked Items}}{\text{Total Demands For Any Item}}$$

COSAL effectiveness contrasts forecasted demand with actual demand. It is not dependent on stock availability, either locally or system wide. A COSAL inventory model is considered more effective as the total number of demands for stocked items approaches the total number of demands for any item. A ratio of one (an effectiveness of one hundred percent) would mean that any demand for a repair part had been anticipated and identified by the model as a demand for a stock item.

59

Because of budget and space constraints, a COSAL Effectiveness goal of one hundred percent is neither practical nor realistic.

To maximize fleet readiness and effectiveness, an efficient inventory management program must also minimize shipboard inventory levels and costs. Until allocative efficiency has been achieved, improvements to inventory management programs can be made. To measure the efficiency of modifications to shipboard inventory programs, the effectiveness results must be compared before and after implementing of those changes.

B. EARLY COSAL INVENTORY MODELS

This section begins with a discussion of what kinds of repair parts constitute a typical shipboard storeroom inventory and what items are non-storeroom items. How the range and depth of storeroom items are calculated is then addressed, followed by a brief introduction to two of the early inventory models and their mathematical computations - the FLSIP and MODFLSIP inventory models.

1. Shipboard Inventory Allowance Listings

With the requirements for a COSAL established and a method for measuring the effectiveness of that COSAL designed, all that remains is developing a mathematical model to calculate the repair parts inventories to be stocked in the ship's storerooms.

In actuality, shipboard inventories are composed of a variety of items "brought onboard" for different reasons or justifications other than mathematical modeling.

a.   *Consumable and Repairable Repair Parts*

All repair parts can be categorized as either consumables or repairables. Consumables are low cost, low variability items, which are "consumed" after issue, either through use or incorporation into a piece of equipment. As a general rule, consumables are not "repaired" when "broken" but discarded. Typical examples of consumables include transistors, resistors, washers, and packing.

Repairables are usually high cost, complex items, which can be repaired when "broken". Based on the skill level and test equipment required, some repairables can be repaired onboard ship while others can only be repaired at depots ashore. Examples of repairables include circuit cards, some pumps, motors and engines (NAVSUP 553, 1991).

b.   *Storeroom Inventory Composition*

A shipboard inventory allowance listing consists of repair part maintenance items for stocking at both storeroom and non-storeroom locations. For budget analysis purposes, location of the inventory does not impact the financial allocation.

(1) Storeroom inventory items. Shipboard storeroom inventory items are physically located in the ship's

storerooms. For data research purposes, storeroom inventory items will be classified based on their stocking justifications as either Storeroom Items **(SRIs)**, Allowance or Technical Override items **(TORs)** or Area of Interest items **(AOIs)**. **SRIs** are those repair parts which are stocked as inventory, based on the results of a mathematical inventory model. They are designated as either insurance items or demand based items.

TORs are stocked regardless of the model projections as exception items, either because of weapons systems reliability interest, planned maintenance or necessity for the safety or welfare of the ship's crew. Typical **TORs** include Readiness Based Sparing items **(RBS)**, Preventitive Maintenance System items **(PMS)**, and Safety items.

While **RBS** has been categorized as a **TOR**, it is really another mathematical approach for inventory sparing. Briefly, an Operational Availability or A_o goal is established for a weapons system by the weapons system sponsor. Through a marginal analysis allocation model, "the RBS process...provide(s) the range, depth and location of spare parts to support required readiness objectives at the least cost given the reliability and maintainability characteristics of a (specific) system/equipment" (NAVICP-M, 1995). RBS matches spares and readiness objectives to financial constraints.

AOIs items are those items which have been designated, usually by the Hardware Systems Command or engineering actions, as necessary for material readiness and reliability concerns of specified weapons systems. **AOIs** are stocked in accordance with those concerns (SPCCINST 4441.170A).

(2) Non-storeroom inventory items. Typical Non-Storeroom items are: Operating Space Items (**OSI**), Maintenance Assistance Modules (**MAMs**), and Ready Service Spares (**RSS**). **OSIs** are items required by both maintenance and technical personnel to perform maintenance actions. Typically, **OSIs** are items such as special tools and test equipment, located in the work space but designated on the COSAL as part of the ship's parts allowance. **MAMs** are specialized repair parts which act as test equipment, designed to "plug-and-play" to locate and isolate system faults. **RSS** are actual spare parts, physically located in the work space to expedite system repairs.

2. **Requirements of the Inventory Model**

The inventory model used to manage **SRIs** must be able to exclude from consideration any repair part which is beyond the ship's ability to use, either due to its physical size or the ship's lack of technical and maintenance expertise. All repair parts are coded with Source, Maintenance and Recoverability (**SM&R**) codes to identify those items whose maintenance requirements may exceed a specific ship's repair capabilities.

The model must read this code and exclude that item from consideration for the ship's storeroom.

Additionally, the model must determine the appropriate range (variety of different items carried) and depth (quantity of individual items) of shipboard inventory allowances for repair parts. While range is normally dependent on the variety of installed equipment, depth is generally restricted to a Minimum Replacement Unit (MRU). A MRU is the lowest repair element of the equipment's configuration necessary to complete authorized repairs on the equipment to return it to full operational status. MRUs vary based on the complexity and technical specifications of the equipment. For example, a pump might require two o-rings as part of the maintenance process. The two o-rings constitute a single MRU. On the other hand, the electronic technicians may not be authorized to disassemble and repair an electronic circuit card for the ship's radar system, only remove and replace it. That circuit card would be the MRU.

The ship's allowance for identified MRUs also depends on the population of equipment that contain the MRU. In the example of the o-rings, if there are several applications which require those o-rings for maintenance, then an allowance quantity is calculated based on the population of installed o-rings, maintenance schedules, equipment failure rates, average time for resupply, etc.

To support the COSAL's objectives, the Fleet Logistics Support Improvement Program **(FLSIP)** inventory model was developed. The FLSIP model directly relates an item's projected failure or its predicted usage rate to the inventory carried to meet the items's predicted shipboard demand.

3. Threshold Qualifications

The model incorporates into its calculations the repair part's **Usage Rate**, a numerical value representing the predicted demand rate for an individual repair part. Usage rates determine whether a repair part meets minimum "threshold" values to be included in the COSAL's Allowance List. They are calculated using the following formula: (SPCCINST 4441.170A)

$$\text{Usage Rate} = \frac{\text{Population} * \text{Best Replacement Factor}}{4}$$

Population is the number of times that a particular component is installed in any onboard equipment, i.e., how many times a specific item appears in all installed equipment and weapons systems. The Best Replacement Factor **(BRF)** is an exponentially smoothed, annually forecasted replacement rate. It is based on both the initial failure rate data provided by the contractor or manufacturer and annual updates using historical demand data collected through the Material Maintenance Management **(3M)** system for individual components. If the part is a new

item, i.e., it has been in the system for less than two years, then the model uses only the BRF value provided by the contractor or manufacturer. The Navy uses "level only" exponential smoothing techniques for computing and forecasting BRF values. That general format is:

$$New\ BRF = \alpha \times (New\ Avg\ Rate\ of\ Demand) + (1 - \alpha) \times (Old\ BRF)$$

The alpha value is a smoothing weight factor whose value may vary each year based on population size and "BRF trending" (increasing or decreasing). If the demand for an item is trending (NAVICP-M uses an application of the Kendall "s" statistic to determine relevancy of trending), then NAVICP-M uses a four quarter moving average demand rather than exponential smoothing. If no trend is detected or if the trend is less than the threshold value, then NAVICP-M uses an alpha value of 0.10 (NAVSUP 553, 1991). A small alpha value emphasizes previously forecasted demands relative to more recent observations; a larger alpha value places a greater emphasis on the more recent demand observations. Small alpha values provide stable predictions, unaffected by spikes in demand (Ballou, 1992). Both exponential smoothing and moving averages are time sensitive and rely on accurately reported data and proper analysis.

Once the BRF has been calculated, it is multiplied by the **Population** and divided by four to derive the expected usage rate

for a ninety-day endurance period. The resulting **Usage Rate (UR)** becomes a qualifying threshold for including or excluding that repair part from the COSAL's allowance list of repair parts.

4.   **Evolution of Inventory Models**

    a.   *Point 25 FLSIP Inventory Model (.25 FLSIP)*

One of the earliest models developed was referred to as the **.25 FLSIP** model because it set the predicted Usage Rate **(UR)** threshold at one failure in four years to achieve the CNO's stocking level objective of .25. For computational purposes, the threshold is calculated on the basis of one failure in sixteen quarters. This established a threshold value of .0625. **URs** are then divided into three possible outcomes relative to their threshold values: (1) **UR** less than .0625, (2) **UR** greater than or equal to .0625 but less than 1.0000, and (3) **UR** greater than or equal to 1.0000.

    (1)   UR less than .0625. If the usage rate threshold is less than .0625, i.e., the predicted failure rate is less than one in sixteen quarters, then the item is excluded as an allowed **SRI**.[1]

    (2)   UR between .0625 and 1.0000. If the predicted usage rate is greater than or equal to .0625 but less than 1.0000 (four or more failures in four quarters), then the

---

[1]CNO Exclusion Criterion was initially set at .15 demands per year or a UR of .0375. In 1973, to reduce costs, the criterion was changed to .25 demands per year and a UR of .0625 respectively.

item qualifies for further consideration as an **SRI** insurance
item. Insurance items are stocked if they support equipment
vital to the ship's primary mission. In an attempt to qualify
the subjective nature of insurance items, mission criticality
codes (**MCC codes**) were assigned to selected vital equipment.
These codes establish a relationship between the ship's
equipment, mission of the platform and material readiness by
describing the relative importance of various equipment to the
ship's mission. A military essentiality code (**MEC**) describes the
essentiality of an individual part to the end item or equipment.
An item mission essentiality code (**IMEC**) describes the item's
relationship to the mission. If a repair part meets the
threshold requirements for insurance and has the appropriate **MEC**
or **IMEC** codes, then the item is included as a **SRI** insurance item.
The **SRI** insurance item's allowance quantity is one each or one
MRU, if the **MRU** is greater than one. Insurance items based on
these criticality data were designed to increase the ship's
contribution to fleet readiness by raising the COSAL's
effectiveness and improving the shipboard inventory of repair
parts. Without continually validating and updating **MECs** and
IMECs, relative to individual ships, efficiency improvements are
only effective in the short run.

(3) UR equal to or greater than 1.0000. If the
predicted usage rate or threshold value is equal to or greater

68

than 1.0000 (four or more failures in four quarters), then the item is carried as a demand-based **SRI**. The allowance quantity for the demand-based **SRIs** are computed based on their expected level of demand.

Categories of items which are excluded from **UR** criteria include Technical Overrides **(TORs)**, Area of Interest Items **(AOIs)**, and non-storeroom inventory items such as Operating Space Items **(OSIs)**, Maintenance Assistance Modules **(MAMs)**, and Ready Service Spares **(RSS)**.

b. *Modified FLSIP Inventory Model*

The next refinement to the COSAL Allowance List was a modified FLSIP model or **MODFLSIP**. MODFLSIP attempted to improve material readiness by further quantifying the insurance **SRIs** in regards to their IMEC codes with additional qualification criteria. Selected IMEC coded items, items considered "more critical," had to meet a lower predicted **UR** threshold to qualify as an insurance **SRI**. That lower threshold is set at **.1 FLSIP**, one failure in ten years or a .025 usage rate. Their allowance quantity remained one MRU. However, if the item's annual demand is between 2 and 4, then an allowance depth of two is authorized. MODFLSIP maintained the .0625 usage rate and allowance requirements for the remaining "less critical" IMEC codes. All other aspects of the .25 FLSIP model remained unchanged.

C.   POINT FIVE FLSIP PLUS (.5F+) INVENTORY MODEL

1.   Test Platform Considerations

Given the continuing need to reduce both the quantity and cost of inventories while maintaining readiness levels, a revised model was developed beginning in 1991. The goal was to reduce the number of repair parts or NIINs carried by 10 percent and overall inventory costs by 20 percent while maintaining or improving readiness levels.

Approximately every five to seven years the Navy schedules its ships for an Integrated Logistics Overhaul (ILO). As part of that process, a ship's new COSAL is printed with all its reported configuration changes. The current configuration of all the ship's weapons systems, supporting equipment, and storeroom inventories are validated against this new COSAL at the ILO site. If weapons systems are upgraded or replaced, NIINs which are no longer required to support those weapons systems are off loaded. If new weapons systems are added, new inventory items are added to support the new equipment. To minimize the administrative costs associated with changing out shipboard inventories, changes requiring significant on-loading and off-loading of storeroom items are only conducted during a regularly scheduled ILO.

The USS Roberts, FFG-37, had previously been scheduled for an ILO in mid 1991. As part of the preparation for that ILO, a new, updated MODFLSIP COSAL was prepared. The ROBERTS' COSAL was

70

chosen as the platform to test the new inventory model, the Point Five FLSIP Plus .5F+.

2. Evolutionary Structure of the .5F+ Inventory Model

The Navy's Inventory Control Point, Mechanicsburg **(NAVICP-M)** developed the criteria for the .5F+ model. The model began as a **.5 FLSIP (.5F)** model. Based on the results of model simulation, the .5F model evolved into the .5F+ model. The remainder of this section will discuss the criteria for the **.5F** model, compare the results of the **.5F** model to the previous model (MODFLSIP), and using model simulation techniques, evaluate the **.5F's** impact on material readiness. As a result of those simulations, the **.5F+** model was developed. This section continues with a discussion of the data sets used to develop the **"Plus"** portion of the **.5F+**, and concludes with the business rules used to add inventory items to the model. Section D will discuss and evaluate the results of the **.5F+**, comparing it to both the **.5F** and MODFLSIP. That section will conclude with a discussion of the efficiency of the MODFLSIP, **.5F**, and **.5F+** inventory models.

3. Basic Model - Point Five FLSIP (.5F)

The .5F model revised the MODFLSIP threshold criteria from one failure in four years to one failure in two years. Any repair part whose usage rate is less than one in two years, i.e., a usage rate or threshold value less than .125, no longer qualified for stocking as an allowed repair part. If the UR was

greater than .125 but less than 1.0000 and had the appropriate MEC and IMEC codes, then the item qualified as an insurance **SRI**. If the UR was equal to or greater than 1.0000, then the item was stocked as a demand-based **SRI**, with an allowance quantity based on its expected level of demand. Like the .25 FLSIP and MODFLSIP, **TORs, AOIs,** and **OSIs** are excluded for **UR** threshold criteria. The .5F model, like previous models, was designed to reduce only the **SRIs**.

4.   **MODFLSIP as the Working Base Model**

ROBERTS had originally been outfitted with a MODFLSIP COSAL. Using all reported equipment modifications, additions, and deletions, NAVICP-M created a new MODFLSIP COSAL for ROBERTS. This latest COSAL contained approximately 125,000 maintenance significant repair part NIINs installed onboard. From this listing of potential allowance candidates, the MODFLSIP model produced a Stock Number Sequence List or SNSL. The SNSL lists all NIINs that qualify for an allowance and their nomenclature, unit of issue and allowance quantity. The MODFLSIP model reduced the 125,000 potential candidates to 12,045 NIINs.

The results are shown by category in Table I. Quantity onboard amounts represent the range (single count NIINs) and the dollar values represent the depth (sum of the range times their allowance quantities times their MRU times unit price).

72

TABLE I. ROBERTS' MODFLSIP Storeroom Allowances

CATEGORY	QUANTITY ONBOARD	DOLLAR VALUE
AOI	841	$ 124,000
TOR	2,077	$ 2,759,000
SRI	9,127	$ 3,279,000
TOTALS	12,045	$ 6,162,000

Since OSI NIINs are part of COSAL inventory allowance, but not part of storeroom allowances, they are not reported as part of this table. USS Roberts' COSAL authorized 765 OSI NIINs with a net value of $4,237,000. The ROBERTS' MODFLSIP COSAL inventory established a working baseline for comparing any cost savings generated first by the .5F model and later the .5F+ model.

Using the new threshold criteria for the .5F inventory model, a new allowance list was generated. The results of applying the new .5F model criteria to ROBERTS' COSAL are shown in Table II. The number of SRI repair parts allowed under MODFLSIP for ROBERTS was reduced from 9,127 to 5,532, a net change of 3,595 line items. The overall SRI inventory value was also reduced from $3.28 million to $1.04 million for a net cost avoidance of $2.24 million. NIINs which qualified for an allowance under MODFLSIP as AOIs, TORs, or OSIs items also qualified under the .5F model and were not reduced or deleted from the model (Point Paper, 1992).

TABLE II. ROBERTS' .5F Storeroom Allowances

CATEGORY	QUANTITY ONBOARD	DOLLAR VALUE
AOI	841	$ 124,000
TOR	2,077	$ 2,759,000
SRI	5,532	$ 1,037,000
TOTALS	8,450	$ 3,920,000

5. Model Effectiveness Testing

The .5F storeroom inventory was then processed through the Fleet Material Support Office's (FMSO) model simulation program, using the actual demands that ROBERTS had submitted for the previous twelve quarters. Using the same criteria that had been established for Gross Effectiveness, the new percentages were recorded as **Model Effectiveness**. As shown in Table III, if ROBERTS' storerooms contained only those NIINs that qualified under the new .5F threshold values, Gross Effectiveness for the thirty-six month window would have dropped from 56.9 percent

TABLE III. Model Effectiveness - 12 Qtrs,.5F Threshold Only

COSAL INVENTORY MODEL	TOTAL DEMANDS FOR ANY ITEM	TOTAL ISSUES FROM STOREROOM INVENTORIES	MODEL EFFECTIVENESS	STOREROOM INVENTORY COST IN MILLIONS
MODFLSIP	3,743	2,133	56.9 %	$ 6.16
.5 FLSIP	3,743	1,762	47.1 %	$ 3.92

under MODFLSIP to 47.1 percent under .5F. Using Model / Gross Effectiveness as a surrogate measure for material readiness, Table III illustrates that inventory costs had been reduced, but at the expense of material readiness. Using only the last four quarters of data (the normal reporting period for effectiveness measurements) a similar reduction in effectiveness was recorded. As Table IV shows, inventory costs dropped from $6.16 million to $3.92 million and effectiveness was reduced from 61.8% to 41.1%.

TABLE IV. Model Effectiveness - 4 Qtrs, .5F Threshold Only

COSAL INVENTORY MODEL	TOTAL DEMANDS FOR ANY ITEM	TOTAL ISSUES FROM STOREROOM INVENTORIES	MODEL EFFECTIVENESS	STOREROOM INVENTORY COST IN MILLIONS
MODFLSIP	1,765	1,092	61.8 %	$ 6.16
.5 FLSIP	1,765	725	41.1 %	$ 3.92

As both Tables III and IV illustrate, compared to MODFLSIP, whether the .5F inventory model is used for twelve months of demand or thirty-six months of demand, as the number of SRIs and the corresponding cost of inventory decrease, Model Effectiveness as a surrogate measure for readiness also decreases. Increasing the threshold qualification value of ROBERTS' SRIs significantly decreased ROBERTS' material readiness. As Table IV also shows, although the .5F threshold produced $2.24 million in potential savings, readiness decreased 20.7 % over four quarters. To

offset this loss of shipboard material readiness, savings

realized from the smaller .5F storeroom inventory would have to

be re-invested in readiness programs that would directly

contribute to higher shipboard readiness, an investment in

weapons systems reliability improvements sufficient to offset the

20.7 % loss of readiness.

Figure 6 illustrates the results of changing inventory

models and the impact on inventory efficiencies between MODFLSIP

and .5F. In this example CU_M represents the maximum Gross

Effectiveness achievable with MODFLSIP. If ROBERTS MODFLSIP

inventory was technically efficient, then its position along PPF_M

would be represented by point TE_M. If ROBERTS MODFLSIP inventory

was inefficient, then its position would be Operating Point OP_M.

The .5F inventory, with its higher threshold values and

corresponding lower dollar inventory mix, would shift both

ROBERTS' curves to the left, from PPF_M to PPF_F and CU_M to CU_F.

After the shift, ROBERTS inventory could be allocatively

efficient (point AE_F), technically efficient (point TE_F) or

inefficient (point OP_F).

When comparing MODFLSIP to .5F on the basis of Tables III

and IV, no conclusions can be drawn regarding the location of

ROBERTS' operating position with either inventory mix. Using

only the data presented so far, the operating point with MODFLSIP

could be allocatively efficient at AE_M, only technically

76
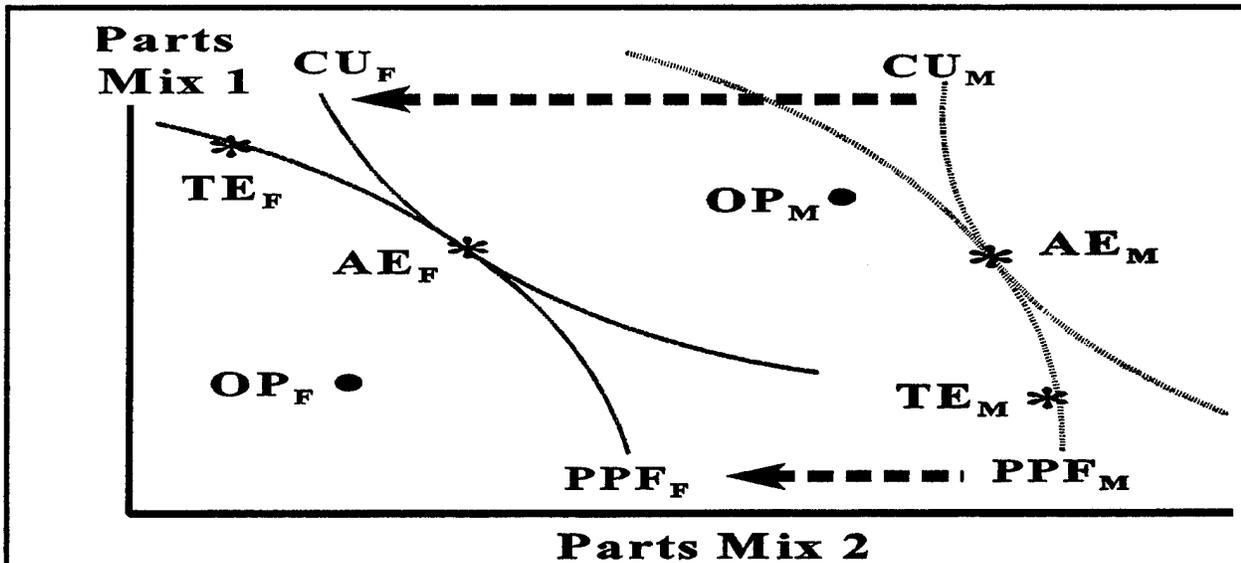
Inventory Efficiency Reduction

AE$_M$ = Allocative Efficiency, MODFLSIP	AE$_F$ = Allocative Efficiency, .5 FLSIP
TE$_M$ = Technical Efficiency, MODFLSIP	TE$_F$ = Technical Efficiency, .5 FLSIP
OP$_M$ = Operating Point, MODFLSIP	OP$_F$ = Operating Point, .5 FLSIP
PPF$_M$ = Production Possibility, MODFLSIP	PPF$_F$ = Production Possibility, .5 FLSIP
CU$_M$ = Consumers Utility, MODFLSIP	CU$_F$ = Consumers Utility, .5 FLSIP

Figure 6. .5 FLSIP Inventory Efficiency

efficient such as at TE$_M$, or neither such as OP$_M$. The same is true with the .5F model and potential operating points AE$_F$, TE$_F$, and OP$_F$. Thus there is no basis for indicating that one model is more efficient than the other.

The drop in effectiveness from MODFLSIP to .5F is expected, given the corresponding drop in inventory investment. If the effectiveness had been unaffected or had even increased with the change from MODFLSIP to .5F, and the inventory investment still dropped, then we could conclude that MODFLSIP was definitely not

77

allocatively efficient and that the .5F was in some sense more efficient. But this did not happen. That neither model obtained 65% Gross Effectiveness also does not provide any information about their allocative or technical efficiency. It could well be that the highest possible effectiveness with the inventory investments of both models (represented by AE_M and AE_F respectively) is less than 65%.

6. Use of Demand-Based Data

Reducing the quantity of **SRIs**, as in the .5F model, clearly lowered ROBERTS shipboard level of material readiness and overall contribution to national security. To increase ROBERTS efficiency, and regain or improve the level of readiness, i.e., move closer towards allocative efficiency, the $2.24 million savings had to be re-invested in fleet readiness. While weapons system reliability improvements are an investment alternative, as previously discussed, they are not the most cost effective.

Another option is improving the effectiveness of the .5F inventory itself. Since Gross Effectiveness is a function of customer demands, by incorporating additional customer demand based **SRIs** NIINs into the .5F model, NIINs not captured by previous models, the .5F inventory would satisfy more customer demands. The more customer demands satisfied by stocked items, the closer the ROBERTS inventory would move towards its allocative efficiency tangency point.

78

One common feature of all previous FLSIP models was that they only used demand data peripherally. Fleet-wide demands were used to annually update BRFs and some SRI insurance item calculations, but neither model used class or ship-type specific demand data as a major input. While the COSAL was hull-tailored to individual ships, the Allowance List was not. NAVICP-M chose to directly incorporate actual demands from similar ship-types into the .5F inventory model as additive data inputs without exponential smoothing. This additive data facilitates the "PLUS" of the .5F+ inventory model. By using specified demand data, NAVICP-M made a paradigm shift to a more customer-oriented approach.

7. Construction of the .5F+ Demand-Based Data Set

To use current demand-based inputs as part of the inventory parameters for ROBERTS's COSAL, a database was designed which grouped the ROBERTS with fourteen similar FFG's. All had been constructed by the same shipyard and had similar equipment and weapons system configurations. This fifteen ship subgroup, or flight, was treated as a separate class of ships. Demand data from all fifteen ships for the previous four years was downloaded from the 3M System database files. This database represented sixty ship-years of data, with a range of 8,769 demand-based NIINs and a net value of $5.15 million. This data file became the .5F+ demand-based data set.

8. Application of .5F+ Demand-Based Data Set

NIINs selected for this group represented potential demand based insurance items. Based on demand levels, they could be added back to specific storerooms as demand based SRIs. Because of budget constraints, business rules for selecting qualifying NIINs from the new database had to be developed. These rules traded budget dollars for frequency of demand. The criterion for selection from this database was established as eight demands in four years across all fifteen ships.

Any allowance candidate whose **UR** failed the .5F threshold criteria was then compared to this newly created demand-based data file. If a NIIN appeared on both the ROBERTS' failed .5F threshold allowance candidate list and the demand-based data set and had experienced a minimum of eight demands in a four year period, then that NIIN was "added-back" to ROBERTS' storeroom inventory allowance creating a .5F+ inventory. Demand could have been registered by one ship, submitting eight requisitions or eight ships submitting a single demand or any combination. Of the 8,769 NIINs available in the data set, 988 NIINs valued at $640,758 were "added-back" to ROBERTS as **SRIs** using the eight demands in four years criteria.

As discussed in Chapter II, casualty reports or CASREPs are one of the major material readiness measurements that the Navy reports to the JCS. A CASREP reports a serious degradation in a

ship's mission capabilities. Because of the impact that CASREPs have on fleet readiness and national security, CASREP demands are coded differently than "normal" demands. Likewise CASREP demands are processed separately, requiring the highest possible visibility. Since CASREPs are so critical, a second demand-based data set was created of only CASREP demands. This CASREP demand database was created using CASREP data submissions recorded in the 3M System files for the previous 24 months from the same flight of ships. Potential SRI add-back candidates for ROBERTS were screened using a different business qualification rule of three CASREP demands in two years. Of the 822 NIINs valued at $2.03 million in this data set, 74 NIINs valued at $344,000 were "added-back" to ROBERTS SRI inventory using the three demands in two years criteria.

D.   MODEL OUTCOME / RESULTS

By "adding-back" to the .5F inventory model those NIINs meeting the eight demands in four years business rule and "adding-back" those CASREP NIINs meeting the three demands in two years rule, the .5F+ inventory model, and a new inventory mix were created. The new inventory mix is listed in Table V. The initial model (MODFLSIP) had required 12,045 NIINs at an overall cost of $6.16 million. The .5F model reduced the storeroom inventory by 3,595 NIINs and $2.24 million at the

TABLE V. ROBERTS .5F+ Storeroom Allowances (With Additions)

CATEGORY	QUANTITY ONBOARD	DOLLAR VALUE
.5F alone	5,532	$ 1,037,000
Demand-Based	998	$ 640,000
CASREP-Based	74	$ 344,000
TOR	2,077	$ 2,759,000
AOI	841	$ 124,000
Total	9,522	$ 4,903,000

expense of readiness. To return the ROBERTS to the same level of effectiveness and readiness, 998 demand-based NIINs and 74 CASREP based NIINs were "added-back" as **SRIs** creating the **.5F+** model. This new model resulted in a net decrease of 2,523 NIINs and a net savings or cost avoidance of $1.26 million relative to the MODFLSIP model.

The new storeroom inventory mix was then processed through FMSO's model simulation program using the last four quarters of data to verify that effectiveness had increased. Those results, as shown in Table VI, compare the MODFLSIP inventory, the **.5F** model (without the demand data set additions) and the **.5F+** model (with the new NIIN additions.)

By adding unique, ship-specific demand-based inventory items, the USS Roberts' Gross Effectiveness for the previous four quarters would have increased by 11.7 %, relative to MODFLSIP, while the investment in ROBERTS' **SRIs** would have decreased by

TABLE VI.   Model Effectiveness - 4 Qtrs, .5F+ Comparison

MODEL	DEMANDS	ISSUES	EFFECTIVENESS	INV COST
MODFLSIP	1,765	1,092	61.8 %	$ 6.16
.5F	1,765	725	41.1 %	$ 3.92
.5F+	1,765	1,298	73.5 %	$ 4.90

$1.26 million. Going beyond the boundaries of the original model and including customer demands, Gross Effectiveness increased by 11.7% and the dollar value of the SRI inventory decreased 20.5%. Using Gross Effectiveness as a surrogate measure for the ROBERTS' contribution to fleet readiness, the .5F+ model increased fleet readiness for fewer dollars. Based on the Gross Effectiveness increase, ROBERTS's .5F+ storeroom inventory is more effective than either the .5F inventory or the MODFLSIP inventory.

As discussed in Chapter II, the Production Possibilities Frontier curve (PPFc) graphically represents all possible combinations of output assuming fixed resources, efficient use of those resources and constant technology, i.e., the PPFc is the optimal mix of goods and services that could be produced from limited resources. Any point along the PPFc is a technically efficient utilization of those resources, assuming the resources are being used wisely with minimal waste. Figure 7 modifies the scope of Chapter II's Technical and Allocative Efficiencies graph (Figure 2). Figure 7 shows that ROBERTS .5F+ inventory is closer to allocative efficiency than the MODFLSIP model. The Goods and

83

Parts Mix 1

Parts Mix 2

.5 FLSIP + Inventory Efficiency

OP$_M$	= Operating Point, MODFLSIP	OP$_F$	= Operating Point, .5 FLSIP
OP$_P$	= Operating Point, .5 FLSIP PLUS	GEC$_{62}$	= Gross Effectiveness Curve 62 %
GEC$_{65}$	= Gross Effectiveness Curve 65 %	GEC$_Y$	= Gross Effectiveness Curve y %
AE$_{62}$	= Allocative Efficiency	AE$_Y$	= Allocative Efficiency
BL$_6$	= Budget Line $ 6.16 Million	BL$_X$	= Budget Line $ x Million
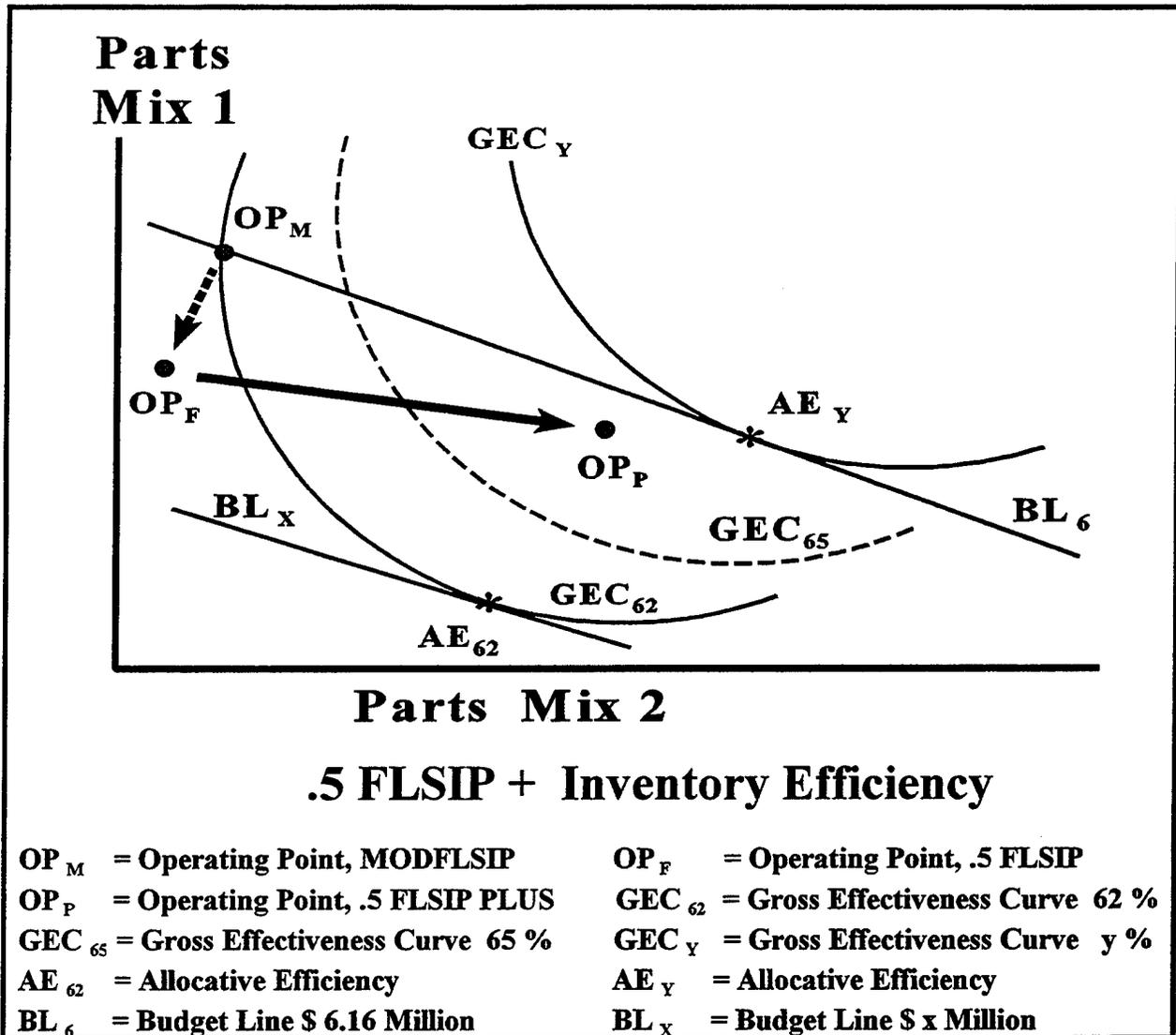
Figure 7. .5 FLSIP PLUS Efficiency

Services axis of Figure 2 have been replaced with different

possible technically efficient storeroom mixes. Consumers'

Utility curves (CUc) are represented by Gross Effectiveness

curves (GEC). Budget Lines (BL) have replaced the PPFc for

comparing the three inventory models, MODFLSIP, .5F and .5F+.

BL$_6$ is the technically efficient allocation of resources for

possible combinations of repair parts within the $6.16 million constraint imposed by MODFLSIP. With BL_6 there is a theoretical allocative efficiency (**AE**) point, AE_Y, which lies at the tangency of BL_6 and a Gross Effectiveness curve, GEC_Y. In other words, given the right mix of inventory, there is an **AE** point for the $6.16 million investment. MODFLSIP was devised to achieve that **AE** point. Using the MODFLSIP mix, ROBERTS Operating Point (OP_M) is actually located at the intersection of BL_6 and the experienced Gross Effectiveness Curve of 62 percent (GEC_{62}). Because higher Gross Effectiveness percentages are possible with the same BL_6, ROBERTS OP_M is not at allocative efficiency. Based on this model, there is a theoretical AE_{62} for GEC_{62}, at an unknown BL_X. However, BL_X is less than $6.16 million. GEC_{65} imposes an additional constraint. Inventory models must also be evaluated on their contribution to material readiness as measured against the standard - 65 % Gross Effectiveness.

From Table VI's data when the .5F model is used, a lower budget line is needed with a corresponding drop in Gross Effectiveness. The .5F established a new, lower OP, OP_F, with both lower **BL** and lower **GEC**. Next, the .5F+ inventory model is processed. Since Gross Effectiveness for .5F+ is greater than either MODFLSIP or .5F, the new OP, OP_P will be located to the right of OP_M. Because **BL** is also less than MODFLSIP, OP_P will be located below BL_6. ROBERTS' .5F+ OP_P is closer to **AE** than

85

MODFLSIP. For ROBERTS the **.5F+** model with its customer based
inputs is closer to achieving allocative efficiency **(AE)** than the
MODFLSIP inventory model.

IV. THE SALINAS VALLEY MEMORIAL HOSPITAL MODEL

This chapter will discuss how a private sector, "not-for-profit," service organization, Salinas Valley Memorial Hospital (**SVMH**) satisfies the needs of its customers through an effective inventory management program. The chapter will begin with a brief outline of the demographics of SVMH and its relationship to the community. It will then discuss SVMH's inventory management policies and procedures. The chapter will conclude with an analysis of SVMH's various measurements of efficiency relative to customer satisfaction.

A. BACKGROUND

1. Organizational Goals

Built in 1953, SVMH is a medium sized, 220 bed, District Hospital located in a mid-size California city with a population of 130,000. Like any other business, SVMH's first objective is financial survival. Only after meeting all expenses can SVMH focus management efforts towards earning a profit. As previously discussed, profit measures a business's success in achieving the business's objectives. Profit could be defined as financial return to investors or a sense of community or governmental service. Profit is the reason the business is in business.

One direct measure that SVMH can use to gauge its overall success and effectiveness, i.e., its profit, is its ability to maintain District Hospital status. Designation as a District Hospital enables SVMH to qualify for special tax status, allowing state discounts for bond rates and other funding advantages. In return, SVMH must demonstrate that financial profits received are reinvested in both facilities and the community. SVMH does this through competitive staff salaries (1200 full time employees and 200 part time employees), facility upgrades, Wellness Centers and other community health care programs (SVMH, 1994).

Additionally, SVMH maintains a fully staffed open heart center and three heart catheter labs (not normally found in hospitals of this size). The hospital's operating guidelines stress continuous quality improvements, financial solvency and community partnership. In support of its mission statement "to improve the health of the people in our District" (SVMH, 1994), SVMH focuses on community preventative medicine through its community-based walk-in clinics.

2. Customer Base

SVMH directly competes with one local county supported hospital as well as several medium sized private and community supported hospitals within a 50-mile radius. SVMH markets its services by advertizing both its medical services and facilities and its relationship to the community. The hospital also uses

88

advertizing to promote goodwill and increase market share. With the closure of Fort Ord and its hospital on the Monterey Peninsula, SVMH's customer base has expanded to include the retired military population.

B.   SVMH'S INVENTORY MANAGEMENT PROGRAM

1.   Consolidated Procurement and Inventory

In 1986 SVMH established the Materials Management Department (MMD) by consolidating several independent departmental purchasing and inventory management functions into a single centralized purchasing and inventory department. In addition to reducing inventory levels through consolidation, SVMH reduced personnel in functional duplication of inventory and procurement, increased employee productivity and increased inventory availability.

Prior to consolidation, each department was responsible for procuring, warehousing, inventorying and reordering its own supplies. Besides the lack of coordination between departments, the inventory function was the responsibility of medical professionals who were not inventory specialists. In some extreme cases the responsible department head was also the major procurement agent. All the other functional aspects of inventory management were likewise disjointed. After consolidation, the medical professionals were able to devote more time to their

primary health care duties within their departments. MMD employs a smaller, dedicated support staff to perform the same inventory and procurement functions, relying on a staff of ten: two buyers, five warehousemen, a mail/courier clerk, a secretary and the director. Similarly sized facilities normally require larger staffs to perform the same tasks.

Consolidation also allowed MMD to provide a higher level of coordinated support through visibility and control of its medical inventory. The newly created department has control over all facets of inventory, from establishing and maintaining inventory levels to procurement, receipt, warehousing and distribution.

2. Budget and Expenditures

SVMH's entire budget for FY 1996 is approximately $105 million in revenues and $100 million in expenses. FY 1996's budget includes a seven percent reduction from FY 1995's budget. MMD's budget, based on historical projections, is 25 percent of total expenses or $25 million. Of that amount, MMD budgets seventeen million dollars for direct inventory procurement – eight million dollars for demand-based consumable medical supplies and nine million dollars for non-stocked, direct turnover items to their customers. MMD replenishes its demand-based inventory on an "as-needed" basis while its direct turnover items are procured on a one-for-one requested basis. MMD also has a contingency fund of one million dollars for unplanned and

unanticipated procurements. The remaining seven million dollars is divided among planned capital expenditures, service agreements, and salaries (Church, 1995).

3. Departmental Scope

MMD is the centralized purchasing agent for 72 of the hospital's 75 departments and divisions, procuring all equipments and supplies used by those departments and divisions. MMD also maintains a demand-based inventory warehouse for approximately 1200 different line items. To assist MMD in managing, tracking, locating and re-supplying their inventory warehouse, MMD uses a networked, PC-based software inventory program, the Enterprise Inventory Control System called NOVA.

4. Inventory Warehousing and Accountability

MMD does not manage any major corrective maintenance items nor any repairable items. In part due to the hospital's west coast location, SVMH has ready accessibility to all major equipment suppliers. Other than minor preventative maintenance and trouble shooting actions, all corrective maintenance is covered by an extensive equipment warranty system.

a. *Wholesale and Retail Inventory*

MMD's demand-based consumable inventory experiences an average once-a-month stock turn. Some fast moving items, such as intravenous or IV solutions, may turn over twice a week. To account for all the inventory, MMD maintains two levels of

inventory – a wholesale level located in the warehouse adjacent to the hospital and a second consumer retail level on the hospital ward or floor. The ward or floor inventory acts as "ready-issue" inventory and the wholesale as "back-up." Approximately 15% of the inventory is located in the hospital as "ready-issue;" the balance is in the warehouse.

b. Sales

Once a stock item has been transferred to "ready-issue" it is then tracked as a "sale." To maintain inventory accuracy and ensure timely resupply and reorder, all "ready-issue" materials are inventoried daily (Church, 1995). By comparing daily inventory records MMD can measure actual usage, validate demand, and prevent inadvertent shortages. Additionally, the inventory records provides MMD with indirect feedback information regarding changing demand patterns.

c. Issues

Ready-issue resupply is not done by exchange cart system but rather through departmental requisitioning. A recent General Accounting Office (**GAO**) report on DOD's medical inventory system found that four of the eight military health care facilities used an exchange cart system. Under this system, a warehouse cart is loaded with the most commonly needed supplies, taken to the hospital floor and "exchanged" for the floor cart. The floor cart is then returned to the warehouse and restocked

for future use. In addition to the investment in carts, this system can also duplicate inventory requirements (GAO/NSIAD-92-58). Instead, MMD offers its customers a catalog listing all the items stocked in its warehouse.

d.   Monitoring

As customers order items, MMD tracks each "sale," developing departmental trends. After tracking orders for approximately ninety days, MMD creates a customized requisition order sheet for each department based on that department's historical demand. MMD offers its customers the option of weekly or monthly requisition sheet updates. Infrequently used items are annotated on the requisition sheet and tracked for possible inclusion at a later date. Non-stocked items are requisitioned separately. A monthly billing summary copy of all transactions and dollar totals expended is sent to each department. The original is sent to SVMH's accounting department for posting and actual budget decrement. Both SVMH and the cognizant department directors can monitor individual departmental spending patterns and performance objectives.

e.   Inventory Count and Reconciliation

While ready-issue materials are inventoried daily, a wall-to-wall physical inventory of all inventory including warehouse stock is counted annually at the end of the fiscal year. That count is then reconciled with the "book" inventory.

The variances between inventory losses and gains as a result of this reconciliation have been historically less than one to one and one-half percent per year. MMD also conducts periodic spot inventory counts, setting parameters such as high dollar value, high volume, high turnover rates or random location validations throughout the year.

5. **Non-participants in the MMD Concept**

However, MMD does not manage or monitor all of SVMH's inventory. Three departments currently do not fully participate: Dietary (food service), Pharmacy, and Engineering (facilities and medical). These departments warehouse, inventory, and manage their own supplies as well as retain some of their own purchasing authority. As a result, MMD lacks visibility of those unique departmental line items, their inventory location, their usage rate, and their on-hand inventory (Church, 1995).

6. **Value of Total Inventory Management Consolidation**

Would consolidating those three remaining departments improve SVMH's overall efficiency? Research by the RAND Corporation shows that while some major companies are consolidated, such as Johnson & Johnson and Microsoft, they are successful because they are really many small, independent units. Some of the operations have consolidated; others have become "closely integrated." The key, according to RAND, is to have the corporate purchasing department (MMD for SVMH) negotiate the most

94

favorable contracts for all departments (Brauner, 1993). SVMH's overall efficiency is reduced since its three non-aligned departments (Dietary, Pharmacy, and Engineering) are currently negotiating on the open market their own short range contracts for supplies and other related services without benefit of MMD's experience, contacts, or expertise.

a.   *Consolidating the Pharmacy Department*

Pharmacy could improve its efficiency by using a MMD negotiated **"Prime Vendor"** (**PV**) style contract. **"Prime Vendor"** is a "stock less" inventory system where the vendor warehouses the inventory, delivering only a two to four days supply at a time. A recent GAO study for the period Sept 1990 through Sept 1991 showed that dramatic reductions in inventory and associated cost savings were possible through the "Prime Vendor" concept. Army Health Services Command reported to GAO the results of their nine month test during 1991 of direct delivery of Intravenous (IV) solutions. Stocked inventory levels of IV solutions decreased by 75 percent, from $290,000 to $73,000 (GAO/NSIAD-92-58).

DOD initiated the "Prime Vendor Program" (**PVP**) in January 1993 by dividing the nation into 22 regions. Each region awarded two PV contracts - one for pharmaceuticals and one for medical supplies. As part of the Defense Personnel Support Center (DPSC) PV contract, all PVP suppliers must provide a 24 hour delivery response time after receiving the order with a 95

percent effectiveness level (DPSC, 1993). Using PVP, DOD has reduced pharmaceutical inventories at a typical Medical Treatment Facility from a two to four week supply located at the Pharmacy department and a three to six month supply at the warehouse (Capano, 1994).

For example, in 1993 the Naval Hospital at Twenty-Nine Palms, CA implemented a PVP contract for their Pharmacy department. The hospital reduced their four week supply of 275 pharmaceutical line items in the warehouse and their one week supply in the Pharmacy to a single week's supply in the Pharmacy. In addition to eliminating 100 percent of their pharmaceuticals from the warehouse, the hospital also reduced their overall pharmaceuticals by 80 percent (Gaither, 1995). The Bureau of Medicine and Surgery's (**BUMED**) recent publication, "Customer Activity Standard Operating Procedures (SOP) Guide," illustrates a sample anticipated inventory reduction from a previous high limit of 60 cases to a PVP inventory of six cases, an overall potential inventory reduction of 84 to 90 percent (BUMED, 1993).

The DOD's PVP goals for reducing inventories, labor, cost, and loss due to expired shelf life, and for deliveries in twenty-four hours or less have all been achieved (Capano, 1994). With MMD acting as the contracting agent for Pharmacy, a Prime Vendor type contract for pharmaceuticals could be established.

The Pharmacy Department should expect to experience similar reductions and savings as DOD.

b. Consolidating the Remaining Departments

The other two departments should also have MMD function as their corporate purchasing agent. However, because their operations are sufficiently distinct from both MMD and each other, their inventory and warehousing functions should not be consolidated into MMD. Those departments can use some of MMD's inventory software capabilities in establishing, tracking and monitoring departmental inventory as well as establishing their own Re-Order Points (ROPs) and reorder recommendations.

Just-in-Time (JIT) inventory concepts could also reduce costs for SVMH's Dietary department. Likewise, Engineering activities would benefit from using MMD as contractor for their supplies and service agreements on equipment maintenance. The visibility that NOVA provides for both inventory locations and usage rates could reduce inventory inefficiencies for these departments as well, inefficiencies caused by losses through misplacement and inappropriate reorder level settings.

C. INVENTORY MODEL

1. Range and Depth Considerations

When MMD was first started, all pre-existing inventory was relocated to a single warehouse for management and distribution.

As both technology and customers' requirements changed over time, new items were added and old items discarded from the inventory. To remain competitive and satisfy customers expectations, innovative techniques had to be developed and implemented.

For example, when deciding which new items should be carried as warehouse stock, careful evaluations were made of several diverse and competing factors - factors such as size, weight, cube, minimum order quantities, expected demand and availability of stock to name a few. However, the most important element is satisfying the customers' requirements. MMD initiated an open dialogue policy which encourages all internal customers to meet with MMD, suggesting which items MMD should stock to best satisfy the customers' individual requirements. If a customer specifies a particular brand name or product type, then that customer must take "ownership" of that item, that is, the customer assumes responsibility for providing MMD justification why only that brand name or product type will satisfy the customer's requirements. Additionally, the "owner" provides MMD with projected demand rates for establishing stocking levels.

One of MMD's roles in this dialogue process is to offer to the customer substitute or alternative inventory possibilities and their associated cost benefits. The customers provide informed input to MMD regarding their choices of items that best meets their needs. Since there is no previous demand history for these new items, the customer must also estimate the anticipated

monthly usage rate. That information, along with cost per unit, minimum order requirements, and physical size determine the initial order quantity.

2. **Enterprise Inventory Control System - NOVA**

a. *Order Recommendations*

Once the decision has been made to stock a new demand-based item, all relevant data is entered into MMD's inventory management program, NOVA. NOVA assists MMD in its inventory management decisions by providing current, real-time data. All procurements, receipts, issues, and inventory counts are also entered into NOVA's on-line, inventory program. Using a continuous transaction review process, NOVA establishes Reorder Points (**ROPs**) based on previous receipts and issues, making inventory ordering recommendations.

MMD uses the type of periodic review system known as the **T,R,M** or the **T,R,RO** System. Under this system, inventory levels are reviewed at specified periods of time **(T)**. If an item's inventory level is below its reorder point **(R)**, then the item is reordered to its maximum level **(M)** or its requisitioning objective **(RO)**. If the inventory level at time of review is greater than the reorder point, no reorder is recommended (NAVSUP Publication 553). MMD may override the reorder recommendation or modify the quantity recommended based on vendor minimum order quantities or vendor minimum price per order restrictions. For

99

new items, NOVA requires a minimum of ninety days historical demand data before establishing either initial ROPs or stocking levels. During that interim period, the customer's input helps to determine the initial ROP. The initial ROP incorporates the lead time of previous orders for similar items from the same or similar vendors. NOVA's recommendation for an order or reorder quantity incorporates demand during lead time, the expected quantity needed for issue while awaiting receipt of the order.

NOVA generates an electronic reorder using MMD inputted vendor sources and their negotiated prices. Since all orders are electronic, the average order confirmation time from data input to order acknowledgment is sixty minutes or less. For reordering purposes, administrative lead time is considered negligible (Church, 1995).

b. Price Variability Reductions

Price variability has been reduced for SVMH because MMD uses negotiated, stabilized (firm, fixed) prices. Prices are guaranteed from a period of twelve months to thirty-six months. MMD also uses National Buying Agreements for price comparisons. With MMD using multiple vendors, they can take advantage of buyers' leverage. If there are major changes in prices, MMD has the option of renegotiating the agreement to take advantage of any economic adjustments. Because of sales volume, MMD has successfully negotiated away freight charges.

MMD does not use the **"Prime Vendor"** concept for their demand-based warehoused consumable inventory items. Unlike Pharmacy, inventory shelf life expiration is not a critical factor for MMD's warehousing consideration. This allows MMD's director to deal directly with several competing suppliers. He feels that a "Prime Vendor" contract would make his organization too dependent on a single vendor, which reduces customer service. The improved customer service derived from competition among several vendors offsets slight increases in inventory cost. When deciding which vendor should receive a contract, key factors are the vendor's responsiveness to meeting SVMH's needs and the vendor's customer service (Church, 1995).

c. Re-ordering Process

While MMD maintains override capability for model quantity reorder recommendations, they usually reorder the quantities NOVA recommends. SVMH's typical quantity overrides include the Christmas – New Years and Cinco de Mayo holiday periods. NOVA does not include any holding costs or warehouse costs in its ROP calculations or its quantity reorders. As part of the reorder recommendations, NOVA displays as many as three possible vendors and the prices for each item. Once the reorder has been queued and accepted by MMD, it is then transmitted to the vendor or vendors via modem through Electronic Data Interchange (EDI).

d. Additional Variability Reductions

To further minimize cost, MMD focuses on reducing variability. Reducing the variability or the uncertainty of an environment increases the productivity and cost savings potential. For example, inventory helps "cover" the uncertainty of unanticipated demands. If the demand was known exactly, then the inventory level would be set to meet that demand plus the time waiting for resupply. No buffer or safety stock would be required. Reducing variability in other situations would further increase productivity and reduce cost.

(1) Requisitioning via Electronic Media. By using EDI as an automated ordering system, MMD reduces variability for manifested supplies. Typically, in less than an hour, MMD confirms their order and learns which items are being shipped and which are back ordered. The MMD buyer can delete the back ordered items from the original vendor and reordering them from a different vendor using the same reorder que.

(2) Scheduling and Workload Planning. MMD further reduces variability by scheduling receipt of all freight deliveries for selected days of the week. MMD also schedules customer deliveries for warehouse issues. Emergencies are handled on an "as required" basis. By scheduling both supplier deliveries and customer issues MMD can efficiently plan and manage personnel resources and balance employee workloads.

(3) Standardization. One outcome of MMD's coordination with customers regarding inventory selection and retention is MMD's ability to standardize inventory. Standardization helps consolidate similar or like items, reducing the number of line items stocked. It also reduces overall inventory since safety levels can be "shared" by similarly demanded items.

By having visibility of materials being used by other departments, MMD can offer those same items as substitutes for brand name items. Unless there is a clear, distinctive clinical advantage for only using a specific item or brand, product evaluation has already been accomplished by other users.

e. *Receipt Fill-Rate*

SVMH consistently receives a 98 - 99% fill rate from their main vendor, and next day, twice-a-week delivery service. When the shipment arrives, MMD has already made storage location assignments, using its electronically transmitted confirmation of the manifest. All of SVMH's major suppliers are located in either San Jose or San Francisco. The normal transportation lead time for any order is next-day delivery. If a critically required item is not available locally and cannot be delivered within twenty-four hours, the vendor locates the item and arranges for Federal Express shipment (Church, 1995).

f. Management Reports

The NOVA inventory program provides a variety of management reports, including obsolete inventory reports (no demand in three months / six months). For example, using the obsolete inventory report, MMD periodically reviews why demand has declined with the primary user or "owner." Together, MMD and the "owner" determine whether the item should continue to be stocked or its inventory level adjusted. If the item is no longer required and its shelf life has not expired, MMD can usually return the slow-moving merchandise directly to the vendor for full credit, minimizing obsolescence and disposal costs. NOVA also produces trend analysis reports to further evaluate stocking positions and inventory levels.

D. SVMH'S MEASUREMENTS OF EFFICIENCY

DOD uses Gross, Net, and COSAL Effectiveness percentages to approximate the .5F+ model's level of customer satisfaction. SVMH, on the other hand, has no precise mathematical formula to directly measure the satisfaction of its internal and external customers. SVMH could use exit survey forms and aftercare surveys to measure their external customers' satisfaction. This data, coupled with a corresponding increase or decrease in hospital admissions could indicate a level of customer satisfaction.

SVMH could indirectly measure MMD's ability to satisfy MMD's internal customers by evaluating feedback received from the various departmental directors. MMD can likewise measure its own performance through similar customer satisfaction surveys. Since MMD is budget constrained, MMD's level of customer service or satisfaction could be based solely on achieving budgeted performance goals or contributing to organizational solvency. As a not-for-profit service organization, the tendency is for management to focus on the organization's ability to contain costs and meet established budget goals as the primary method of evaluating the organization's overall performance (Digman, 1995).

However, SVMH's focus is stated in their Mission Statement and Operating Guidelines: maximizing the quality of health care service provided to the people of Salinas. Therefore, SVMH uses measurements which link the performance of MMD to levels of customer service provided rather than cost cutting. In addition to feedback from their customers, there are three quantitative indicators that SVMH can use to evaluate MMD's customer satisfaction. Those indicators are: (1) Inventory Stockpiling by customers, (2) Vendor resupply fill-rate and (3) Stock turn.

1. **Inventory Stockpiling.**

Whenever customers lack confidence in their supplier's ability to fill their requirements in a timely fashion, customers seek alternative methods to insure that their needs are met. One

105

form of insurance is "stockpiling," ordering and storing

inventory in excess of anticipated normal usage. Not only does

"stockpiling" increase inventory costs, it also masks poor

management practices. Through "stockpiling," customers create

their own mini-storage locations. Inventory is reordered by the

customer to resupply these mini-storage locations based on the

customer's available funds rather than meeting the customer's

actual demands.

In a typical example, the customer loses confidence in the

resupply system and begins to build a insurance "stockpile." The

initial quantities that the customer orders would be based on

available funding and not necessarily be related to the

customer's current usage patterns. Under a demand-based system,

the inventory manager would record the higher demand patterns and

increase the stocking levels to support that higher demand. With

a limited budget, the inventory manager would not order slower

moving inventory to support this higher level of "false demand."

When the customer believed that the level of "insurance"

stockpile was sufficiently large, the orders would cease. As the

customer began to use the "stockpile," reorders may or may not be

submitted. The customer could decide to "stockpile" a different

commodity and stop reordering the first item. The inventory

manager would now detect zero demand and could either allow the

on-hand inventory level to drop based on low experienced demand

patterns or delete that product line altogether. When the

106

customer finally resubmitted reorders, there would not be sufficient inventory to support the request, directly contributing to stock outs and further eroding the customer's confidence in the resupply system.

During a recent external audit of SVMH, little evidence was found of any hidden, "stockpiled" inventory. This lack of stockpiling indicates that both employees and supervisors have a high degree of confidence in MMD's ability to provide them with their requirements when needed (Church, 1995). Customers do not feel the need to maintain their own "insurance" inventory. This indicates that MMD is satisfying the majority of their internal customers' consumable medical supply requirements. Whenever MMD can satisfy the demands of their internal customers (the hospital staff), SVMH can better meet its mission objective, improving the health demands of its external customers (the patients).

2. **Vendor Resupply Fill-Rate.**

The second indicator of MMD's customer satisfaction is MMD's inventory resupply fill-rate. Normally, a stock resupply fill-rate indicates how well a vendor is meeting its customers demands. In SVMH's case, MMD is both the vendor's customer and hospital's supplier. Since MMD's inventory stocking policy is entirely driven by customers' interaction and demands, MMD's customer satisfaction levels can be measured by MMD's ability to resupply these internal customers.

As stated earlier, MMD receives a vendor resupply fill-rate of 98 - 99%. Because of the variety of features built into the NOVA program and MMD's aggressive utilization of those features, MMD can offer that same fill rate directly to its customers. By receiving a high fill-rate from its suppliers, MMD is able to invest fewer dollars in its inventory of fast movers and invest more dollars in its inventory of slow moving critical items as well as bulky, high transportation cost items. The high vendor stock resupply rate that MMD receives provides a greater flexibility in determining MMD's optimal inventory mix.

3. Stock Turn.

A third indicator of MMD's level of customer satisfaction is their average monthly inventory stock turn. Although MMD does not have a formal issue-to-demand formula, such as the COSAL's Net and Gross Effectiveness measurements, MMD can approximate those measurement through stock turn. Stock turn ratios can approximate more formal, in-depth customer satisfaction measurements.

The primary purpose of any inventory mix is to satisfy customers' demands. Inventory can also be used as an insurance policy to satisfy demands while waiting for receipt of stock, act as a buffer to offset unexpected events such as weather, strikes, and other delays in shipment, and reduce procurement costs through bulk purchases.

As customers' "buy" stocked items, MMD replenishes its inventory. Fast moving items are replenished more often than slow moving items. The ratio of total sales or issues to the dollar value of all inventory carried to is stock turn and is measured as "low stock turn" or "high stock turn." Stock turn can be used to measure the efficiency of the entire inventory investment subject to budget constraints. MMD operates with a fixed annual budget of eight million dollars for inventory.

a. Low Stock Turn

Low stock turn indicates that the customer is not "buying" the stocked inventory in amounts proportional to the inventory investment. The inventory investment may be too large relative to customer demands. The inventory mix may be wrong (MMD's inventory is not aligned with the customer's requirements resulting in "dead stock" - inventory that remains unsold and is eventually disposed) or the inventory mix does not meet the customer's current requirements in range or depth. If MMD invests too much in items which the customer does not want and has insufficient funds remaining to invest in the items the customer does want (range and depth), stock turn may be low.

A low stock turn can also result from reordering an insufficient quantity to meet customers' current demands (depth) or not reordering issued parts in a timely fashion. If the right mix of parts are stocked, ordered in a sufficient quantity and on

109

time, then the customers' demands might not be met because of a low vendor fill rate. If MMD consistently receives a low fill rate from its suppliers on selected critical items, MMD might invest more in those items as "insurance," requiring a larger safety stock for those items and have less funds available to satisfy other customer needs. Therefore, a low stock turn rate can indicate either stocking the wrong inventory mix (wrong items, insufficient range, or depth) relative to customer demands or receiving a low vendor resupply fill-rate, and hence poor customer service. However, for some situations a low stock turn rate may be ideal, particularly if the inventory mix includes many high-valued critical items with erratic demand patterns.

b. High Stock Turn

High stock turn could indicate that the customer is "buying" the stocked inventory in amounts proportional to the inventory investment, i.e., the inventory appears to satisfy the customers' needs. On the other hand, the inventory investment may be too small relative to customer demands, requiring constant re-ordering to satisfy customers. High stock turn would be inefficient if the inventory ordering costs were greater than the inventory holding costs. An inventory mix that did not meet the customer's current requirements in range or depth could have a high stock turn if MMD invested in selected "fast movers" which the majority of customers needed. The sales from the fast movers

110

relative to inventory levels would mask "dead stock". If the right mix of parts are stocked, ordered in a sufficient quantity and on time, and the vendor is providing a high fill rate, then a high stock turn is more likely.

c. Results of MMD's Stock Turn

While a few inventory items can make overall stock turn appear higher or lower, inventory budget constraints relative to stock turn allows overall stock turn to be used as a quasi-service indicator. MMD averages a complete inventory stock turn of all items once every month with fast movers turning more often. Relative to MMD's budget, SVMH considers MMD's stock turn to be high.

4. Efficiency Measurement Conclusions

Using MMD's three quantitative indicators, lack of inventory stockpiling, high vendor resupply fill rates and adequate stock turn, indicate that MMD is providing their customers with a high level of customer satisfaction. Based on these measurements, coupled with positive feedback reports from customers, MMD's inventory management operations appear to be technically efficient and in close proximity to its allocatively efficient tangency point.

111

V. COMPARISONS BETWEEN DON AND SVMH

This chapter will begin with a brief discussion of the different types of business organizations and the appropriate category for the Department of Defense (**DOD**), Department of the Navy (**DON**) and Salinas Valley Memorial Hospital (**SVMH**). Although the missions, goals and objectives for DON and SVMH are different, it is useful to compare their relative success in meeting those goals and objectives. The chapter will compare DON and SVMH's relative efficiency in managing their inventory and setting inventory requirements.

A.   FOR-PROFIT AND NOT-FOR-PROFIT (NFP) ORGANIZATIONS

From a business perspective, organizations can be classified by their market sector (private or public), by their production output, and by their profit motivation. Private sector organizations depend upon revenues generated from their limited customer base; financial support for public sector organizations, such as the federal, state, and local governments, depends on tax generated revenues. While private sector organizations provide a variety of goods and services, public sector organizations usually provide services necessary for the safety, security, and welfare of the entire population.

113

All organizations engage in production - creating goods and services by transforming input resources (raw materials, cash, capital, labor) into output resources. Production output may be a tangible product, such as manufactured goods, or it may intangible, such as transportation, education, customer service or a sense of national security. Organizations which produce tangible goods are commonly referred to as manufacturers; producers of intangible products are usually referred to as service organizations (Heizer, 1993).

Organizations are also classified based on their structure relative to profit motivation as either for-profit or not-for-profit (**NFP**). How an organization structures itself towards achieving its "profit" may influence management decisions in all areas of strategic planning, including diagnostics, formulation, implementation and evaluation. Structure also determines the metrics that the organization uses to measure its effectiveness in mission accomplishment as well as its overall efficiency.

1. Need to Study Not-For-Profit (NFP) Organizations

While DON and SVMH differ in their market sector (public and private), both may be classified as **NFP**, service organizations. Understanding the similarities and differences between for-profits and **NFP**s will assist not only in comparing DON to SVMH, it will also illustrate methods and processes that **NFP**s can adopt from the for-profits.

114

The objective of any organization, whether public or private, manufacturer or service, for-profit or not-for-profit (**NFP**), is economic survival - meeting all expenses. Only after all the organization's expenses have been satisfied, can the firm engage in "profit-seeking." As previously stated, "profit" is defined as the reason the firm is in existence, its purpose. The most apparent distinction between for-profits and private **NFPs** is their tax status, as defined by the US Tax Code. Lester Digman, in his book "Strategic Management: Concepts, Processes, Decisions," makes additional distinctions, including mission, economic constraints, and environmental differences. Digman concludes that while there may be differences in strategic content between the for-profits and the NFPs, there are many similarities in their strategic processes. Digman categorizes **NFP** organizations into four basic types: publicly funded (which includes government); institutions (including hospitals and schools); "third sector organizations" (such as research institutes); and "fourth sector organizations," publicly chartered for-profit firms such as AMTRAK (Digman, 1995).

2.   General Characteristics of NFPs

Based on Norman Waks studies for the MITRE Corporation, **NFPs** appear to primarily provide services, rather than produce goods. Most business that manufacture goods for sale are for-profit businesses. Waks concludes that, as a group, **NFPs** tend to be

more "service oriented and people based, rather than product oriented and capital-equipment based" (Digman, 1995). Some organizations, such as hospitals, can be either for-profit or NFP, and still be classified as a service organization.

    3.   Reasons for Operating as a NFP.

    Digman lists four reasons why a business would choose to operate as a NFP enterprise, rather than a for-profit enterprise. In Digman's context, profit refers to the distribution of income or personal financial gain to individual or individuals other than through salaries or bonuses. Those reasons are:

1. *Cannot make profits*. By law or regulation, due to the nature of the services provided, these organizations must be **NFP**. Examples of this type organization would include most publicly funded governmental agencies, such as DOD and DON.

2. *Should not make profits*. These organizations are allowed to make a profit but "are involved in activities here it is considered improper to do so." Examples of this organizational type would include most institutions such as hospitals and colleges.

3. *Should make but not retain profits*. These organizations try to earn as much profit as possible, not for retention, but for further distribution. Examples of this type of organization would include most charitable institutions.

4. *Optional NFP*. These are organizations that can make and retain profits, but their management believes that they can best accomplish their mission by remaining **NFP**. Examples of this type of NFP would include many third sector organizations, such as research institutes and educational facilities.

4. Differences Between For-Profits and NFPs

a. Goals and Objectives

The major difference between for-profits and NFPs is the firms' missions, goals, and objectives. Unlike for-profits, NFPs fill gaps or voids in services which the for-profits are either unable or unwilling to profitably provide. For example, the largest NFP organization, the federal government, provides national security. In a for-profit firm, financial profit is a basic consideration for setting goals and objectives. Firms usually evaluate programs based on their contribution to profit margin, potential market share and return-on-investment ratios.

The primary goal of the NFP is non-economic. Digman's studies show that NFPs focus on "improving the quality and coverage of their service,...containing costs within budget, and increasing their budget" (Digman, 1995). The goals and objectives of most public NFP organizations have either been established by mandate or by groups external to the organization, with little or no input from the members of the organization.

b. Managerial Control

For-profit firms tend to be organized along structures which are the most conducive to achieving and maintaining their competitive advantage. Their internal policies and controls are both self-imposed and self-administered.

117

For most public **NFP** firms, their organizational
structure, hiring and firing practices, and many of their
operating policies and procedures may be dictated from outside
the organization itself. The influence of these outside
stakeholders (those individuals outside the organization who
maintain an interest or control the organization's operations) in
all phases of management and decision making is much greater in
these **NFPs** than the for-profits. Public **NFP** stakeholders include
taxpayers, Congress, interest groups, unions, other governments,
etc. Non governmental **NFP** stakeholders include users (patients,
clients, customers), board of directors, unions, contributors,
other **NFPs**, etc. "The key to success (for **NFPs**) is the
satisfaction of key stakeholders" (Bryson, 1988). To be
successful, for-profits must also pay careful attention to the
customers needs and demands.

c.   *Measurements of Success*

In a for-profit organization the market's economic laws
of supply and demand communicate the customers' desires. The
for-profit organization measures success in correctly and
expeditiously satisfying the customers' needs and expectations
through sales, market share, and profit data. For-profits have a
variety of financial performance measures to capture the
relationship between input and successful production output.
For-profits measure such information as income-to-revenue (sales)

ratios, return-on-investment ratio, sales-volume variances, etc. In **NFP**s such as DOD no such direct correlation exists.

If a for-profit organization is not responsive to changes in the marketplace, that information is quickly and directly communicated to the firm by a drop in sales. In response to those market changes, the successful firm adjusts its strategic and tactical management decisions. These adjustments could involve changes in product design, technological changes in production process, layout and location, etc. To survive and make a profit, the firm must become more efficient, effective and responsive.

Since most **NFP**s produce services, which are not typically bought and sold in a traditional competitive market, efficiency and effectiveness relative to financial input is often more difficult to assess. For example, DOD's service output is an intangible sense of national security. Relating DOD's output to its input or budget appropriations is interpretive at best. If the external **NFP** stakeholders perceive that the organization is not adequately meeting the needs of its customers, they can often directly influence or even override the organization's policies and procedures, reduce the organization's budget, or initiate other adjustments.

Unlike for-profits, most **NFP**s have no "profit centers" but rather "cost centers." "Profit centers" can measure the

success of inputs to outputs as "profit" and reward their employees accordingly. The focus of a "cost center" is budget and expenses. Since savings and cost avoidance are easier to measure than improvements in service, there is a tendency to reward cost cutting and pay salaries independent of the results of input to output. As a result of this weak reward system, **NFP** managers tend to be more "risk adverse," not wishing to jeopardize or antagonize their external stakeholders.

5. Relationship Between For-Profits and NFPs

While for-profits and **NFPs** have different missions, goals and objectives, different motivations, different organizational and managerial structures, and different measurements of success, to remain successful and retain their competitive advantages, each must operate as efficiently as possible. John Byrne of *Business Week* magazine quotes John R. Garrison, president of the National Easter Seal Society, regarding the need to run **NFPs** more business-like: "But almost everyone now realizes that commitment isn't enough anymore. You also have to have professionalism, or you're going to go out of business" (Byrne, 1990).

In an environment where customer service and satisfaction is the essence of a successful organization, unless for-profits and **NFPs** meet their customers' needs and expectations by operating in an efficient, business-like fashion, they must suffer the consequences - loss of customer support. For SVMH, loss of

120

support means SVMH will not survive; for DOD, loss of support means even greater influence, more direct control by outside stakeholders, or perhaps reduced investment in national defense.

B. DON'S AND SVMH'S MISSIONS AND OBJECTIVES

1. DON's Mission and Objectives.

DOD's mission might be simply stated as maximizing DOD's readiness to counter any threat to national security within its budget constraints. As part of DOD, DON would share that mission, contributing the "Navy's portion" of readiness to national security. To accomplish this goal, DON should develop business-like logistic support strategies which meet their customers' demands as efficiently as practicable within existing budget constraints. Over time, DON should continuously improve the manner in which they meet those demands.

2. SVMH's Mission and Objectives.

Like DON, SVMH is also a **NFP**, a service organization whose mission is to "improve the health of the people in our District" (SVMH, 1994). To be successful, SVMH must provide and "maintain quality standards of patient care" while "monitor(ing) a process of continuous quality improvement" (SVMH, 1994). To accomplish their goal, SVMH must first ensure that their operating costs do not exceed revenues, i.e., SVMH must make sufficient monetary profit to achieve financial stability. After ensuring financial

121

stability, non-governmental **NFPs** can accomplish their mission. SVMH must meet its customers' demands as efficiently as practicable, within their budget constraints.

3. Mission Similarities

DON and SVMH are **NFPs** with a similar mission: provide quality service to their stakeholders. Both are **NFP** service organizations whose basic considerations are not driven by financial profit but by providing that quality service. Although they have quite different goals, efficient inventory management is critical to the success of both organizations in terms of satisfying their missions.

C. DON AND SVMH INVENTORY MANAGEMENT PROGRAMS

For DON and SVMH to accomplish their missions, each must provide adequate levels of customer service to their own internal customers. Internal customers must have the necessary tools, equipment, and supplies to productively contribute to the organization's overall mission. A failed contribution by an internal customer can jeopardize the ultimate mission for the external customers (the American public for DON and the clients and patients for SVMH).

To ensure that each internal customer has the tools, equipment, and supplies necessary, both DON and SVMH have created inventory management programs to satisfy internal demands;

specifically, to provide the right part at the right location at the right time in the right quantity for the lowest cost possible. Both DON and SVMH inventory management programs are designed to satisfy the customers' demands. Both use demand-based data and probabilities of stock-out to identify required inventory levels and safety levels - insurance spares or backups. DON's inventory management program for shipboard use is the Point Five FLSIP Plus (.5F+) model; SVMH's is the Material Management Department or MMD.

1.   Comparing Inventory Types Stocked.

To satisfy customer demands, both DON and SVMH maintain multi-echelon levels of inventory. For DON, wholesale inventory is maintained throughout the world at various depots, Fleet Industrial Supply Centers (FISCs), etc.; for SVMH, wholesale inventory is maintained at its warehouse. Both maintain consumer level inventories, onboard ships for DON and in the floor or wards' ready issue storage locations for SVMH. With the exception of a few, minor preventative maintenance items, SVMH only stocks consumable items; DON stocks both repairable and consumable items.

Is there a critical distinction between repairable and consumable items in terms of mission accomplishment? The purpose of inventory is to provide the internal customer with the items necessary to complete the task at hand. For DON, that task may

be corrective maintenance on a weapons system, for SVMH, it may be providing a saline solution for a patient under going open heart surgery. The procurement, storage, packaging and inventory requirements for consumables and repairable items are different. Managing repairables involves relatively more complicated mathematical models for determining inventory levels and greater infrastructure support for the repair process. However, the purpose for inventory, whether all consumable, all repairable or a combination of both, remains the same: satisfying the needs of the customer in a timely fashion within budgetary restrictions. Differences in the types of inventory that each organization manages (repairables and consumables for DOD; consumables only for SVMH) and the level of complexity in the management of those inventories are not critical differences for this thesis.

2. Comparing Inventory Selection Criteria

Both DON and SVMH have well developed inventory management and logistics programs. The major point of departure between DON and SVMH is their method of selecting inventory items to stock on board the ships for DON and to warehouse for SVMH. Of particular interest is their different approaches to integrating actual customer demand data.

a. SVMH's Selection Criteria and Results

SVMH is evaluated by its ability to provide quality health care for its patients and improve the overall health of

124

the community. When a new item of inventory is required to meet

that need, MMD consults directly with the customer to determine

the extent to which pre-existing inventory will meet that need.

If necessary, the new item is procured and warehoused. Inventory

levels and demand patterns are constantly monitored. If the

inventory requirement increases, inventory levels are adjusted

accordingly. If MMD detects changes in the frequency or quantity

of demand, MMD again consults the customer to determine future

stocking levels. Inventory which is no longer required is

identified as early as possible and exchanged for inventory which

is required, reducing obsolescence and disposal costs.

MMD continually monitors and reviews customer demands,

enabling them to rapidly respond to their customers' changing

requirements. Because MMD keeps in close communication with

their internal customers, SVMH can better satisfy their external

customers.

b.   *DON's Selection Criteria - Point Five FLSIP Plus*

DOD's overall performance is evaluated in terms of its

capability and readiness to meet and counter threats to national

security. Inventory and logistics support contribute

significantly to DOD's performance. As new weapons systems

develop, DON uses various mathematical models to predict spare

parts usage rates.

125

Because of the time required to develop accurate, stable actual usage rates, customer demands are not fully utilized. The resulting models are imprecise in predicting actual customer demands. Inappropriate inventory levels were not typically corrected until the associated weapons system was modified or removed. Before the Point Five FLSIP Plus (.5F+) model, actual fleet customer demands were only used peripherally for inventory selection. The .5F+ is the first DON model to directly incorporate the fleet customers' actual demands into the inventory stocked onboard.

c.   DON's Inventory Selection Criteria Results

Although DON is implementing the .5F+ model with its more customer-oriented focus, time and budget constraints limit inventory modifications to every five to seven years, the normal time of the ILO cycle. The inventory mix in the storerooms are changed from MODFLSIP to .5F+ during the ILO. More frequent and smaller storeroom inventory changeovers would increase the individual ship's contribution to material readiness.

There was one attempt to accelerate .5F+ implementation outside the normal ILO cycle during September - October 1995 onboard the USS San Jacinto (CG 56). This improved the timeliness for introducing customer demand-based input, but the budget for rapidly implementing the .5F+ had not been pre-programed. Sufficient NAVSEA funding for the .5F+ "add backs" in

126

this mini-ILO was not available. Funding for ILOs and any

shipboard inventory exchanges is normally reserved (programed

into DON's budget) several years in advance. The financial

"work-around" required did not fully resolve the funding issue.

Additionally, some of the long lead time NIINs had not been

requisitioned early enough to meet the new, compressed schedule.

As a result, JACINTO received less than an optimal storeroom

overhaul. But the NIINs that JACINTO did receive will increase

the ship's overall material readiness.

3.   **Prospects for DON's and SVMH's Inventory Management
       Programs**

a.   *Benefits of Customer Involvement in the Process*

DON has recently begun moving towards inventory models

which place an increased emphasis on customer demand for

establishing inventory stockage policies. The differences

between previous inventory models and .5F+ model demonstrate the

benefits of directly incorporating the customer into the process.

As DON begins to realize the need to incorporate customer input,

more frequent .5F+ implementations similar to USS San Jacinto's

should be undertaken. SVMH, on the other hand, has been

incorporating their customers into their inventory management

process with demonstrated results.

b.   *Results of Non-customer Involvement*

DON and SVMH are comparable in many regards. Both

organizations will benefit by operating as business-like as

possible. For any **NFP** to continue to accomplish their mission in today's environment, they must also be efficient organizations. As service organizations, both DON and SVMH can learn from the November, 1995 bankruptcy of the Jamesway Corporation.

Jamesway Corporation was a ninety store, regional discount retail sales chain located in the Northeast for the past thirty-four years. Jamesway is currently liquidating everything from corporate office furniture to retail store fixtures. The cause of Jamesway's demise can be blamed, in part, on loss of market share to Wal-Mart, K-Mart and specialty stores. However, there were other, more critical problems: mediocre customer service and strategic errors, such as accumulating real estate holdings in retail outlets rather than investing, as did Wal-Mart, in inventory and distribution systems. Jamesway suffered from a "seeming inability to reshuffle merchandise to better serve rapidly evolving customer preferences" (New York Times, 1995). Wal-Mart's inventory technology system allows management to determine what sales items are needed by which of over 2,000 stores and then expedites delivery. Jamesway, by contrast, was unable to determine customer preferences.

While economic bankruptcy may not be a possibility for DON, "organizational bankruptcy" is a possibility. If this occurs, GAO and other outside stakeholders might force efficiency and similar adjustments on DON's operation.

SVMH uses EDI and NOVA for their inventory and distribution system management to monitor and determine their customers' needs and avoid obsolescence. Before the .5F+ inventory model, DON's storeroom inventory did not adequately reflect their customer's needs. Unless DON continues to aggressively incorporate customers' needs and expectations into its inventory management system, DON, like Jamesway, will continue to be unresponsive to their customers' needs, provide mediocre customer service and accumulate excessive inventory that either remains "unsold" or is obsolete and valueless. DON, like Jamesway, may also go "bankrupt."

D.   COMPARING RESULTANT EFFICIENCIES

1.   COSAL Effectiveness - A DOD Measurement for Efficiency

DOD can directly measure the success or failure of achieving efficient outcomes by measuring the impact of inventory changes on readiness goals. For the USS Roberts, the initial MODFLSIP produced an average Model Effectiveness rate of 61.8 percent over four quarters at a cost of $6.16 million. When the threshold was changed to .5F (without the demand-based items added), the storeroom inventory cost was reduced to $3.92 million, a savings of $2.24 million. However, readiness declined to 41.1 percent. The .5F+ model added several demand-based items at a cost of $.98 million. Model Effectiveness, a surrogate measurement of

129

readiness, increased to 73.5 percent. Changing the product mix

of the storeroom items to reflect customer demands generated a

$1.26 million net savings and a 11.7 percent net increase in

Model Effectiveness. This is a measurable efficiency increase.

2. SVMH'S Measurements of Efficiency

SVMH has no mathematically precise method to measure

customer satisfaction. However, MMD can indirectly measure its

technical and allocative efficiency by measuring the level of

customer satisfaction that it provides. Technical efficiency is

achieved by optimizing procurement of necessary goods and

services within the limited budget constraints. Allocative

efficiency is achieved when the customers demands are satisfied

to the greatest extent possible with those same goods and

services. As MMD increases its level of customer service, SVMH

move closer to its allocative efficiency point. To measure its

level of customer service, MMD can use the following surrogate

indicators: Inventory Stockpiling, Vendor resupply fill-rates

and Stock turn.

a. *Inventory Stockpiling*

The absence of decentralized stockpiling indicates that

MMD is satisfying their customers consumable medical supply

requirements. Since customers do not feel the need to maintain

their own inventories, they must have sufficient confidence that

MMD can provide them with their requirements in a timely fashion.

b. *Vendor Resupply Fill-Rates*

Since MMD's inventory stocking policy is entirely driven by customers' demands, MMD's customer satisfaction level can be measured by MMD's ability to resupply their customers. MMD's resupply fill-rate is 98 - 99% from its vendors and suppliers, so MMD can offer comparable service directly to their customers.

c. *Stock Turn*

MMD's final indicator is their average stock turn. A low stock turn could indicate that MMD's inventory does not adequately reflect the customers' requirements. The customer is not "buying" the inventory that MMD is stocking. However, MMD averages once-a-month stock turn. In conjunction with the other two surrogate indicators, this provides further evidence that MMD provides a high level of customer service.

3. Effectiveness Results Comparisons

The demand-based systems that DON and SVMH use appear to work very well for each organization. While both organizations employ different metrics to determine the relative rate of effectiveness, the measurements seem to confirm that demand driven inventory systems improve overall effectiveness for DON and maintain a high level of effectiveness for SVMH.

VI. TRADE OFF ANALYSIS

Previous chapters have focused on the efficiencies and cost savings generated by both DON's Point Five FLSIP Plus (**.5F+**) COSAL inventory model and Salinas Valley Memorial Hospital's (**SVMH**) Material Management Department's (**MMD**) inventory management program. Chapter V compared the efficiencies of both inventory management programs. This chapter will discuss the trade-offs used to achieve those efficiencies, beginning with the need for trade-offs themselves, and then focusing on inventory trade-offs in the **.5F+** model. That latter discussion will center on trade-offs associated with developing and modifying inventory models, items selected for stocking, and the impact of changing inventory models on readiness. Section C will discuss specific trade-offs in the **.5F+** model involving inventory off-loaded and Section D will discuss the trade-offs in **.5F+** model involving inventory afloat. The final section will summarize some of these trade-offs and their impact on DON and SVMH, respectively.

A. NECESSITY OF TRADE OFFS

1. Scope of Trade-Off Analysis

Since ships and hospitals have neither the funding nor the storage facilities to stock all required parts, trade-offs are necessary. As a general rule, trade-offs are economically

motivated, forcing a choice between two acceptable alternatives.
Other trade-offs are politically driven. For example, in 1988,
the Navy's proposed long-range budget, the Fiscal 1990-94 Program
Objective Memorandum or POM, traded-off maintenance dollars,
spare parts procurement, and aircraft material readiness rates to
complete the construction of the 600-ship fleet (Greely, 1988).
In FY95, the Operations and Maintenance budget was increased by
trading-off procurement dollars for maintenance dollars. The
FY96 budget will continue this trend, this time trading-off fleet
modernization dollars for readiness and quality of life issues
(Readiness, 1994). This chapter will analyze the economic trade-
offs associated with inventory management programs and inventory
models.

2. Function of Inventory Management Programs

Most inventory programs incorporate mathematical models to
determine the storeroom inventory parts mix that maintains the
highest degree of parts availability. For DON, the goal of
inventory is to maximize sustainability and readiness while
minimizing cost; for SVMH, the goal is to maximize medical
consumables availability and customer service while minimizing
cost. The inventory models must determine both the range and
depth of inventory allowances. The models' goals, for both DON
and SVMH, are to balance costs and effectiveness, trading-off
inventory costs for material availability. However, any trade-

134

off must also consider limited resource availability, storage space constraints, budgetary restrictions, transportation costs, inventory costs and other factors which may affect material availability.

B. INVENTORY MODEL TRADE-OFFS

As with any model, trade-offs must be used to best allocate finite resources. This section analyzes of some of the trade-offs which must be resolved to implement the model. Two of those trade-offs are: timeliness of implementing the new inventory mix, and the data source used in constructing the model. Once a mathematical approach has been determined, the next trade-off concerns which items to include and which to exclude. For the .5F+ model, that trade-off defines the candidate selection criteria. However, reducing shipboard inventories can affect both readiness and the budget. The .5F model trade-offs will be discussed and compared with the trade-offs of the .5F+ model.

1. Preliminary Trade-off Considerations

a. *Costs of Implementation vs Gains in Readiness*

To maximize the efficiency gained by changing the inventory model, the new inventory mix should be implemented as soon as possible. To minimize the material movement costs, the inventory exchange (on-loading new and off- loading previous inventory items) should be scheduled well in advance. For SVMH,

because of continually monitoring the inventory demand patterns, inventory exchange is a continual process. For DON, inventory is exchanged during scheduled availability periods, such as an Integrated Logistics Overhaul (ILO). Since ILOs are typically scheduled for an individual ship once every five to seven years, scheduling trades-off the costs of implementation against the potential gain in readiness and possible inventory savings.

b. *Probabilistic vs Demand History - Data Accuracy*

Designing the model itself involves a trade-off during the model development. The .5F+ model removed some of the slow-moving items from the ship by increasing the threshold value of repair parts. To regain any loss of readiness, the model added-back repair parts identified by actual demand-based data.

The .5F+ model utilizes requisitioning data submitted by the individual ships through the 3M system, relying upon accurate submission and accurate demand history data capture. The model is only as good as its reported and captured data. The mathematical reliability of the MODFLSIP model's probabilistic methods (usage rate driven) was traded-off for potentially inaccurate demand data in the .5F+ model. The .5F+ model's custom designed Allowance List trades-off a tailored inventory, based on demands from a group of similar customers, for a risk of potential error. The risk of error results from inaccurate data submissions and the limited customer data base. The data base

for the ROBERTS Allowance List was small (fifteen users) compared to the fleet-wide users data base used in the MODFLSIP.

2. Initial Inventory Selection Criteria Trade-offs

The USS Roberts had approximately 125,000 allowance candidates for Storeroom Items or SRIs. After implementing MODFLSIP's .0625 usage rate threshold, those candidates were reduced to 19,702 allowance items valued at $10,399,000. Of that total 9,127 were SRIs valued at $3,279,000. Using this MODFLSIP inventory as the baseline, a trade-off was made regarding which NIINs would be subject to the higher .5F threshold and which NIINs would not. Not all MODFLSIP shipboard allowance items were candidates for reduction. Only those NIINs designated as SRIs were considered candidates. The inventory levels of all other items were established by methods other than MODFLSIP or demand, and were restricted from the .5F+ model. Notable restricted NIINs include Readiness Based Sparing (**RBS**), Technical Over Rides (**TORs**), and Operating Space Items (**OSIs**).

3. Trade-Off Results of Point Five FLSIP (.5F)

The .5F inventory model raised the qualifying threshold from one failure in four years to one failure in two years. This reduced the number of ROBERTS' SRI NIINs from 9,127 to 5,532 and reduced the SRI inventory from $3.28 million to $1.04 million. Since the purpose of the SRI inventory is to effect shipboard repairs, fewer NIINs should indicate fewer opportunities to have

the needed repair part onboard. Model Effectiveness percentages using data from the previous four quarters, as recorded by the Fleet Material Support Office (**FMSO**), showed that .5F inventory model also lowered the ROBERTS effectiveness from 61.8 percent under MODFLSIP to 41.1 percent under .5F.

Graphically, this cost vs readiness trade-off is shown in Figure 8. Readiness is plotted along the horizontal axis beginning with zero percent (no weapons systems are operational) and increasing to 100 percent (all weapons systems are fully operational). The cost of the SRI Inventory is plotted along the left vertical axis in millions of dollars, increasing in value as the points move upward. The Storeroom Inventory Cost curve ($SRIC_1$) shows the relationship between SRI cost and Readiness. As more dollars are invested in SRIs, readiness increases.

A second vertical axis has been added to the graph. This axis represents the time weapons systems are "down" awaiting parts. OPNAVINST 4441.12B has established the performance measurement of Average Customer Wait Time (**ACWT**) as the link between parts support and operational requirements (readiness). The ACWT goal of 125 hours for all high priority requisitions, which includes CASREPs, measures the average time to satisfy all customer demands from requisition submission through issue. ACWT measures the time required to issue a part - from the two hour goal of making a shipboard issue from available stock to the

SRI Cost

DTc

SRIC₁

Time

$ 3.28

GE_M

DT_F

$ 1.04

DT_M

GE_F

41 % 62 %
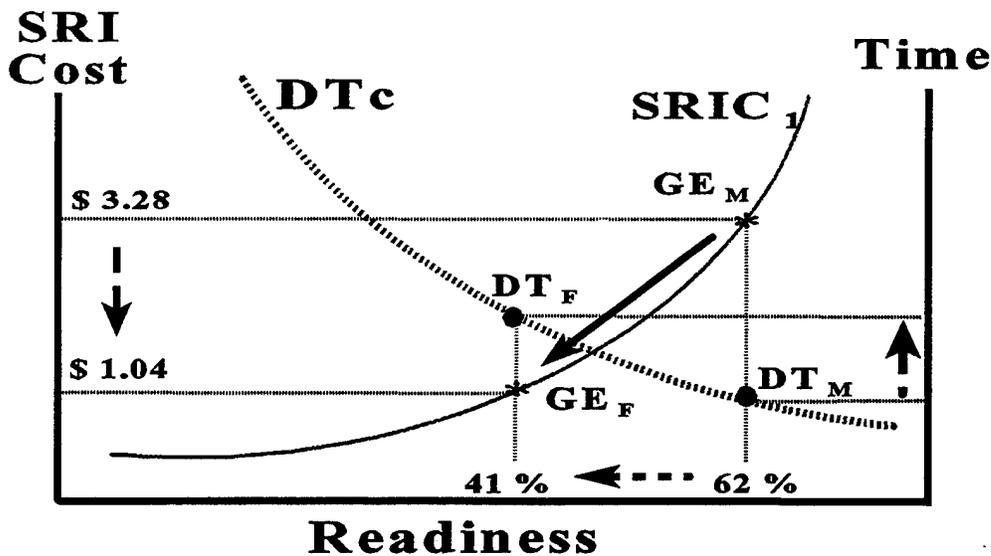
Readiness

Cost vs Readiness - .5F Model

GE_M = Gross Effectiveness - MODFLSIP	GE_F = Gross Effectiveness - .5F
DT_M = Downtime (ACWT) - MODFLSIP	DT_F = Downtime (ACWT) - .5F
SRIC₁ = Storeroom Inventory Cost curve 1	DTc = Down Time curve

Figure 8. Loss of Readiness with .5 FLSIP

average time of 87 days required to issue a part not in the system (OPNAVINST 4441.12B, 1989). The Downtime curve (**DTc**) represents the relationship between time required to issue a part and readiness. Increases or decreases in readiness are shown as movements along the **DTc**.

As the FMSO model simulation demonstrated, changing from MODFLSIP to **.5F** decreased the investment in SRI inventory. This is represented by movement down and to the left along the SRI

Inventory Cost Curve ($SRIC_1$), from MODFLSIP SRI point **(GE_M)** to .5F SRI point **(GE_F)**. The .5F trade-off negatively impacts readiness as shown by the lowered gross effectiveness moving from 62 percent to 41 percent. Similarly, as SRI inventory declines, the amount of Downtime increases, as measured by ACWT. As fewer parts are available to satisfy customer demands from shipboard issue, ACWT for those parts increases. This is shown as a movement upward and to the left along **DTc** from **DT_M** to **DT_F**. As the model changes from MODFLSIP to **.5F**, the cost of SRI inventory declined, ACWT increased and readiness decreased.

4.   **Trade-Off Results Point Five FLSIP Plus (.5F+)**

From DOD's perspective, avoidable declines in readiness are unacceptable. Customer service levels (material readiness) were traded-off for the inventory cost savings of the **.5F** model; the **.5F+** model offset that loss. By using a demand-based investment of $.98 million, Model Effectiveness (readiness) rose to 73.5 percent. Changing the product mix of the SRI increased readiness over MODFLSIP by 11.7 percent and a net savings or cost avoidance of $1.26 million.

The "Plus" feature of the .5F+ model "added back" demand based NIINs to the storeroom as SRIs. New business rules for "adding back" those NIINs were developed by trading-off budget dollars (storeroom inventories not to exceed $4.93 million) for demand frequency. This reflected the criteria of eight demands

in a four year period. There were 8,769 potential NIINs

available to ROBERTS in the demand based data file, valued at

$5.15 million. The selection criterion "added back" 988 NIINs

valued at $640,758. The CASREP data set used a similar trade-

off. Of the 822 possible NIINs valued at $2.03 million, 74 NIINs

valued at $344,000 were selected.

Graphically, this trade-off of inventory cost vs readiness

for the .5F+ model is shown in Figure 9. Like Figure 8,

readiness is represented as an increase or decrease in the

percent of effectiveness. As in Figure 8, changes in readiness

levels can be represented as movements along the **DTc** curve. When

the MODFLSIP SRI inventory was changed to the .5F SRI inventory,

there was a downward movement along the SRI Inventory Cost Curve

(**SRIC₁**) from the MODFLSIP SRI point (**GE_M**) to .5F SRI point (**GE_F**).

This same cost curve is shown in Figure 9.

Changing from the .5F model to the .5F+ model, with its

unique demand-based "add-backs", the entire SRI Inventory Cost

curve shifts to the right. **SRIC₁** is replaced by **SRIC₂**, the SRI

Inventory Cost Curve for .5F+ with a new inventory point (**GE_P**).

This shift results from going beyond the original **SRIC₁**

parameters by changing the inventory selection criterion in .5F+.

The inventory investment for the .5F+ is greater than .5F,

but one million dollars less than the MODFLSIP. However, the

effectiveness rate of the .5F+ inventory model, seventy-four

141

Cost vs Readiness - .5F+ Model

GE$_M$ = Gross Effectiveness - MODFLSIP	DT$_M$ = Downtime (ACWT) -MODFLSIP	
GE$_F$ = Gross Effectiveness - .5F	DT$_F$ = Downtime (ACWT) - .5F	
GE$_P$ = Gross Effectiveness - .5F+	DT$_P$ = Downtime (ACWT) - .5F+	
SRIC$_1$ = Storeroom Inventory Cost curve 1	SRIC$_2$ = Storeroom Inventory Cost curve 2	
DTc = Down Time curve		
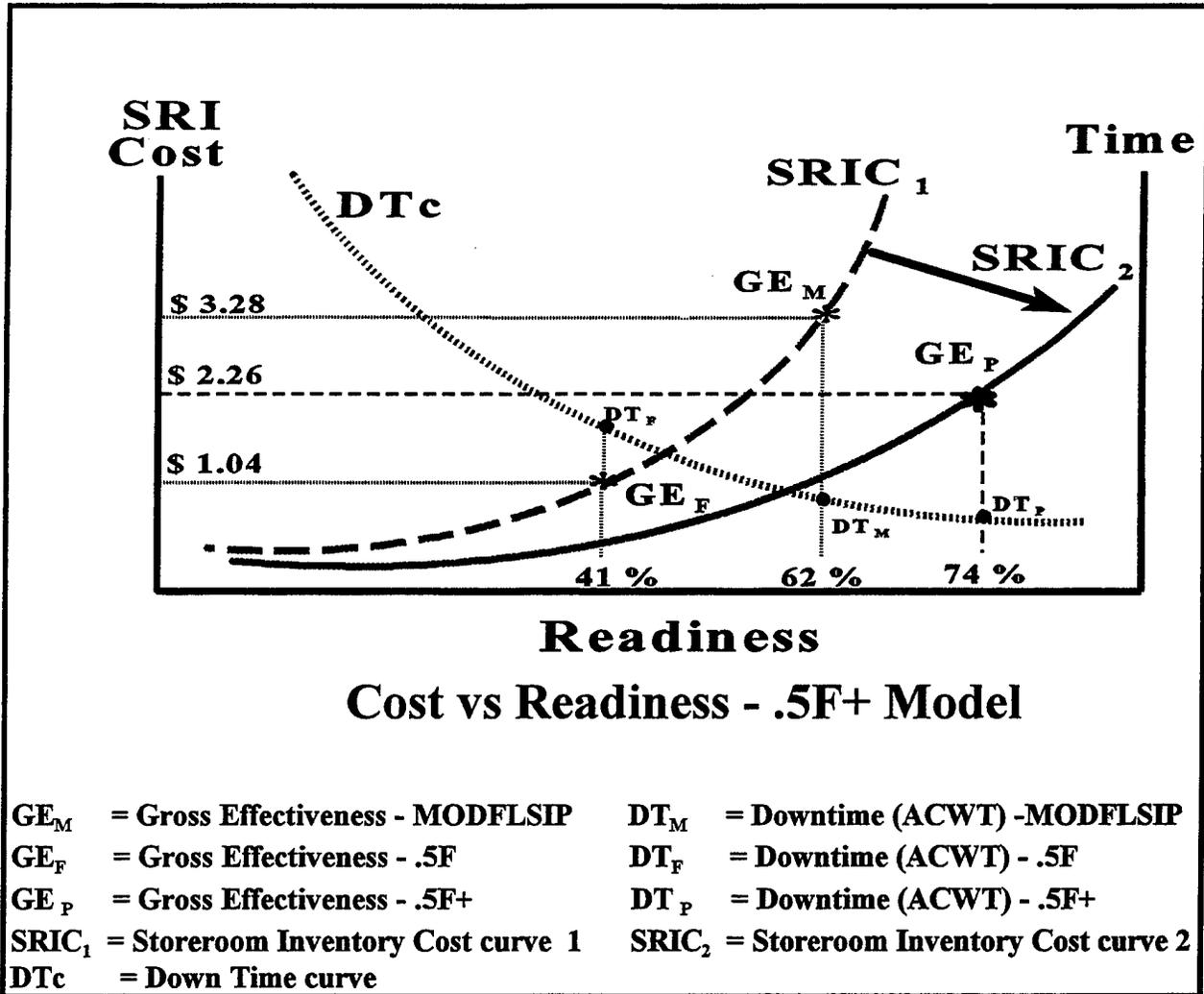
**Figure 9. Readiness Gains with .5 F+**

percent, is greater than that of the more expensive MODFLSIP model, sixty-two percent. Increased readiness levels resulted from "adding back" the higher demanded items, reducing ACWT, moving along **DTc** from **DT$_F$** to **DT$_P$**. The **.5F+** model successfully reduced inventory levels onboard ROBERTS and increased readiness by changing the trade-off.

Using Gross Effectiveness as a surrogate measurement of readiness, the **.5F+** model is more technically efficient than MODFLSIP. By achieving a higher level of readiness, GE_P, at a cost lower than GE_M, ROBERTS improves allocative efficiency.

C. ASHORE TRADE-OFFS

To maximize the cost savings differential between MODFLSIP and **.5F+**, the off-loaded, low demand NIINs must be re-utilized. This section will analyze two of the trade-offs associated with re-locating shipboard inventory ashore: the trade-off on safety stock levels and the trade-off on warehousing costs.

Some of the Navy managed NIINs can be returned to the Navy supply system through the Fleet Industrial Supply Centers (**FISCs**) for credit. FISCs will only give credit for NIINs which have a current demand history or pending back orders. If the FISC does not immediately need the item, the Item Manager (**IM**) is contacted. The IM ensures that all items under his/her control meet restocking objectives. In accordance with applicable policies and guidelines, the IM initiates both procurement and disposal actions for their items. If neither the FISC nor the IM have any requirements for the items, then no credit will be given for the NIIN. Items not accepted by the FISC or IM for credit can either be disposed or distributed to the appropriate type commander for redistribution. In some cases, reuse items are used

as .5F+ "add-backs" for other ships. Items marked for disposal have marginal salvage value.

Some NIINs can be returned to the Defense Logistics Agency (**DLA**) depots for credit using a similar approach as the Navy. However, DLA requires a higher experienced demand rate than the Navy to retain an item.

1.   **Cost vs Safety Stock.**

Any item accepted by the FISC or DLA would either fill an outstanding requirement or be added to the safety stock level. Any outstanding contracts for the item could be canceled and the funds reprogrammed. Safety stock levels are driven in part by the requirements determination process. Safety stock either replenishes actual demands or anticipates future demand. Future requirements can come from either forecasting models or contractor estimated failure rates.

There is a direct relationship between inventory holding costs and the level of safety stock. As the level of inventory increases, holding costs increase. However, increasing safety stock increases readiness by reducing the risk of stockouts. Parts accepted as safety stock by the FISC and DLA increase both holding costs and readiness.

From 1980 through 1988, the Navy's inventory of parts (both surface ships and submarines) increased from $2.7 billion to $9.3 billion. GAO estimates that the Navy spends $24 million dollars

a year to warehouse 140,000 different line items that are no longer needed. According to GAO, the Navy must revise its policy regarding acceptable stockout risks and mission essentiality. GAO's research concluded that the Navy's current policy authorizes a safety stock level for almost all inventory items (GAO/NSIAD-91-176).

2. **Cost vs COSAL Spares Ashore (CSA) Stocking Points.**

When the .5F+ model was initially proposed, a COSAL Spares Ashore (**CSA**) warehouse was planned for FISC Norfolk, FISC San Diego and FISC Pearl Harbor. The CSA warehouse was designed to store off-loaded items after implementing **.5F+**. Items identified as non-centrally stocked DLA items would be considered for storage. In essence a non-centrally stocked item is any DLA managed item whose demand rate is less than DLA's minimum stocking requirements. All other items would either be returned for credit, redistributed or disposed. The goal of CSA is "to ensure system availability of low demand and insurance spares which would have been (carried onboard) ... where wholesale support is determined to be insufficient" (NAVICP-M, 1995).

The Navy believes that holding costs would be less than the cost of re-procurement (i.e., all costs associated with replenishing inventory). The NIINs off-loaded under the .5F+ model were originally procured to satisfy predicted future demands under the MODFLSIP sparing philosophy. If the original

145

MTBF engineering or contractor estimates established during the provisioning phase were accurate, then those off-loaded NIINs would still be required. Their frequency of demand just doesn't justify stocking them on board.

A second argument for establishing CSA stocking points assumes that stock out costs are greater than the inventory holding costs. Stock out costs include more than the item's replacement and logistics costs. In the for-profit organization, stock out costs also include estimates of lost sales, lost profit, and lost customer goodwill. For DOD, the replacement cost and logistic delay time are a small portion of the stock out cost. When DOD loses its "profit," material readiness and national security decrease. For-profits can use previous sales records to estimate lost sales and profit. For DOD, there is no estimated dollar value for the national security cost of losing a major weapons system. One final DOD argument for CSA warehouses is that corporate infrastructure can't always meet DOD's needs for low demand parts in a timely fashion.

However, the GAO has consistently criticized DOD for maintaining intermediate, secondary inventories. GAO believes that the cost of holding excess material includes more than storage costs. GAO lists obsolescence, deterioration, lost opportunity cost of investment and a casual attitude regarding inventory safety and security as primary reasons for the high warehousing costs (GAO/HR-93-12).

146

The Navy maintains that degrading readiness to save holding cost is an unacceptable trade-off. Figure 10 graphically illustrates the relationship between total inventory cost and the number of storage facilities or warehouses. Both the GAO and DOD views of the relationship between warehousing costs, inventory costs, and readiness are represented using total cost. Under the total cost concept, the decision maker determines which cost elements are relevant to the decision (would be affected by the decision), such as increased value of service, and which are not. After costing out the relevant elements, the decision maker can identify the alternative which minimizes the expected sum (total) of all the relevant costs (Brown, 1995).

In Figure 10, costs are plotted along the left vertical axis, and warehouse retention alternatives are plotted along the horizontal axis. Costs associated with operating and maintaining warehouses are shown as the upward sloping curve **WC**. As the square footage of warehouse space increases, DOD's overall costs increase. Increasing the square footage of warehouse space is a movement along **WC**. As warehouse square footage increases, there are more inventory locations to store off-loaded shipboard items. As more items are held in storage, i.e. not disposed, the cost of reprocuring those items decreases. The change in reprocurement costs is shown as curve **RPC**. The **RPC** curve slopes downward to the right. Total cost **TC** is the sum of **WC** and **RPC**.
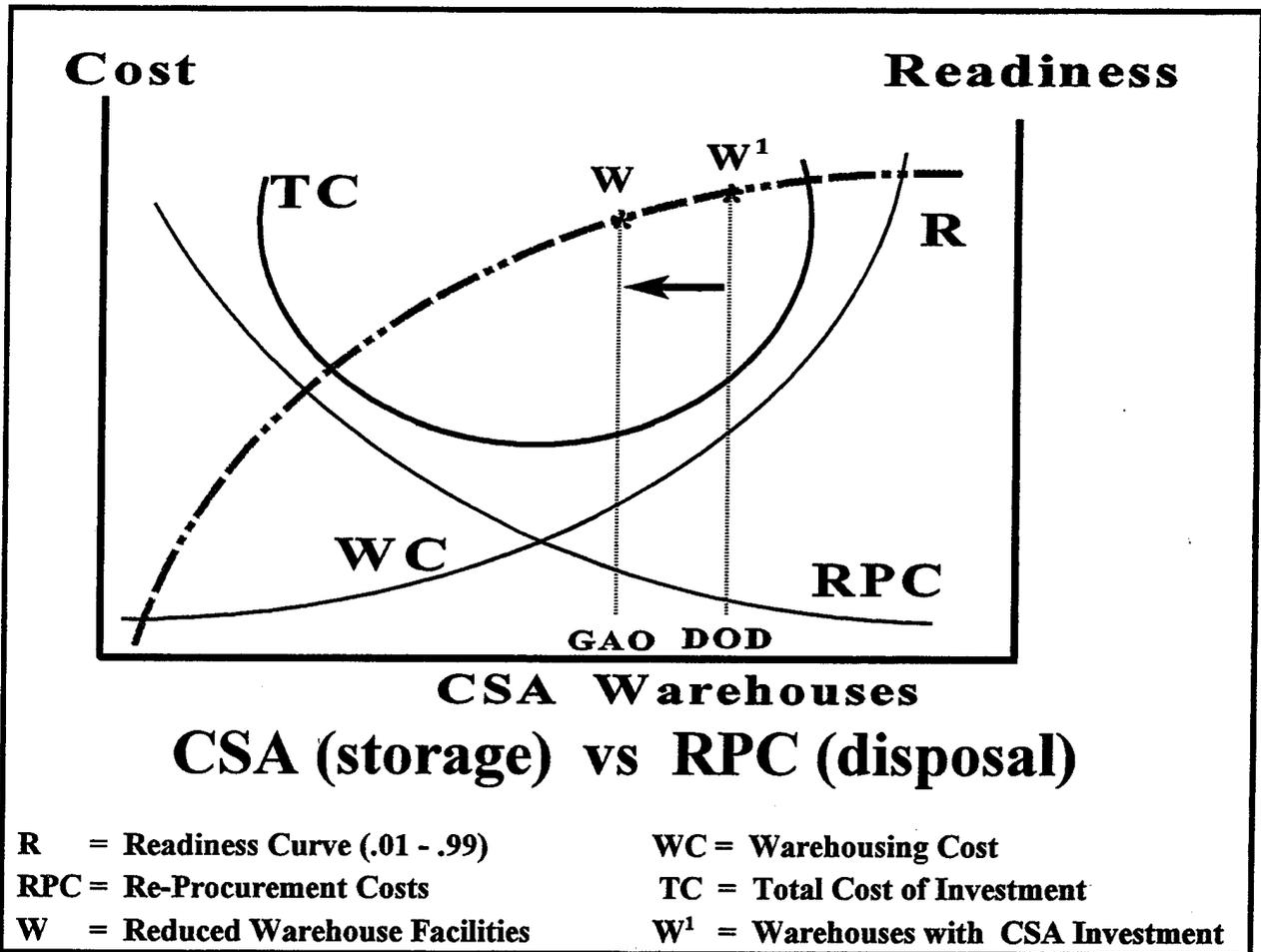
Figure 10. Maintaining COSAL Spares Ashore Warehouses

A readiness graph has been overlaid on the CSA Warehouse cost graph to illustrate the relationship between the inventory stored at warehouse locations and readiness. Figures 8 and 9 showed that readiness is a function of inventory costs as well as ACWT. As such, readiness was the horizontal axis. In Figure 10 cost and readiness are shown as a function of warehouse space. The readiness axis has been shifted to the right vertical axis beginning with zero percent (no weapons systems are operational)

148

and increasing to 100 percent (all weapons systems are fully operational).

In this example, readiness depends on the availability of inventory - inventory stored at shipboard locations and inventory stored at warehouse locations. The readiness curve **R** illustrates that as the range and depth of NIINs off-loaded under the **.5F+** model increase, i.e., are stored in CSA warehouse locations, more NIINs are available to satisfy predicted future readiness demands. Readiness increases as more NIINs are retained than are disposed, assuming that the ACWT for reprocurement is greater than the average shipping time. As warehouse storage space increases, readiness increases as does the cost of achieving that readiness. In this trade-off, GAO believes that any decline in readiness that DOD might experience as DOD moves from its desired warehouse space (W^1) to GAO's total recommended warehouse space (**W**) is adequately compensated by the realized cost savings. DOD believes that reducing readiness to save holding cost is unacceptable.

D. AFLOAT TRADE-OFFS

Reducing shipboard inventory trades-off inventory costs and location. Location can be defined as part availability and customer accessibility to inventory. Items in a DOD managed warehouse ashore, whether a DLA, FISC or CSA warehouse, are more

visible to all DOD customers than if those same items were located in a ship's storeroom. Using current technologies and policies, asset visibility and accessibility is not practical for afloat units.

1. Cost vs Inventory Location.

MODFLSIP brought 9,127 SRI NIINs onboard, trading-off location ashore for higher inventory levels afloat. The .5F+ model also traded-off inventory for location by reducing the total number of SRI NIINs from 9,127 to 6,604. Lowering afloat inventory levels was expected to increase the risk of non-support (risk of not having the right part at the right location). However, .5F+ utilized a Differentiated Distribution Strategy for inventory placement. This strategy places fast- moving items closest to the customer and the slower-moving items at a few centralized stocking points (Ballou, 1992). Placing the ship-type demand based items at the location closest to the customer - onboard ship, decreases overall risk of non-support. In addition to having the right part, readily available spare components are equivalent to "the case of an operating component and a parallel component in standby (i.e., standby redundancy)" Blanchard, 1992. By investing in these customer-based demand item inventory levels, the trade-off gains in location justify the increase in inventory cost by increasing readiness and weapon system reliability.

2. Cost vs Transportation.

Every spare part located in an afloat storeroom is one less part that must be transported to that afloat location when that item is demanded. Using MODFLSIP, Model Effectiveness was rated at 61.8 percent. Stated differently, 61.8 percent of the time the right part was available to effect repairs. Conversely, 38.2 percent of the time the transportation system was required to deliver parts from stocking points ashore to fill those demands. In the normal trade-off relationship, high inventory levels (cost) reduce transportation costs; low inventory levels increase transportation costs. Using the MODFLSIP Model Effectiveness percent as the baseline, decreasing inventory levels should increase transportation costs to achieve the same level of customer service.

Transportation costs depend upon the customer's "urgency of need" for demanded parts and fall into two categories:

a. Resupply through normal transportation channels

b. Extraordinary measures to meet emergency demands. Transportation costs increase with the "urgency of need." For example, low "urgency of need" inventory stock items are resupplied through normal channels and have a correspondingly low priority. These parts are shipped at the cheapest transportation cost, trading-off time (speed of delivery) for money (cost of delivery). CASREP parts have the highest "urgency of need" and

require the fastest mode of transportation. Therefore, they incur the highest transportation cost.

Figure 11 graphically illustrates this relationship between the level of inventory and the cost of transportation for CASREP parts. As ROBERTS' SRIs decreased from 9,127 NIINs under MODFLSIP to 5,532 SRI NIINs under .5F, there was downward movement along the SRI Inventory Cost Curve SRIC from IC_M to IC_F. With fewer parts onboard, the probability increases that some of the "missing" parts will be required to correct CASREPs. There should be a corresponding increase in the cost of transporting those CASREP required parts to the ship. This expected transportation cost increase is represented by an upward movement along the Cost of transporting CASREPs curve CAS_1 from A for MODFLSIP to A_1 for .5F.

Likewise, when 1,072 SRI NIINs are "added-back" to create .5F+, CASREP transportation costs are expected to be reduced. The new CASREP transportation cost should be located at point A_2 along curve CAS_1. However, the .5F+ selection process tailored inventory investment to the customer's previous demands. Seventy-four NIINs which had previously been required to satisfy CASREPs on similar ships were "added back" to ROBERTS' storeroom inventory. The resulting effect is a downward curve shift of the CAS_1 curve to CAS_2 and a new lower transportation cost, B. Extraordinary transportation costs were no longer necessary to

Figure 11. CASREP Transportation Savings from .5F+

The figure contains the following legend:
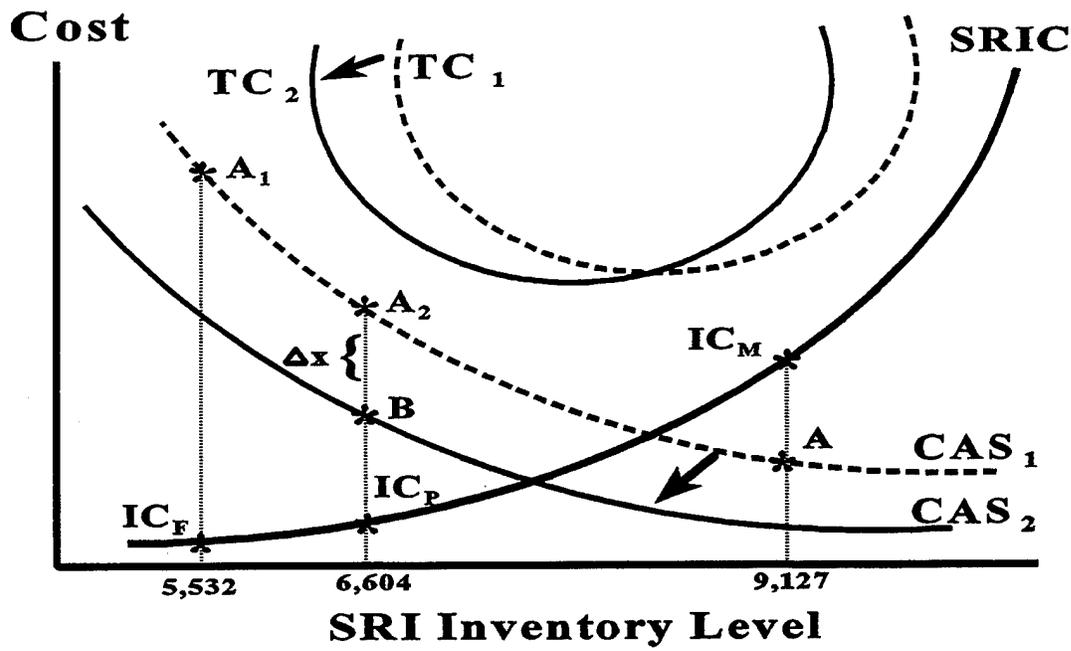
TC_1 = Total Cost curve 1	TC_2 = Total Cost curve 2
CAS_1 = CASREP Transportation Cost 1	CAS_2 = CASREP Transportation Cost 2
IC_M = Inventory Cost - MODFLSIP	IC_F = Inventory Cost - .5F
IC_P = Inventory Cost - .5F+	SRIC = Storeroom Inventory Cost Curve

move these parts to the ROBERTS. While the actual transportation

cost of **B** along the CAS_2 curve may be greater than or less than

A, it is less than the expected transportation cost of A_2 on the

CAS_1 curve. This difference, **delta x,** represents the cost

savings in CASREP transportation. The lower transportation costs

shifts the Total Cost Curve TC_1 downward and to the left, to TC_2.

153

E. SUMMARY OF TRADE-OFF ANALYSIS

Because all organizations face finite budget resources, trade-offs regarding business decisions must be made. For DON, implementation of the .5F+ model required several trade-offs. Instead of relying entirely on probabilistic and forecasted demand data, the .5F+ traded-off mathematical certainty for potentially inaccurate ship-type specific demand data. By restricting the range of candidates, the .5F+ model traded-off potential savings for stakeholders' input. Furthermore, the trade-off between readiness and cost avoidance implied by the transistion from MODFLSIP to the .5F model was improved by the .5F+ model.

Based on system requirements, transferring slow-moving inventory ashore also involves trade-offs. The more common ones are: holding costs for safety stock levels vs cost of stock out, and warehousing costs of additional storage facilities vs reductions in readiness. From the afloat perspective, the new .5F+ inventory traded-off the net cost of new inventory mix (offset by credit for material turned in to the FISCs) for onboard location, and traded-off .5F+ inventory for CASREP transportation costs.

Although data is not available for SVMH, similar trade-offs are also part of MMD's inventory management program. For example, by not implementing a Prime Vendor contract, MMD has

154

traded-off potential reductions in warehouse inventory and operating expenses associated with a Prime Vendor contract for heightened vendor responsiveness, increased contract award flexibility, and internal customer service.

VII. CONCLUSIONS / RECOMMENDATIONS

This thesis compared the Navy's latest COSAL inventory model, the Point Five FLSIP Plus (.5F+) model, with the inventory management program of a not-for-profit, service organization, Salinas Valley Memorial Hospital (**SVMH**). Measuring, analyzing, and comparing the efficiencies of each organization indicates the reasons for their relative successes in optimizing their budget dollars. This chapter will exam some of the limitations in measuring and barriers to achieving those efficiencies. The chapter will also make recommendations for improving both efficiency and the level of customer service, concluding with suggestions for further research.

A. DIFFICULTIES OF MEASURING ALLOCATIVE EFFICIENCY

One of management's first steps in determining the efficiency of its organization is to locate its operating point (**OP**) relative to its Production Possibilities Frontier (**PPF**). Once the organization's **OP** has been determined, then the distance and direction from **OP** to allocative efficiency (**AE**) can be plotted. Strategic plans and policies can then be devised and implemented to move that organization closer to its **AE**. To determine an organization's **OP** requires accurate measurement tools and proper utilization.

157

1. Limitations of SVMH's Measurement Tools

For SVMH to measure its technical or allocative efficiency, it must locate its **OP** relative to its **PPF**. One major limitation for SVMH is its measurement tools are only indicators and can only indirectly determine the actual level of customer service that its Material Management Department (**MMD**) provides. As imprecise as those measurements may be, they provide the best available approximation of SVMH's **OP**. Lack of inventory stockpiling, high vendor resupply fill rates and large stock turn ratios together indicate that SVMH's **OP** is relatively close to its allocative efficiency point.

2. Limitations of DON's Measurement Tools

To a great extent, DON reports gross effectiveness percentages when measuring readiness. As part of its readiness report to the JCS, DON records readiness by the number of ships CASREP-free and the number of aircraft mission-capable. The greater the number of available, mission-capable platforms, the greater the DON's contribution to national security. As fleet readiness percentages increase relative to the limited budget constraints, DON moves towards its allocative efficiency point.

a. Isolated Effectiveness Percentages

Effectiveness percentages that are isolated from total military capabilities have a disadvantage. Effectiveness percentages are based on quantitative issues from stock, so data

158

can be manipulated for higher effectiveness percentages. For example, a customer may need a dozen transistors. The warehouse makes a single issue, using "box" as the unit of issue. In terms of gross effectiveness, this transaction is recorded as a single issue filled against a single demand. Those same transistors might also be issued using "each" as the unit of issue. In this case the warehouse would record twelve issues filled against twelve demands. Since gross effectiveness measures the ratio of total issues to total demands, the warehouse has filled eleven additional issues, "satisfying" eleven additional demands. The more issues from stock in response to demands increases gross effectiveness percentages. Other system gaming techniques such as requiring aircraft to fly only once a month to be counted as operational or weighting the operational capability of deployed units more heavily than that of non-deployed units distorts the total readiness capabilities for national security purposes.

b. Definition of Readiness

Using contributions to readiness to measure efficiency requires a precise definition of readiness. However, DOD tends to limit readiness reporting to personnel, equipment and training deficiencies while GAO believes that readiness reports should incorporate jointness and forecasts of downstream changes to readiness (GAO/NSIAD-95-29). This difference in definition influences both GAO's and DOD's perceptions of DOD's efficiency.

159

3. Reports of Efficiency

Both SVMH and DOD gather and report data to their key stakeholders. Because each organization has a different focus, each measures its technical and allocative efficiencies differently. SVMH reports on its mission effectiveness in terms of customer satisfaction and efficiency. DON reports on the contributions of its' unit inventory management to readiness and national defense by measuring effectiveness percentages, i.e., percentage measurement of stock availability for filling customer requirements.

B. BARRIERS TO ACHIEVING ALLOCATIVE EFFICIENCY

Once an organization has located or approximated its OP as accurately as possible, the organization must recognize the barriers which may prevent it from achieving allocative efficiency. Those barriers include: data validity, responsiveness to customers' needs, management information systems, and stakeholders perceptions.

1. Data Validity

The first barrier concerns the validity of the data itself. Since the organization bases many of its future production and operational strategies on the location of its OP, the organization's data must be as accurate and reliable as possible. The organization has a responsibility to satisfy its customers'

needs and preferences to the greatest extent possible. The customers, however, may choose not to reveal all necessary information regarding their preferences. Customers may "hide" inventory stockpiles because they lack confidence in the supplier's ability to meet their requirements expeditiously. The customers may also decide that the paperwork required to properly report demand data is too tedious and time consuming. Without complete, accurate data, the organization cannot realistically assess its true position along the **PPF**. On the other hand, the customers may want to communicate their preferences, but the organization may not have an adequate and timely customer feedback mechanism.

Not only does MMD use empirical data, such as lack of inventory stockpiling, fill rates and stock turn ratios, they also meet with their customers periodically to validate the inventory mix. These meetings allow customers to update their preferences. The meetings also reassure the customers that SVMH is working to meet their (the customers') needs. From SVMH's perspective, the customer is an integral part of its overall inventory management process.

DOD relies almost exclusively on demand data from its warehouses to determine appropriate warehouse inventory stocking levels. The COSAL inventory model incorporates customer demands through annual updates to the Best Replacement Factor (**BRF**). The

BRF is then used to establish threshold levels to qualify SRI items for future COSAL use. The Point Five FLSIP Plus (.5F+) model is a partial departure from that norm. It incorporates more of the customers' input directly into the final product. Customer skepticism about the system's ability to provide the customer's requirements, based on previous supply system performance, remains a problem for DON.

For SVMH, the customer actively participates in designing and selecting inventories, so customer confidence is high. It is to the customers' advantage in both organizations to accurately report their preferences and demands, becoming an integral part of the inventory decision-making process. For DON, the .5F+ model should help restore customer confidence in the system's ability to meet changing needs.

2. Responsiveness to Customers' Needs

The second barrier, to allocative efficiency concerns the organization's ability to implement modifications if they identify changes in customer requirements. To meet the customers' changing preferences, the organization must be an effective organization in the sense of "doing the right thing." The organization must be able to correctly identify the needs and wants of their customers in order to satisfy those customers. Without knowing precisely what the customer wants, an organization may be extremely efficient in providing "the wrong

thing." Similarly, the organization must be able to identify all the key stakeholders and customers. "The key to success in public and nonprofit organizations is the satisfaction of key stakeholders" (Bryson, 1988).

SVMH has successfully identified all key stakeholders and customers. Additionally, SVMH has provided MMD with the capability to rapidly modify and change its product mix through monitoring customers' preferences and tracking changes to inventory daily. With a product return-for-credit program and low on-hand inventory, MMD can rapidly modify its inventory to match changing customers' needs with little adverse financial impact.

DON has also identified key stakeholders and customers and monitors and records inventory demands. Originally that customer data was used almost exclusively to update **BRF**s. However, that update had little or no impact on pre-existing shipboard inventories. Customer input was recorded but was not being fully utilized. While the **.5F+** model modifies shipboard inventories in response to customers' changing requirements, unlike SVMH, DON delays changing its product mix. DON only implements **.5F+** changes during the Integrated Logistic Overhaul (**ILO**), a bulkhead to bulkhead storeroom inventory validation and replacement process. ILOs for individual ships normally occur once every five to seven years.

Modifying storeroom inventories during ILOs may be cost effective, but it is not a rapid response to customers' changing requirements. As weapons systems move through their life cycles, the range of maintenance parts for those weapons systems changes. Not keeping pace with those changes can reduce allocative efficiency. Experience with the USS San Jacinto demonstrates that, given sufficient long range planning, interim .5F+ mini-ILOs can meet customer's changing requirements and increase both material readiness and allocative efficiency. While DON may never be able to adopt SVMH's credit exchange rate, the longer parts remain onboard unused, the shorter the period of time that other naval activities have to reutilize those repair parts before they become obsolete.

3. Management Information Systems

The third barrier to efficiency is the organization's vision of technology. The current management information technology capabilities of SVMH and DOD are quite different.

SVMH makes full use of available technology, including Electronic Data Interchange (EDI). MMD can provide its customers with online, real-time, continuous status on any line item from point of order, through receipt, issue and subsequent re-order. The availability of any ordered item, both emergency or routine, is readily confirmed by the supplier. If the item is not available, MMD can immediately order the item from a different

source. Information regarding stock availability, shipping status, shipping manifests, expected shipping dates, and receipt dates are available within sixty minutes of placing the order.

MMD also maintains positive "asset visibility" over all inventory. Inventory "sold" to ready-issue storerooms is tracked and inventoried daily for verification. MMD not only has the capability to transfer inventory from warehouse to ready-issue storerooms, it has the capability of directing inventory transfers between ready-issue storerooms.

The only segment of DON's extensive logistic tracking system available to the shipboard user is its CASREP function. This function provides the customer with status and visibility of CASREP parts. However, this status system requires the supplier, transshipper and customer to manually track each item. Current follow-up status is often available only by telephone. Message traffic is often not available for 12 to 24 hours after data transmission.

While MMD can maintain in-transit visibility of all materials shipped, DON's shipping status is generally by exception, i.e., shipment delays. Because of the high financial and readiness costs associated with material lost in shipment, DOD has embarked on a Defense Total Asset Visibility (DTAV) plan to track material from procurement, through transportation and storage pipelines to end-user (Hughes, 1994).

Unlike SVMH, DON has limited asset visibility. While most of the shore-based assets are visible (notable exceptions include type commander inventory stockpiles or "goldpiles"), most shipboard inventories are "invisible." On occasion, the Navy Inventory Control Point, Mechanicsburg, PA (**NAVICP-M**) has queried individual ships regarding availability of parts needed to satisfy a CASREP for another ship. NAVICP-M based its requests on the ship's initial COSAL SRI outfitting data, not on any currently held inventory data.

4. Stakeholders' Perceptions

The final barrier to achieving allocative efficiency is stakeholders' perception. In the example of "Forced Efficiency" in Chapter II, stakeholders (GAO) perceived that DOD was not operating as efficiently it could. GAO was successful in imposing restrictions and limitations in an attempt to force DOD to become more efficient. However, by reducing the budget to force DOD to act more efficiently, DOD was denied the very funding it needed to procure information – information which could have been used to determine DOD's **OP** and initiate plans to move towards allocative efficiency.

C. CONCLUSIONS

Research into both DON's and SVMH's inventory management programs revealed two very similar organizations with a common

goal of satisfying customers' demands. Based on that research, several conclusions were made regarding each organization. Those conclusions and amplifying information are as follows:

- SVMH is a more effective and efficient organization than DON.

- SVMH's success is due to its strategic planning.

- SVMH has totally integrated their customers into their inventory process.

- DON has made improvements in efficiency.

- DON, through .5F+, incorporates limited customer input.

- .5F+ increases readiness through customer participation.

1.   SVMH as an Effective and Efficient Organization

When an organization satisfies its stakeholders, which include internal and external customers, then that organization is an effective organization. It will "make a profit."

SVMH is highly effective at meeting its customers' demands for a quality, low cost, and timely product. SVMH maintains its competitive advantage by meeting these basic requirements through a variety of strategies and tactics, particularly "product strategy," "procurement strategy," and "quality tactics." SVMH's "product strategy" is to produce quality health care service, continually improving that product, and maintaining strong communication links between SVMH, its customers, and its suppliers. SVMH's "procurement strategy" evaluates suppliers

167

based on quality and service, integrating those suppliers into both SVMH's "production" system and chain of customers, and developing modified "Just-In-Time" inventory techniques. SVMH's "quality tactics" include using quality to select suppliers, encouraging employees to participate in the "production" process, and relying on continuous improvement as the major factor to contain costs and enhance service (Heizer, 1993).

The result of SVMH's strategic planning has produced an efficient organization. By consolidating its purchasing and supply functions into a single department,(MMD), SVMH was able to realize actual savings in several areas. By standardizing supplies, variability of inventory (duplication of similar products) was reduced, which lowered overall costs. Automation and EDI reduced the requirements for part-time buyers from each department in the hospital to two full-time buyers for the entire hospital. Additional savings in inventory levels, warehousing costs, procurement costs, and a high customer service level demonstrates that SVMH has achieved a high allocative efficiency for its inventory management program.

2. Effectiveness and Efficiency of DOD

Over the past several years DOD has established many new initiatives to meet customers' demands for a low cost, quality product, expeditiously delivered to the end user. For example, many of the new defense procurement programs are designed to

deliver high quality weapons systems and their supporting repair parts as inexpensively and quickly as possible. Based on guidelines published by the National Contract Management Association (NCMA), the Federal Acquisition Streamlining Act of 1994 was designed to achieve these goals by requiring future contracts to:

1. Use commercial contracting methods as much as possible,

2. Fully utilize electronic procurement procedures,

3. Reduce / eliminate paperwork, and

4. Streamline the contracting function (NCMA, 1994).

Other initiatives to expedite delivery of weapons systems and parts include procuring commercially available items for military use and eliminating military-unique specifications from contracts. One of DON's contributions to inventory efficiency enhancements has been the .5F+ COSAL model.

3. Effectiveness and Efficiency of .5F+ Inventory Model

The success of the .5F+ model, like SVMH's success, results from putting the needs of the customer first. By incorporating customer driven, demand-based data, customer service levels were improved, as reflected by the increase in gross effectiveness from 61.8 percent under MODFLSIP to 73.5 percent under .5F+. The overall cost of storeroom items (SRIs) was reduced by $1.26 million for the frigate USS Roberts. The .5F+ model is more

efficient than the previous MODFLSIP model because it provides the customer with more of the right parts at the right location for a lower cost than MODFLSIP.

D.   RECOMMENDATIONS FOR IMPLEMENTATION

For DON to achieve some of the customer effectiveness successes and realize some of the efficiencies that SVMH has accomplished, DON should implement the following recommendations:

- Use "Dialogue and Deliberation" to involve the stakeholders and customers in the inventory process

- Develop a shipboard EDI system

- Implement .5F+ COSAL outside of ILOs

- SVMH implement a Prime Vendor contract for Pharmacy

A more in depth explanation of each recommendation follows.

1.   Direct Customer Participation in DON's Inventory Selection Processes

SVMH and .5F+ moved closer to their respective allocatively efficient points by utilizing customer demand data to determine their optimal inventory mix. For DON to achieve the same level of effectiveness and efficiency as SVMH, DON must mimic SVMH's methodology to incorporate stakeholders developing and determining inventory levels. While SVMH has a smaller facility, inventory, and logistics operation compared to DON, SVMH's efficiency can be duplicated.

170

SVMH's strategic management methodology is similar the "Dialogue and Deliberation Alternative Approach to Strategic Planning" model designed by Dr. Nancy Roberts of the Naval Postgraduate School. The purpose of dialogue "is to go beyond any one person's understanding and to achieve insights that could not have been achieved individually" (Roberts, 1993).

Dialogue and deliberation seeks new ways to involve all stakeholders, including customers, in the decision-making process. Involving customers and other stakeholders will benefit DON by increasing customer awareness and understanding of the process, informing stakeholders about both the limitations of modeling and budget constraints and the necessity of trade-offs, and increasing customer confidence and trust in the decision-makers themselves. Stakeholders' participation is not intended to be a referendum but rather an educational process so that stakeholders can proffer informed opinions.

The deliberative aspects of this process require the decision-makers to evaluate the opinions and possible alternatives offered by stakeholders and customers. The final step requires management to weigh all the inputs and reach a final decision – an informed decision that rests with management alone. The goal of a dialogue and deliberation in the strategic management plan is to ensure that "all sides of a strategic issue might learn and through that process, create a sustainable mandate for the organization in the future" (Roberts, 1993).

171

With stakeholder involvement and customer awareness
increased, two barriers to allocative efficiency are reduced or
eliminated: stakeholders' perceptions and data validity.
Stakeholder and customer involvement also ensures that DON is an
effective organization, satisfying its stakeholders and "making a
profit." Adopting SVMH's approach to inventory determinations
will increase the relative efficiency of DON's inventory program
and increase its level of customer service.

2. Development and Implementation of a Shipboard EDI System

SVMH is able to achieve real savings in inventory management
by fully utilizing Electronic Data Interchange (EDI) technology.
MMD knows with certainty which items are being shipped, which
items are back ordered and their shipping dates, actual date of
receipt (morning or afternoon delivery), and actual quantity
shipped. EDI eliminates variability, duplication of data entry,
improves speed and accuracy of information, brings customers and
suppliers closer together, and reduces information gaps.

With shipboard EDI, DON would increase customer service,
improve logistic efficiencies, reduce inventory through "Just-In-
Time" like principles, and reduce the average time a customer
waits to receive inventory. With EDI, the third barrier to
allocative efficiency - lack of an adequate information
technology, is reduced or eliminated. Fully adapting EDI in the

172

inventory process, DON should be able to more easily move closer to allocative efficiency.

3. Rapid Response to Customers' Requirements Through Early Implementation of .5F+ COSAL

SVMH monitors their customers' demand patterns, preferences, and changing requirements. Monitoring and direct customer interface coupled with ease of inventory transition enables SVMH to rapidly change the product inventory mix. DON's .5F+ model incorporates many of these same elements. However, by delaying storeroom inventory off-loads until Integrated Logistic Overhaul (ILO) availabilities, maximum potential contributions to material readiness are delayed and allocative efficiency is reduced.

It might not be cost effective to schedule more frequent ILOs, but interim or mini-ILOs might be scheduled between regularly scheduled ILOs. The mini-ILO would not turn inventory over bulkhead-to-bulkhead, but rather incorporate selected readiness critical equipment. DON could partially modify its inventory to meet customers' needs. While not eliminating the organizational responsiveness barrier to allocative efficiency, mini-ILOs would reduce it.

4. Adaptation of Prime Vendor Contracting for SVMH's Pharmacy Department

SVMH Pharmacy's department should have MMD negotiate a Prime Vendor (PV) Contract as previously described in Chapter IV. SVMH would realize cost benefits in personnel, opportunity costs from

173

inventory reduction, and reduced waste from disposal of shelf-life expired pharmaceuticals. Improved customer service levels means better service to SVMH's internal and external customers. Finally, lower cost of operations, specifically warehousing and inventory loss costs, generates savings which can be passed directly to the customer as a lower cost of pharmaceuticals.

E.   RECOMMENDATIONS FOR FURTHER RESEARCH

Areas for further research concern implementation of the previous recommendations, as well as in depth investigation of questions raised after using the .5F+ model.

1.   Stakeholders' Participation in DON's Strategic Management Planning

Dr. Roberts' has completed preliminary research regarding the "Dialogue and Deliberation Strategic Management Model." Additional research into the mechanics of incorporating this model into DON's process for determining shipboard inventory mixes, stocking levels, and expected availability outcomes must be completed before realizing efficiency gains from full stakeholder and customer participation. Since one of the goals of "Dialogue and Deliberation" is to provide information to the participants, this model could be used to provide input and alternative availability outcomes.

For example, both a steam driven lubricating oil pump and a fire control radar system servo motor are critical to operating

174

the ship. If, due to budget constraints, spare parts funding can only support one of these weapons systems, inventory sparing models use reliability data or readiness goals to make that determination. "Dialogue and Deliberation" might resolve the problem by placing the fire control spares in the ship's storeroom and the lube oil pump spares at a warehouse's ashore location. However, the customers would have provided input regarding which parts to place at each location.

2. Establishing an EDI Compatible Shipboard Information Technology System

Electronic Data Interchange between suppliers, vendors, and shore based customer activities generally requires telephone communication linkages and compatible computer-based programs. Incorporating the customer afloat presents a different set of problems, including satellite communication bandwidth and precedence competition. The first step to realizing the full EDI benefits afloat requires development and implementation of an Information Technology System similar to DTAV (Hughes, 1994).

3. Cost-Benefit Analysis of Interim ILOs

Off-loading partial storeroom inventories during interim or mini-ILOs can increase overall readiness. Does the increase in readiness justify the cost of the interim ILO? Are mini-ILOs every eighteen to twenty-four months more cost effective in terms of readiness, configuration management, and shipboard maintenance than the current schedule of an ILO every five to seven years?

4. What .5F+ Parts Should Not be Off-loaded

All inventory storeroom parts off-loaded as a result of the .5F+ model are sunk costs, i.e., their cost has already been expended. The current .5F+ model establishes COSAL Spares Ashore warehouses on both coasts and Pearl Harbor for selected off-loaded parts. This saves re-procurement costs and reduces procurement lead time for those items. Effective 1997, DLA will impose a $5.15 per square foot charge for all managed items for warehouse space. Can the net storeroom space made available after off-loading MODFLSIP and on-loading .5F+ be sufficiently "reutilized" onboard to offset this new cost?

Under current .5F+ business rules, if an item did not qualify under .5F+ but did qualify under MODFLSIP and had eight or more demands per ship type, then that item would remain onboard as part of the .5F+ COSAL model. If the item had less than eight demands it would be off-loaded for reuse, storage or disposal. Should there be a condition in the off-load business rules to retain onboard MODFLSIP items with less than eight but greater than four demands, which would otherwise be devalued as excess inventory? Is this cost effective considering the trade-off between warehouse costs and shipboard space constraints?

5. Analysis of Average Customer Wait Time (ACWT)

The .5F+ COSAL inventory model places more of the maintenance required parts closer to the customer by analyzing

previous customer demand history. Alternative COSAL sparing

models, such as Readiness Based Sparing (RBS), stock inventory

based on negotiated weapon system readiness goals. Until a

definitive cost benefit analysis can relate the shortage cost of

a particular weapon system to its impact on national security

readiness goals, the only comparison between alternative COSAL

sparing models must be between Average Customer Wait Time (ACWT)

and Readiness as measured by net, gross and COSAL effectiveness.

F.   SUMMARY

This thesis hypothesized that by studying and analyzing

other organizations and institutions, their approach to inventory

management could provide a different perspective for alternative

solutions to improving DON's inventory management. Areas of

investigation included measurements of efficiency and inventory

selection to meet customers' requirements. SVMH identifies their

customers as internal (employees and suppliers) and external

(patients, clients and stakeholders which includes most of the

Monterey Peninsula). They then craft a strategic plan which

encourages maximum participation of all customers in SVMH's

operation. Their success in achieving this goal can be measured

by their effectiveness at "doing the right thing" and their

efficiency in providing quality health care service at a

reasonable price.

Historically, DON utilized limited customer input in their decision-making process. Prior to the .5F+ COSAL inventory model, customers demands were recorded to set future inventory levels. The customer received no direct benefit from that input. The .5F+ model utilizes direct customer input in determining the customer's own inventory mix. Using the customer's input has increased readiness and reduced inventory costs relative to prior methodologies. If DON continues to actively solicit customer input, DON should achieve the customer service gains realized by Salinas Valley Memorial Hospital.

APPENDIX

FORMULAS

1. Relationship between Marginal Benefit and Marginal Cost

$$\frac{MB_X}{MC_X} = \frac{MB_Y}{MC_Y} = \frac{MB_Z}{MC_Z}$$

2. Inherent and Operational Availabilities

$$A_i = \frac{MTBF}{MTBF + \overline{M}ct}$$

$$A_o = \frac{MTBM}{MTBM + MDT}$$

3. Maintenance DownTime

$$MDT = (\overline{M}) + (LDT) + (ADT)$$

4. Net, Gross, and COSAL Effectiveness

$$\text{Net Effectiveness} = \frac{\text{Total Issues From Stock}}{\text{Total Demands For Stocked Items}}$$

$$\text{Gross Effectiveness} = \frac{\text{Total Issues From Stock}}{\text{Total Demands For Any Item}}$$

$$\text{COSAL Effectiveness} = \frac{\text{Total Demands For Stocked Items}}{\text{Total Demands For Any Item}}$$

5. Usage Rate

$$\text{Usage Rate} = \frac{\text{Population} * \text{Best Replacement Factor}}{4}$$

6. Best Replacement Factor (BRF) Exponential Smoothing

$$\textit{New BRF} = \alpha \times (\textit{New Avg Rate of Demand}) + (1 - \alpha) \times (\textit{Old BRF})$$

LIST OF REFERENCES

Ballou, R.H. **Business Logistics Management**, Third Edition, Englewood Cliffs, NJ: Prentice Hall, Inc., 1992.

Blanchard, B.S. **Logistics Engineering and Management**, Fourth Edition, Englewood Cliffs, NJ: Prentice Hall, Inc., 1992.

Brauner, M.K. and Gebman, J.R. **Is Consolidation Being Over-Emphasized for Military Logistics?**, RAND Issue Paper, March 1993.

Brown, David G. Lecture Notes, **MN 3372, Material Logistics Course**, Naval Postgraduate School, Monterey, CA, Academic Year 95-1, Winter Quarter, January - March 1995.

Bryson, J.M. **Strategic Planning for Public and Nonprofit Organizations**, First Edition, San Francisco, CA: Jossey-Bass, Inc., 1988.

Byrne, John A., "Profiting From the Nonprofits," **Business Week**, March 26, 1990, p. 67.

Capano, A.M. **The Effects of the Department of Defense's Prime Vendor Program on Navy Medical Readiness**, Master's Thesis, Naval Postgraduate School, Monterey, CA, December 1994.

Church, Phil. Director, Materials Management, Salinas Valley Memorial Hospital, Personal Interview Salinas, CA, 02 and 12 May, 15 October 1995.

Committee on Armed Services, House of Representatives, **Hearings on Fleet Readiness**, January 1976.

Congressional Budget Office. **Reducing the Deficit: Spending and Revenue Options**, March 1994.

Department of Defense, (DODINST 5000.2), **Defense Acquisition Management Policies and Procedures**, February 1991.

Department of the Navy, Bureau of Medicine and Surgey (BUMED), **Customer Activity Standard Operating Procedures (SOP) Guide**, Washington, DC, May 1993.

Department of the Navy, Office of the Chief of Naval Operations, (NWP 10) **Naval Warfare Publication NWP 10-1-10 Operational Reports**, November 1987.

Department of the Navy, Office of the Chief of Naval Operations, (OPNAVINST 4441.12B), **Retail Supply Support of Naval Activities and Operating Forces.**, 1989

Defense Systems Management College, (DSMC), **Introduction to Defense Acquisition Management**, Second Edition, Fort Belvoir, VA: Defense Systems Management College Press, March 1993.

Digman, L.A. **Strategic Management: Concepts, Processes,Decisions.** Second Edition, Houston, TX: Dame Publications, 1995.

Dillard, John, LTC, USA, Project Manager, Joint Advanced Special Operations Radio System, Personal Interview, Naval Postgraduate School, Monterey, CA, 04 October 1995.

Fields, Paul J. Lecture Notes, **MN 3374, Production Management Course**, Naval Postgraduate School, Monterey, CA, Academic Year 95-3, Summer Quarter, July-September 1995.

Gaither, William R., LT, MSC, USN, Officer-In-Charge, Materials Management Department, Naval Hospital, Twenty-Nine Palms, CA, Personal Interview, Naval Postgraduate School, Monterey, CA, 10 October 1995.

Gates, William R. Lecture Notes, **MN 4145, Policy Analysis Course**, Naval Postgraduate School, Monterey, CA, Academic Year 95-2, Spring Quarter, April-June 1995.

Goure, D. "Is There a Military-Technical Revolution in America's Future?," **Washington Quarterly**, Autumn 1993, pp. 175-192.

Greeley, Brendan M. "Navy Reduces Readiness To Finance 600-Ship Fleet," **Aviation Week and Space Technology**, March 7, 1988, p. 16.

Gwartney, J.D. **Macroeconomics Private and Public Choice**, Sixth Edition, Orlando, FL: Harcourt Brace Jovanovich, Inc.,1992.

Heizer, J.H. and Render, B. **Production and Operations Management: Strategies and Tactics**, Third Edition, Englewood Cliffs, NJ: Prentice Hall, Inc., 1993.

Hughes, A.D. **Analysis of In-Transit Visibility as a Method of Reducing Material Lost in Shipment**, Master's Thesis, Naval Postgraduate School, Monterey, CA, March 1994.

Joint Chiefs of Staff, **National Military Strategy of the United States**, May 1995.

Kanter, Rosabeth M. "How to Compete," **Harvard Business Review**, Vol 68, No. 4, July/August, 1990, p. 7-8.

National Contract Management Association "Acquisition Reform Under the Federal Acquisition Streamlining Act", NCMA, Vienna, VA 1994

Naval Supply Systems Command, (NAVSUP Publication 553), **Inventory Management**, 1991.

Navy Inventory Control Point - Mechanicsburg, (NAVICP-M), .5 FLSIP Plus COSAL and Readiness Based Sparing (RBS), Working Papers, COSAL Spares Ashore, LCDR Paul Bevin,RNTSC, Program Coordinator, Code 055, 30 October 1995.

Neelley, Charles G. **Allowance Lists: Insurance for Fleet Readiness**, Master's Thesis, George Washington University, Washington, DC, April 1965.

New York Times, November 15, 1995, p. C1, C4.

"Readiness Concerns Dominate 1996 Budget," **Aviation Week and Space Technology**, July 18, 1994, pp 25-26.

Roberts, Nancy C.,"Dialogue and Deliberation: An Alternative Mode of Strategy Making", Research Paper prepared for the Berkeley Symposium on Public Management Reasearch, July 1993.

Salinas Valley Memorial Hospital, **Mission Statement and Operating Guidelines**, August 1994.

Ships Parts Control Center, POINT PAPER "Revise COSAL Allowance for Storeroom Items (SRI)", SPCC, Code 05, Mechanicsburg, PA., 14 February, 1992.

Ships Parts Control Center, "Revised COSAL Allowance for Storeroom Items (Infrastructure .5 FLSIP Plus COSAL)" Draft DBOF 'Flex' Initiative of Ships Parts Control Center, Code 05, Mechanicsburg, PA., 5 January 1993.

Ships Parts Control Center, (SPCCINST 4441.170A), **COSAL Use and Maintenance Manual**.

United States Defense Logistics Agency, Defense Personnel Support Center (DPSC), **Medical Prime Vendor Program, Desk Reference**, Philadelphia, PA, March 1993

United States General Accounting Office. **Defense Inventory Management**, (GAO/HR-93-12), December 1992.

United States General Accounting Office. **Defense Inventory Shortcomings in Requirements Determination Process** (GAO/NSIAD-91-176), May 1991.

United States General Accounting Office. **DOD Medical Inventory: Reductions Can Be Made Through the Use of Commercial Practices**, (GAO/NSIAD-92-58), December 1991.

United States General Accounting Office. **Military Readiness: DOD Needs to Develop a More Comprehensive Measurement System**, (GAO/NSIAD-95-29), October 1994.

United States General Accounting Office. **Opportunities to Reduce Warehouse Space**, (GAO/NSIAD-95-64), May 1995.

White House, Office of the President, **A National Security Strategy of Engagement and Enlargement**, February 1995.

INITIAL DISTRIBUTION LIST

No. Copies

1. Defense Technical Information Center 2
   8725 John J. Kingman Rd., STE 0944
   Ft. Belvoir, Virginia 22060-6218

2. Library, Code 013 2
   Naval Postgraduate School
   Monterey, California 93943-5101

3. Commander, Naval Supply Systems Command 1
   Attn: Code SUP 41242
   Washington, D.C. 20376-5000

4. Mr. Phil Church 1
   Director, Materials Management
   450 East Romie Lane
   Salinas, California 93901

5. Professor William R. Gates 1
   Systems Management Department, Code SM/Gt
   Naval Postgraduate School
   Monterey, California 93943

6. Professor David G. Brown 1
   Systems Management Department, Code SM/Bz
   Naval Postgraduate School
   Monterey, California 93943

7. Professor Thomas P. Moore 1
   Systems Management Department, Code SM/Mr
   Naval Postgraduate School
   Monterey, California 93943

8. Lieutenant Colonel John T. Dillard, USA 1
   Systems Management Department, Code SM/Dj
   Naval Postgraduate School
   Monterey, California 93943

9. Commander, Navy Inventory Control Point (Mech) 1
   Attn: Code 055A
   Lieutenant Commander Paul Beavin, RNSTS
   5450 Carlisle Pike, P.O. Box 2020
   Mechanicsburg, Pennsylvania 17055-0788

10. Lieutenant Commander Michael D. Pawley, USN   2
    10 Clemson Drive
    Aiken, South Carolina 29801