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A MODEL FOR PREDICTING THE INVENTORY OF NAVY SPARES

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July 1991

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As part of the yearly planning process, OSD analysts assess the services' budget requests for secondary items. Although good planning dictates that these requests be judged by the effects of the budgets on inventories and the readiness and sustainability of the operating forces, these links have not been developed. This study takes the first step in providing such links by developing an aggregate model for use by OSD analysts to predict the future inventories of Navy spares. Inventories are predicted from spares budgets, Fleet characteristics that determine spares usage, and historical factors derived from past data. The model was constructed by identifying the principal flows of inventory in the supply system, and relating them to the inputs using simple linear expressions. The paper validates the model using data from the 1980-88 buildup, and illustrates the model's use in forecasting. Appendices briefly describe the inventory management systems of the three military services and cost-estimating relationships for spares usage by ships and aircraft.

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PREFACE

This paper was prepared by the Institute for Defense Analyses (IDA) for the Office of the Assistant Secretary of Defense (Program Analysis and Evaluation), under contract MDA 903 89 C 0003, Task Order T-Q7-621, issued 1 July 1988. The objective of the task was to determine the data base, framework, and models required to relate appropriated funding to inventories of secondary items. Although the research addressed the sources of data for the secondary items of all the services, the analytical framework and modeling focused on Navy spares, one component of total secondary items.

This work was reviewed within IDA by Bruce N. Angier, Matthew S. Goldberg, and Karen J. Richter. James Perry, one of the authors of this paper, is an IDA consultant. The authors wish to thank Charles L. Marriot for sharing his extensive technical expertise on the Navy Supply System.

EXECUTIVE SUMMARY

INTRODUCTION

This paper describes a model for predicting the inventory of Navy spares. The model was constructed by the Institute for Defense Analyses (IDA) at the request of the Office of the Assistant Secretary of Defense, Program Analysis and Evaluation (PA&E). Its purpose is to serve as a tool for appraising budget requests for spares by the military services. The model, which takes the form of a spreadsheet consisting of 48 lines, including 16 historical factors, has been delivered to PA&E on a floppy disk.

Appendices to the study cover an overview of stock funding (Appendix A), introductions to the Navy, Army, and Air Force supply systems (Appendices B-D), and a description of efforts, using regression analysis, to construct relationships to estimate the usage of ship and aircraft spares (Appendix E).

POLICY ISSUE

The relation between spares budgets and inventory is the first link of a "resources to readiness" methodology for appraising spares budgets by their ultimate outputs. By being able to relate spares budgets to inventory, and ultimately readiness, OSD will be in a better position to answer such questions as these:

- Are we buying enough spares to support future force levels?
- Are we anticipating wartime operating tempos?
- How much can we cut the spares budget, in times of retrenchment such as these, without reducing unit readiness?

A simple statistic that indicates the need for good management of Navy spares is the fact that the Navy spent $6 billion on spares in FY 1989.

DESCRIPTION OF THE MODEL

The inventory model is designed at the aggregate level, to predict major trends in spares inventory so that the Office of the Secretary of Defense (OSD) can check on the general consistency of the major planning assumptions made during the yearly planning cycle: the spares appropriations (O&MN, SCN, APN, WPN and OPN), which the operating forces use to purchase spares, and the size and operating tempo of the Fleet, which determine the usage of spares. Although the analysis was conducted at the level of several Budget Projects that define ship and aircraft consumables and repairables, the output of the model is expressed by the total dollar value of inventory.

The model was constructed by modeling the inflows and outflows of inventory among the major components of the supply system: the contractors and other suppliers of spares to the Navy; the Navy Stock Fund, which orders spares from the suppliers; the Navy Industrial Fund, which fixes broken repairables; the hardware systems commands, which order initial spares for new systems; the user stockrooms onboard ships and at shore stations, which hold parts for use; and the ships, aircraft, and Navy installations (laboratories, test and evaluation sites, hospitals, etc.) that are the ultimate users of the spares.

The inventory flows between these organizations were modeled by simple linear equations consisting of yearly planning assumptions (spares budgets, Fleet descriptors) and historical factors derived from past data. These flows are combined with the levels of inventory at the start of a forecast period to yield the yearly levels of spares inventory held at the two major points, the Navy Stock Fund and the user stockrooms of the operating forces.

The spares appropriations and Fleet descriptors are treated as the determinants of the ultimate source and use of spares flow into the Navy. This reflects an assumption that the managers of the stock fund place orders for stock to anticipate purchases by the operating forces using appropriated funds. Because some orders take years to fill, the model includes an algorithm that uses the procurement lags to calculate the effect of unanticipated changes in appropriations. (Inventory levels cannot respond immediately to unforeseen budget changes because past orders for stock will be delivered whether we like it or not.) The Fleet descriptors, particularly the size and operating tempo of the ship and aircraft Fleet, are clearly the aggregate determinants of spares usage.

The historical factors describing the operations of the Navy supply system were derived from data in stock fund reports. The factors used to calculate spares usage—dollar of ship spares usage per dollar of capital value, and dollar of aircraft spares usage per flying hour—were generated from data obtained from the VAMOSC-Ships and VAMOSC-Air databases. (VAMOSC stands for Visibility and Management of Operating and Support

Costs.) Appendix E relates these factors to cost-estimating relationships (CERs) for spares usage derived from regression analysis.

VALIDATION OF THE MODEL

The inventory model was checked by applying it to the 1980-88 time period and comparing the resulting inventory levels with those reported by the Navy Comptroller (NavCompt). The model's calculations were adjusted to reflect changes in the accounting system during the period. Aircraft repairables, for example, were not brought under stock fund accounting until 1985, before which time they were either not accounted for under any system, or managed under user control without adjustment for inflation since purchase.

The inventory levels generated by the model agreed almost precisely with the NavCompt figures for the stock fund inventory. There was a wide divergence, however, for the user inventory: the model predicted a sharp rise in inventory, but the NavCompt levels dropped precipitously. Although we were unable to pin down the source of the disparity, some contributing factors are readily apparent. First, the NavCompt reduction contradicts the conventional wisdom of a buildup in support during the Reagan years in the 1980s: the Fleet grew in size, support budgets rose, fill rates increased, and there was an increase in readiness as measured by the number of casualty reports. Another reason for questioning the accuracy of the NavCompt figures is that the Navy lacks an automated financial accounting system for user inventories.

All this is not to deny problems with the model, however. Foremost is a major problem with the VAMOSC-Air database, which was used as the source of aircraft usage. This source almost certainly underestimates Navy usage. A 1983 audit by the VAMOSC-Air project manager located at the Patuxent Naval Air Test Center found that the database was then capturing only about one-third of all supply actions—and there have been no "get well" efforts since then. The Navy has recently taken steps to improve the database, however. The Naval Center for Cost Analysis has been given the responsibility, and some funding has already been approved. Whether the Navy will eventually spend enough for a full overhaul remains to be seen, and, in any case, it will take time to generate good historical data. Having no better source of data, however, we used the VAMOSC-Air usage figures, but tried to minimize problems by using the last two years of data (which, we were told, had received more attention than data for previous years). We also performed a sensitivity analysis to show the effect of mis-estimation of aircraft spares usage.

Another data problem concerns the historical factor for spares usage by non-combat users such as test and evaluation sites, laboratories, and hospitals. There are no historical data on this usage, and we used an educated guess by two consultants, each with many years of experience with the Navy supply system. The guess could be low, however, leading the model to overestimate inventory.

SUMMARY

In summary, the study demonstrates that a "top-down" model can be used to predict the inventory of spares. The model is in the form of simple equations in a small spreadsheet, is user friendly, and can be quickly modified to meet changing conditions. The model has been validated to the extent that we have reliable data with which to compare its predictions. The model can be an important tool for assessing the adequacy of the Navy's budget requests for spares.

This model for predicting the inventory of Navy spares could be applied, with some obvious changes, to the Army and Air Force as well. The equations for predicting the usage by the operating forces would have to be re-formulated, of course, and the historical factors would have to be re-estimated. We suspect, however, that the general structure of the model and the flow equations would serve as a good basis for Army and Air Force models, since these services are adopting a stock fund management system for spares, just as the Navy has.

RECOMMENDATIONS

Based on the study's findings, we offer the following recommendations to PA&E:

- OSD must continue to receive, from the Navy, the yearly data listed in Table 3 of the report. These data will allow OSD to monitor and re-evaluate the VAMOSC data on spares usage by ships and aircraft; data on Fleet capital value and aircraft flying hours for use in calculating the historical factors relating to usage; and stock fund data for estimating the historical factors that capture the operations of the supply system.
- OSD should encourage the Navy to fully fund a "get well" program for the VAMOSC-Air database. Otherwise, we will never be able to make confident predictions of spares usage by aircraft.
- OSD should ask the Navy Comptroller to institute an automated financial accounting system for the user inventories. Otherwise, we will never know what these inventories really are. Because it will be impossible to check the predictions of our inventory models, we will never have confidence in our

ability to assess the implications of spares budget requests. It would be convenient if the Navy would publish a consolidated report of stock fund and user inventories, all reported at the Budget Project level (BP 14, 28, 34, 81, and 85) so that one can distinguish between consumables and repairables for ships and aircraft.

- OSD should ask the Navy to estimate the usage of spares by the non-combat forces: test and evaluation sites, laboratories, hospitals, etc.
- OSD should ask the Army and Air Force, once their stock fund management systems are in place, to supply OSD with the same types of information as mentioned in the first item. These data are needed so that OSD can modify the inventory model, and evaluate and update new historical factors for these services.

CONTENTS

FIGURES

TABLES

I. INTRODUCTION

This paper describes a model constructed by the Institute for Defense Analyses (IDA) for predicting the future inventory of U.S. Navy spares. The model is aggregate, designed to help defense analysts ensure consistency between major planning assumptions concerning spares inventories: the budget appropriations that ultimately determine the number of spares that are bought, and the Fleet parameters that determine the number that are used.

The remainder of this section describes the policy issues leading to IDA's involvement in this project. Succeeding sections describe the structure of the model (Section II), list the data used in developing and validating the model, and show how the calculations look in a spreadsheet (Section III). These are followed by a validation exercise conducted by taking a past period and comparing the model's predictions with inventories reported by the Navy Comptroller (Section IV), and a demonstration of how the model would be used for forecasting future spares inventories (Section V). Then, there are special topics designed to show the sensitivity of the model's predictions to the input data (Section VI), and how the model uses procurement lags to accommodate the case of unanticipated budget changes (Section VII). The report ends with a brief summary (Section VIII).

The four appendices discuss how the military services manage secondary items, especially spares. Appendix A presents some general material about the appropriations and stock fund methods for procuring spares, and introduces specific descriptions of the Navy, Army, and Air Force supply systems that are contained in Appendices B through D. The description of the Navy system in Appendix B serves as detailed background for the analysis of Navy spares inventories in the text, although the text is intended to be relatively self-contained. Appendix E reports the results of the regression analysis that was undertaken to develop cost-estimating relationships for ship and aircraft spares usage. These results were used as a guide in modeling the usage of spares for the inventory model described in the text.

A. BACKGROUND

The study was motivated by a desire by the Office of the Secretary of Defense (OSD) to obtain a "resources-to-readiness" link for secondary items (spare parts, fuel, clothes, medical and dental services, and subsistence). Such a relationship would help the OSD assess the services' budget requests for secondary items by relating them to the outputs they are intended to produce: the readiness of the military services to conduct missions on short notice, and the sustainability of the services to perform those missions on a continuing basis during wartime. Specifically, the model would help to answer such questions as: Are we spending enough to support future force levels? Have we made adequate allowances for wartime operating tempos? How much extra readiness could we get with increased spending?

The spares inventory model reported in this paper is the first step toward developing this resources-to-readiness link for secondary items. The linkage, shown graphically in Figure 1, shows that spending money on secondary items leads directly to increased inventories, which in turn contribute to readiness (and sustainability). The size and tempo of operations of U.S. military forces are major factors in the linkage. The larger and the more active the forces are, the greater their usage rate of secondary items, and the smaller the buildup of inventory achieved from a given stream of resources. Size and operating tempo (optempo) also affect the degree of readiness and sustainability achieved from a given inventory level; the thinner secondary items are stretched, the less readiness and sustainability is produced across the board.

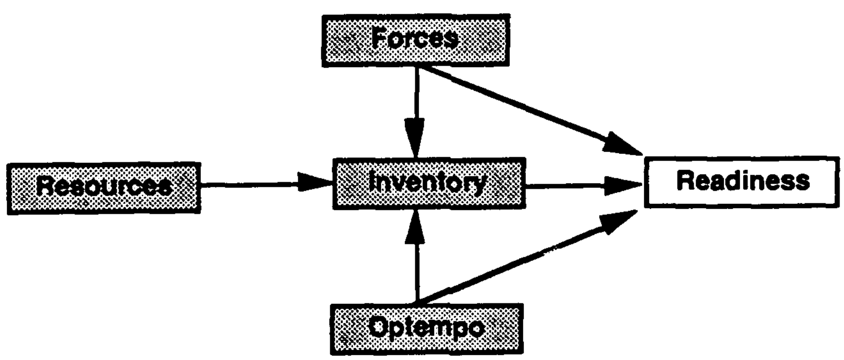


Figure 1. Spares Inventory Model

This study focuses on a part of the problem, the resources-to-inventory link for Navy spares. Spares are critical to readiness and sustainability, and are a costly component of secondary items, the Navy budget alone adding up to approximately $6 billion annually.

Navy spares were selected for this initial effort because the Navy manages its spares almost completely with a stock fund, the procurement method to which the Army and Air Force are moving. The scope was limited to the resources-to-inventory link as a first step. The continuation of the research would involve adding the link between inventories and readiness, and extending the general methodology to cover spares of the other services and the other secondary items of all the services.

There is a question about the generality of the inventory model: Would it work for the Army and Air Force supply systems as well as for the Navy? The fact that the Army and Air Force are moving toward greater use of a stock fund management system for spares suggests that a model that does a good job of predicting Navy inventory levels would work well for the Army and Air Force as well, once they convert to a stock fund system. The Army and Air Force might not construct an exact duplicate of the Navy system, but we expect that the model is general enough to apply to all three services. The empirical factors in the model might require revision, but the theoretical structure should require little modification.

However, in order to derive empirical factors for Army and Air Force versions of the model, those services would need to develop data similar to those we assembled for the Navy model. Moreover, these data should be given to OSD so that the model can be used for its intended purpose of overseeing the spares budget. Updating the empirical factors, for example, would require the stock fund data (or their analogue) and Fleet characteristics (or their analogue). Knowing budget appropriations for spares (as opposed to total appropriations) would also be helpful, although they could be derived from the totals, as discussed in the report.

B. CAVEATS

Consistent with the project's goal of producing an overall planning tool, the model is designed at a high level of aggregation, to predict trends over the Department of Defense (DoD) planning horizon of six years or so.

The model cannot answer such questions as: Should the budget be a few percent higher? Are we buying the right mix of items? Are we positioning these items at the right echelons? These questions, which have a direct bearing on the link between inventory and readiness, will need to be addressed in further research. (Appendix A discusses the difficulty of ordering the right mix of spares in a regime of frequent changes in defense planning, given the existence of procurement lags lasting to five years. According to the

Inventory Management Project Officer at the Naval Supply Systems Command, 42 percent of the items in the Navy Stock Fund are "inactive"—not expected to be used through the budget year two years hence—and 60-70 percent of the inactive items have no projected usage at all.

The inventory model is similarly ill-equipped to consider "micro" questions such as: What are the appropriate reorder levels? Are we making sensible decisions regarding repair vs. buy? Is the stock fund being run efficiently? The model does not attempt a detailed analysis of the complex supply system. Our philosophy was to construct a simple model that captured the main determinants of inventory levels, and to test it out in a validation exercise.

For our purposes, spares are defined as the items the Navy buys in five Budget Projects:

- BP14 Ship consumables
- BP28 DLA items
- BP34 Aircraft consumables
- BP81 Ship repairables
- BP85 Aircraft repairables.

Consumables are items like bolts, coils, and generators that are used to repair larger items like radars; consumables are thrown away when they break, repairables are fixed if possible. The terms "repair parts" and "spares" are often used for consumables and repairables, respectively, but we use "spares" in the more inclusive sense, to refer to both. DLA items are those stocked by the Defense Logistics Agency.

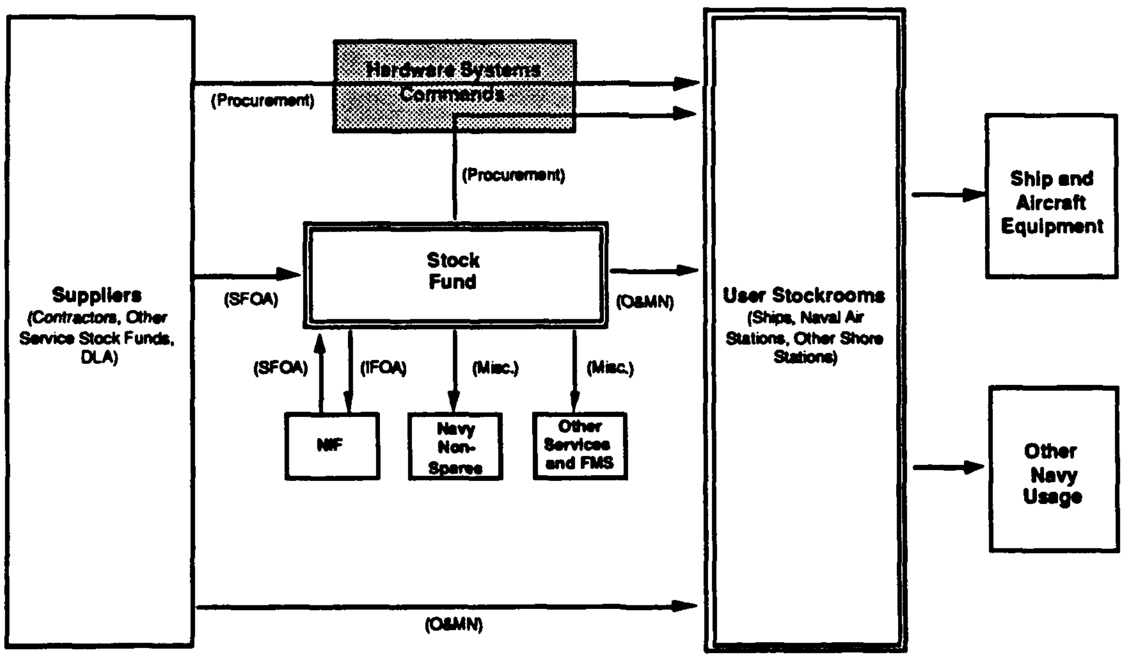
The budgets we dealt with in this model are Total Obligational Authority (TOA). For purposes of this study, TOA refers to the sum of two principal budget categories: Operations and Maintenance, Navy (O&MN), and Procurement, which we define as the sum of the four Navy procurement accounts used to buy spares: Shipbuilding and Conversion, Navy (SCN), Aircraft Procurement, Navy (APN), Weapons Procurement, Navy (WPN), and Other Procurement, Navy (OPN). We deal with these budgets in total, as well as the share used for spares. Except where noted differently, all costs in this report are in millions of FY 1991 dollars.

II. STRUCTURE OF THE MODEL

In this section, we illustrate the structure of the model by briefly describing the structure of the Navy supply system, identifying the flows of inventory and explaining the equations that relate the inventory flows to the budget and Navy Fleet inputs.

A. STRUCTURE OF THE SUPPLY SYSTEM

Figure 2 shows the main elements of the Navy supply system. More extensive descriptions of the Navy, Air Force, and Army supply systems, containing many more institutional details, are given in the appendices. The arrows in Figure 2 show the physical flow of spares, and the notations in parentheses denote the types of funds that are used to pay for the spares (and that flow in the opposite direction).



Notes: SFOA = Stock Fund Obligational Authority, IFOA = Industrial Fund Obligational Authority, FMS = Foreign Military Sales. Miscellaneous includes Military Personnel and O&MN, as well as a variety of other expenditures.

Figure 2. Flow of Inventory in the Navy Supply System

The two double-framed boxes mark the inventories that are predicted by the model. Each of these inventories, Stock Fund and User Stockrooms, is estimated by modeling their respective inflows and outflows (the arrows in Figure 2), and taking the difference as follows:

yearly inflow – yearly outflow = change in inventory during the year.

The ultimate suppliers of Navy spares include the stock funds of the other military services, as well as the Defense Logistics Agency and private contractors. The operational units that are the ultimate users of spares are the ships, aircraft, and "Other Navy Usage" by organizations such as hospitals, laboratories, and test and evaluation sites. The ships and aircraft include those in intermediate and depot-level repair sites ashore, as well as those that are deployed.

Between the ultimate suppliers and users are the organizations that manage the flow of spares—that order the spares from the suppliers, store them until needed, and distribute them to the operational units. The "user inventories," in our terminology, are the spares that are located in the stockrooms aboard ships and at shore stations, and that are used by mechanics in repairing the ships, aircraft, labs, etc. These stocks are often called "end use" inventories. The Navy Stock Fund (NSF) is a rotating capital fund that obtains stockage from ultimate suppliers for sale to the users and the Hardware Systems Commands (HSCs).

The HSCs are the Naval Sea Systems Command (NAVSEA), the Naval Air Systems Command (NAVAIR), the Space and Naval Warfare Systems Command (SPAWAR), and the Naval Facilities Engineering Command (NAVFAC). The HSCs obtain their stocks directly from ultimate suppliers, and by ordering them from the NSF. Finally, the Navy Industrial Fund (NIF) is a rotating capital fund that repairs items returned to the Navy Stock Fund (NSF) from the user stockrooms. (The retrograde movement from the stockrooms is not modeled separately, but is handled implicitly through the NIF repair cycle.) The "Navy Non-Spares" and "Other Services and FMS" boxes in the figure are discussed shortly.

There is a qualification to the picture in Figure 2, that all inventories near the point of ultimate use are "user" inventories and the inventories that support them are stock fund inventories. The spares on some large ships, LHA and LPH amphibious ships, tenders, and AFS stores ships among them, are controlled by the stock fund. Some stocks on the aircraft carriers (CVs and CVNs) are controlled by the stock fund, and some are end-use items.

B. OPERATION OF THE SUPPLY SYSTEM

How the supply system works is best explained by an example. Consider the case of a shipboard mechanic who needs to fix a radar and turns in a bad repairable to the ship's stockroom and signs out a good one. The stockroom could have obtained the good spare in any of three ways. If the radar system is new, the "initial spare" would have been obtained from one of the HSCs initial outfitting accounts, free of charge. The HSC, in turn, could have obtained the spare either by direct purchase from an ultimate supplier or by ordering it from the NSF, paying for it, in either case, by congressionally appropriated procurement funds in budget titles SCN, APN, WPN, or OPN. If purchased from the NSF, the NSF would, in turn, replenish its stock by purchase from original suppliers, using its own working capital.

If the radar had been around for a while, on the other hand, the ship would have obtained the "replenishment spare" from the Navy Stock Fund, and paid for it with the ship's O&MN Operating Target (OPTAR) funds obtained from congressional appropriation. The NSF, in turn, would replenish its stock as above, using its own working capital. As an infrequent option, the ship could have bought the replenishment spare directly from suppliers, again using O&MN funds.

(Congress does not control the way a stock fund spends its money in the same way it appropriates funds for specific purposes. Congress merely provides the stock fund with its initial capital, in addition to "capital augmentation" occasionally granted for special purposes. The stock fund's operations are not completely uncontrolled, however, in that it must receive Stock Fund Obligational Authority from the OSD Comptroller. Appendix A presents a more detailed discussion of stock fund operations and pricing policies.)

There are a few other interactions to discuss in Figure 2. The first two deal with the problem caused by the fact that the five Budget Projects (BPs) that define the data for this study do, in fact, include some items other than Navy spares, our principal focus of interest. These items include: clothes and subsistence paid for by Military Personnel funds; Medical and Dental paid for mostly by O&MN; and some spare items that the Navy Stock Fund, as the single DoD manager, purchases for use by the other services and also for Foreign Military Sales. These "Navy Non-Spares" and "Other Services and FMS" sales had to be subtracted from the stock fund inventory.

The discussion, so far, has been on new stockage. Spares inventory levels are also affected by repair and disposal actions. In the example, when the shipboard mechanic turns in the bad spare, the stockroom sends it back to the stock fund. If the bad spare is a consumable, no change is entered in either the stockroom's or stock fund's inventory. This is proper because the item is valueless; consumables cannot be repaired, and are discarded.

If the spare is a repairable, on the other hand, and can actually be fixed, a repair cycle is set in motion. The stockroom is given a credit equal to the new price of the item minus an average repair cost (and minus a small allowance for inventory to replace items that cannot be repaired). The credit is an estimate of the spare's value at that time. The stock fund inventory is increased by the same amount. The stock fund sends the broken part to the Navy Industrial Fund (or perhaps commercial site) for repair, and no money changes hands because the repairable is still shown on the books of the stock fund. The NIF fixes the spare, using its own labor and any consumables it needs for the repair, which it buys from the stock fund. The NIF then returns the repaired spare to the stock fund, and a financial transaction takes place since it is now worth more. The stock fund pays the NIF the value added, which is the NIF's labor cost plus overhead plus the cost of the consumables used in the repair. (Since the NIF paid the stock fund for the consumables in a separate transaction, the net charge to the stock fund is the NIF's labor plus overhead.)

Taking everything together, the Fleet receives a credit equal to the new price less the estimated repair cost, and buys a new or repaired spare for the new price, so on balance, the Navy's O&MN is reduced by the repair cost alone, the value added.

C. EQUATIONS DESCRIBING THE INVENTORY FLOWS

This section explains the derivation of the expressions for estimating the yearly inflows and outflows from the stock fund and user stockroom inventories just discussed. Section III shows how the resulting changes in inventory are used to compute the yearly inventory levels.

The expressions for the inventory flows are shown in Table 1. In keeping with our intention of constructing an aggregate planning tool, the yearly flows are estimated by combining yearly values of a major planning variable with one of several constant "historical factors," the R's. The planning variables are (1) the O&MN and Procurement budgets for spares that form the ultimate source of spares for the Navy, and (2) the total capital value of the Fleet and the total number of aircraft flying hours that we use as determinants of the ultimate usage of spares. Recent data for these variables are listed in the next major section.

Table 1. Stockage Flows of Navy Spares Inventory Model

INFLOWS TO NAVY STOCK FUND
<u>Receipts from suppliers due to TOA</u>
Navy spares TOA × R1
<u>Unanticipated receipts</u>
See text
<u>Purchases of repaired items from NIF</u>
Navy spares TOA × R2
OUTFLOWS FROM NAVY STOCK FUND
<u>Sales to Navy users directly</u>
Navy spares O&MN × R3
<u>Sales to Navy users via HSC</u>
Navy spares procurement × R4
<u>Sales to NIF</u>
(NSF sales to users + HSC) × R8/(1 – (R8 + R9 + R10))
<u>Sales to Navy Non-Spare Users</u>
(NSF sales to users + HSC) × R9/(1 – (R8 + R9 + R10))
<u>Sales to other services and FMS</u>
(NSF sales to users + HSC) × R10/(1 – (R8 + R9 + R10))
INFLOWS TO USER INVENTORIES
<u>Received from NSF directly</u>
Navy spares O&MN × R3
<u>Received from NSF via HSC</u>
Navy spares procurement × R4
<u>Purchases from suppliers directly</u>
Navy spares O&MN × (1 – R3)
<u>Purchases from suppliers via HSC</u>
Navy spares procurement for the third prior year × (1 – R4)
OUTFLOWS FROM USER INVENTORIES
<u>Spares usage by ships</u>
Fleet capital value × R5
<u>Spares usage by aircraft</u>
Flying hours × R6
<u>Other Navy usage</u>
(Spares usage by ships and aircraft) × R7/(1 – R7)

The historical factors are ratios of financial and other variables averaged over time. For example, R1 is the ratio of Navy Stock Fund receipts from suppliers to spares TOA (the sum of O&MN and Procurement for spares). The historical factors are defined and listed in Table 2. The data used to estimate them are described in Section III.

Table 2. Historical Factors

		80-87	87-88
B1	Ratio of spares O&M to total O&M	0.12	0.17
B2	Ratio of spares Procurement to total Procurement[a]	0.07	0.06
R1	Ratio of NSF receipts from suppliers to spares TOA[b]	0.92	1.01
R2	Ratio of NSF spending on repair to spares TOA	0.12	0.11
R3	Percentage of user budget purchased from NSF[c]	76%	79%
R4	Percentage of HSC budget purchased from NSF[d]	14%	49%
R5	Usage of ship spares per dollar of ship capital cost ($ per $)	0.00362	0.00362
R6	Usage of aircraft spares per aircraft flying hour ($ per hr)	871	871
R7	Percentage of total spares usage by "others"	10%	10%
R8	Percentage of NSF sales made to the NIF	22%	15%
R9	Percentage of NSF sales made to Navy non-spare users	4%	3%
R10	Percentage of NSF sales made to other services and FMS	11%	13%
Percentage of NSF O&M sales with various procurement lead times:			
R11.0	0 years	0%	0%
R11.1	1 year	38%	31%
R11.2	2 years	21%	20%
R11.3	3 years	27%	30%
R11.4	4 years	11%	15%
R11.5	5 years	3%	4%
R11	Average procurement lead time for NSF O&M sales (years)	2	2
Percentage of NSF Procurement sales with various procurement lead times:			
R12.0	0 years	0%	0%
R12.1	1 year	4%	2%
R12.2	2 years	22%	22%
R12.3	3 years	42%	43%
R12.4	4 years	26%	26%
R12.5	5 years	7%	7%
R12	Average procurement lead time for NSF Procurement sales (years)	3	3
R13	Percentage of NSF O&MN plus Procurement sales made to O&MN funds	88%	76%
R14	Percentage of NSF O&MN plus Procurement sales made to Procurement funds	12%	24%

Notes: Most of the historical factors are averages over the period shown. Ratios were calculated by summing the numerators and denominators before dividing (rather than calculating yearly ratios and then averaging). The "80-87" factors for R8 and higher were computed with 1981-87 data because 1980 was missing. For both sets of factors, R5 is computed for 1989, R6 is averages over 1986-87, and R7 is a rough estimate.

[a] Procurement = SCN + APN + WPN + OPN.

[b] TOA = O&MN + Procurement.

[c] R3 is obtained by dividing NSF O&MN sales by total spares O&MN.

[d] R4 is obtained by dividing NSF Procurement sales by total spares Procurement.

The first column of figures in Table 2, most of which are averages over most or all of the 1980-87 period, were used for the validation exercise presented in Section IV. The second column of figures, which are averages over the last two years of data, FY 1987-88, was computed to show the sensitivity of the inventory predictions to the historical factors for different time periods.

The first two historical factors would be used in calculating the spares budgets, which are required inputs for the model, at times in the yearly budget cycle when only the total budgets might be known.

In selecting an analytical form for the flow equations (inflows and outflows), we followed the dictum that "simpler is better," and chose a simple linear form:

$$\text{yearly flow} = \text{yearly planning variable} \times \text{historical factor.}$$

The success of the validation exercise described in Section IV suggested that the linear formulation was satisfactory.

The following subsections discuss the expressions listed in Table 1.

1. Inflows to Navy Stock Fund

The Navy Stock Fund obtains its new stockage through purchases from suppliers (private contractors, other service stock funds, and the Defense Logistics Agency). We have modeled these receipts. A central assumption of the model is that the stock fund plans these purchases in anticipation of future Navy spares TOA, and that spares TOA is based, in turn, on expectations about Fleet size and optempo. In other words, spares TOA is being used as a proxy for the variables that determine the Navy's need for spares. To apply the model at a time in the budget cycle when spares budgets are not known, the analyst must estimate them from total budgets—for example, by multiplying them by the recent ratio of spares to total budgets. These ratios, derived from data in Section III, have averaged 16.6 percent for O&MN and 6.4 percent for Procurement in recent years.

Note that NSF receipts are not set strictly equal to Navy spares TOA. First, the stock fund managers know that the Navy operating forces will not buy all their stockage from the stock fund, but will spend some of their TOA in direct purchases from ultimate suppliers. Second, as already discussed, the Navy Stock Fund buys more than just Navy spares in the five Budget Projects. It buys some non-spare items for the Navy, and some spares and other items for non-Navy users. Our model assumes, however, that Navy spares TOA is a good predictor for all NSF receipts, that the demands for items other than Navy spares move together with the demands for Navy spares.

To further illustrate this key behavioral assumption, suppose it is 1991 and the managers of the stock fund see that the Navy has a spares TOA of \$100 in 1995. That is, the Navy is planning to spend \$100 for spares in 1995. The managers of the stock fund know that the role of the stock fund is to supply a major part of those demands, say 90 percent, and they place enough orders in the intervening years to produce $90 worth of deliveries in 1995. They request and receive Stock Fund Obligational Authority to make these purchases.

Our behavioral assumption ignores the possibility that stock fund managers might explicitly decide to meet future demands partly by drawing down existing stocks, rather than by exclusively buying new stocks in anticipation of future budgets. Our understanding is that they have not done this to any appreciable extent in the past. If planners think this will occur in the future, our model could be simply modified by reducing R1 in the first term in Table 1.

Other factors may enter the deliberations of the stock fund managers as they plan orders, but we assume that future spares TOA is a reasonable proxy for these considerations, good enough to yield a model with good predictability. As with all the model's assumptions, we will test the validity of this assumption in the validation phase.

Procurement lags have not entered the picture so far because we have been assuming that the spares budgets are fully anticipated, known years in advance. This means the stock fund can place orders in time to produce deliveries soon enough to meet the demands reflected in planned levels of TOA. The next stock fund inflow, "Unanticipated Receipts" in Table 1, deals with the case of unanticipated budget changes, where lags must be considered explicitly. We can retain our principal behavioral assumption that TOA equals deliveries, even in the case of unanticipated budget changes, by determining the lagged deliveries the unanticipated budget changes would lead to, and adding these to the anticipated spares TOA. The algorithm for determining these lagged deliveries is described in Section V. It handles both increases and decreases in anticipated budgets.

The final stock fund inflow in Table 1 accounts for the fact that the stock fund inventory can grow also by purchasing repaired items from the Navy Industrial Fund. We assume that these purchases also are keyed to Navy spares TOA.

2. Outflows from Navy Stock Fund

The outflows from the Navy Stock Fund are straightforward. The users are the sole spenders of O&MN funds, and the portion of their budget that they spend on NSF items is therefore the extent of the NSF sales to the users. The same logic holds for the next expression, since the Hardware Systems Commands (HSCs) are the sole spenders of Procurement funds.

The last three terms capture the sales of consumables to the NIF for purposes of repair, the sales of non-spares items (clothing, subsistence, and medical/dental items) to Navy users, and the sales of spares to other services and for Foreign Military Sales. The R's are a little more complicated in these cases, due to a conflict between convenience and modeling. The historical factors R8, R9, and R10 are *defined* (Table 2) as the average ratios of NIF sales (and the other two sales) to *total* NSF sales, since we thought this was the most common form of the information. The NIF sales (and the other two sales), however, are *calculated* by a linear relation to only a *part* of NSF sales, the sales made to Navy users directly and via HSC, which we modeled from O&MN and Navy Procurement. This is what led to the complicated R's in the last three equations of the NSF outflows. (If a jar has 20 percent red marbles and the rest white, the number of red equals the number of white times .20/(1 – .20).)

3. Inflows to User Inventories

The first two terms are identical to the first two NSF outflow terms, being the "receiving" part. The third and fourth terms are the complements of the first two terms: What the user does not purchase from the NSF, it buys from suppliers directly, and the same is true for HSC purchases. The percentage of user O&MN purchased from NSF plus the percentage purchased directly sum to unity. There is a slight variation in the last term. HSC procurements from ultimate suppliers are orders, not deliveries like HSC purchases from the stock fund, so deliveries in a given year are lagged. We used three years, the average lag for procurement purchases.

4. Outflows from User Inventories

Spares usage by ships is keyed to the total capital value of the Fleet, found by adding up the procurement cost of all active ships expressed in FY 1991 dollars. The cost of the lead ship of the class was used. We used total capital value because it was found to be a good determinant of ship spares usage in regression analysis reported in Appendix E.

Aircraft spares usage was assumed to be proportional to total Fleet flying hours, a common assumption in aircraft studies. Note that whereas ship usage is related to a force level only (total capital value of the Fleet at a given point in time), aircraft usage depends on both forces and optempo (total aircraft flying hours per year). It would be satisfying, in future work, to search for relationships relating both ship and aircraft usage to both forces and optempo, and even complexity of the equipment.

Data are lacking on spares usage by end users other than ships and aircraft, such as laboratories, test and evaluation sites, and hospitals. We assumed this "Other Navy Usage" was 10 percent of total usage, the best guess by an expert in the supply system. The R term is complicated for the reason given in the previous discussion of outflows from the Navy Stock Fund.

III. DATA, CALCULATION OF HISTORICAL FACTORS, AND ILLUSTRATIVE SPREADSHEET

A. DATA AND HISTORICAL FACTORS

Tables 3 and 4 show the data that were assembled for use in constructing the model and deriving the historical factors. Definitions and data sources are given in notes to Table 3. The historical factors calculated from the data are shown in Table 2 in the previous section.

For purposes of the validation exercise, we estimated the historical ratio for ship spares usage by dividing the usage of ship spares by the capital value of the Fleet, both for FY 1989. The usage figure was obtained by adding up the categories of ship support cost that dealt with spares in the VAMOSC-Ships database. (VAMOSC stands for Visibility and Management of Operating and Support Costs.) We have not made an independent check of the VAMOSC-Ships database, but it is generally regarded as accurate. Our discussions with Information Spectrum, Inc., the contractor that maintains the database, suggests that VAMOSC-Ships has received "tender loving care" for many years.

The historical factor for aircraft usage was calculated by dividing aircraft spares usage by total flying hours for FY 1986-87. The spares usage was obtained from the VAMOSC-Air database. Unlike VAMOSC-Ships, however, VAMOSC-Air is not regarded as an accurate source, and Section IV includes a sensitivity analysis showing the effect of alternative assumptions about aircraft usage on spares inventory.

Appendix E presents some regression analysis that supports our choices of factors for estimating ship and aircraft spares usage.

The lags were obtained from a one-year snapshot of Navy Stock Fund deliveries; 5 percent of BP14 items took one year to obtain, etc. The lags for the various BPs were translated into lags for the two appropriations by using the distribution of O&MN and Procurement NSF sales across BPs as weighting factors.

Table 3. Cost Data (Costs in Millions of FY 1991 Dollars)

	80	81	82	83	84	85	86	87	88
Total Budget									
O&MN	23,638	25,777	26,824	27,547	28,009	30,816	27,856	27,308	28,111
Procurement[a]	24,103	28,236	33,189	42,014	36,781	37,109	35,914	35,602	39,794
TOA	47,741	54,014	60,013	69,561	64,790	67,925	63,770	62,909	67,905
Budget for spares									
Actual									
O&MN	1,669	1,793	2,530	2,934	3,064	4,094	4,745	4,798	4,370
Procurement[a]	1,731	2,292	2,411	2,861	2,902	2,344	2,028	2,601	2,210
TOA	3,400	4,085	4,941	5,795	5,966	6,438	6,773	7,399	6,579
Percentage of total									
O&MN	7.1%	7.0%	9.4%	10.7%	10.9%	13.3%	17.0%	17.6%	15.5%
Procurement	7.2%	8.1%	7.3%	6.8%	7.9%	6.3%	5.6%	7.3%	5.6%
TOA	7.1%	7.6%	8.2%	8.3%	9.2%	9.5%	10.6%	11.8%	9.7%
NSF repair expenditures									
BP81		152	277	247	313	378	377	374	
BP85						731	1,507	1,196	
Total		152	277	247	313	1,109	1,885	1,570	
NSF obligational authority									
Orders	3,334	4,477	5,188	5,118	7,375	6,171	5,251	4,564	
Deliveries			2,413	3,621	4,267	4,298	5,923	5,310	4,506
NSF capital augmentation									
Budget				305	614	670	433	386	308
Deliveries						221	479	555	390
NSF sales summary									
O&MN									
BP14 Ship Consumables				319	369	443	393	341	241
BP28 Defense Log. Agency				1,158	1,088	1,107	1,053	1,082	1,075
BP34 Aircraft Consumables				225	410	365	276	327	306
BP81 Ship Repairables				616	678	826	816	777	624
BP85 Aircraft Repairables						753	407	1,179	1,290
Total O&MN		831	2,415	2,318	2,546	3,494	2,945	3,706	3,535
Procurement									
BP14 Ship Consumables				5	7	5	7	5	5
BP28 Defense Log. Agency				10	13	16	22	21	14
BP34 Aircraft Consumables				2	3	8	3	4	18
BP81 Ship Repairables				44	103	93	70	71	94
BP85 Aircraft Repairables							807	1,055	1,058
Total Procurement		29	83	61	127	122	908	1,156	1,190
Other									
NIF		372	1,083	1,094	1,201	1,302	1,091	1,074	1,008
Navy Non-Spares		72	208	196	223	219	184	221	248
Other Services & FMS		128	375	394	416	574	754	950	846
Total Other		572	1,666	1,684	1,840	2,095	2,029	2,245	2,102
Total O&MN + Procurement		860	2,498	2,379	2,673	3,616	3,853	4,862	4,725
Total sales		1,432	4,164	4,063	4,513	5,711	5,882	7,107	6,827

Table 3. Cost Data (Costs in Millions of FY 1991 Dollars) (Continued)

	80	81	82	83	84	85	86	87	88	89
NSF receipts										
BP14 Ship Consumables	481	632	668	794	847	973	791	713	674	
BP28 Defense Log. Agency	1,227	1,145	1,741	1,860	1,999	2,268	1,858	1,779	1,877	
BP34 Aircraft Consumables	916	884	874	1,177	1,479	1,562	1,306	1,426	1,493	
BP81 Ship Repairables		349	536	1,140	1,358	1,676	1,313	1,468	1,183	
BP85 Aircraft Repairables						1,064	2,365	1,721	1,821	
Total	2,625	3,010	3,819	4,971	5,683	7,544	7,633	7,107	7,047	
Spares inventory (NavCompt)										
NSF										
BP14 Ship Consumables	998	1,003	1,497	1,565	2,192	2,669	2,821	2,710	2,990	
BP28 Defense Log. Agency	565	612	818	1,224	1,283	1,330	1,617	2,180	2,309	
BP34 Aircraft Consumables	1,547	1,610	1,792	2,119	3,167	3,336	3,700	4,249	4,583	
BP81 Ship Repairables			3,418	4,265	5,301	8,224	8,779	8,528	9,761	
BP85 Aircraft Repairables							17,923	16,502	17,259	
Total NSF	3,110	3,225	7,525	9,173	11,943	15,559	34,839	34,169	36,902	
Users										
O&M	3,109	3,278	3,022	2,941	2,411	1,344	2,648	3,078	2,825	
Procurement	9,370	9,248	8,065	7,756	7,208	8,903	4,268	1,451	1,733	
Total users	12,479	12,526	11,086	10,696	9,620	10,247	6,916	4,530	4,558	
Total inventory	15,589	15,751	18,611	19,869	21,563	25,805	41,755	38,699	41,460	
Spares Usage										
Ships										
Number	436	443	455	460	468	478	492	490	490	
Capital cost	251,864	255,624	267,044	286,756	295,391	304,201	321,814	328,482	336,853	350,000
Spares usage										1,268
Aircraft										
Number	5,564	5,717	5,504	5,520	5,599	5,514	5,482	5,901		
Flying hours (millions)	1.48	1.87	1.84	1.84	1.87	1.94	1.94	1.91		
Spares usage							1,553	1,804		

Sources: Total and spares budgets, and NavCompt spares inventory were obtained from the Office of Budget and Reports in the Office of the Navy Comptroller. Most NSF data were obtained from NSF budget exhibits SF-4 (Inventory Status) and SF-6 (Reimbursable Issues). Exceptions are orders (under NSF obligational authority), which were obtained from SF-2 (general Narrative Justification), and NSF repair expenditures, which were obtained from SF-3 (Operating Budget Requirements). Total ship capital cost was derived by combining numbers of ships from the VAMOSC-Ships database and lead-ship unit costs obtained from the Naval Center for Cost Analysis. Aircraft flying hours were obtained from the VAMOSC-Air database. Ship and aircraft spares usage were obtained from the VAMOSC-Ships and VAMOSC-Air databases.

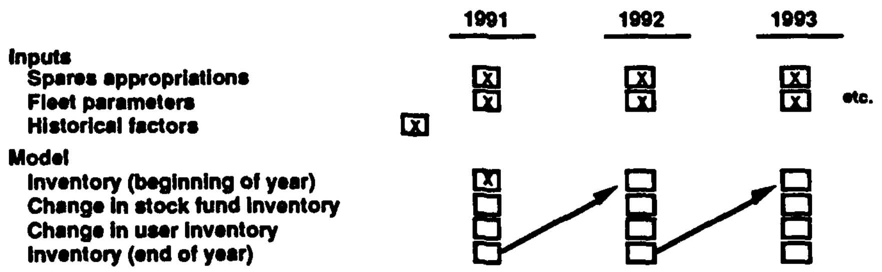
a Procurement = SCN + APN + WPN + OPN.

Table 4. Percentage of Sales by Budget Project and Years

Percentage of sales with delivery lag of:	0 years	1 year	2 years	3 years	4 years	5 years	Average Lag
By Budget Project							
BP 14 Ship Consumables		5%	52%	41%	2%		
BP 28 Defense Log. Agency		100%					
BP 34 Aircraft Consumables		5%	52%	41%	2%		
BP 81 Ship Repairables			22%	44%	27%	7%	
BP 85 Aircraft Repairables			22%	44%	27%	7%	
BP 81 repair	100%						
BP 85 repair	100%						
By Appropriation							
1981-87							
O&MN		38%	21%	27%	11%	3%	2.2
Procurement		3%	22%	42%	25%	7%	3.1
1987-88							
O&MN		31%	20%	30%	15%	4%	2.4
Procurement		1%	22%	43%	26%	7%	3.1

B. ILLUSTRATIVE SPREADSHEET

The remainder of this section discusses how data and historical factors are combined to calculate inventory levels. Figure 3 illustrates the structure for several years. The three types of inputs—spares appropriations, Fleet parameters, and historical factors—would be combined with the flow equations derived in the previous section to produce the yearly changes in inventory levels. (Inflow minus outflow equals change in inventory, done separately for the stock fund and user stockroom inventories.) Table 5 shows a simple spreadsheet for these calculations. The figures are actually the first several years of the 1980-88 validation exercise, using the 1980-87 historical factors described in Section IV. (Data for 1987 yield inventory flows for 1987, and thus beginning-of-year inventory for 1988.) The extra terms in Table 5 (Transfers and Repricings) are explained later.



Notes: Change in inventory = inflows – outflows. Boxes marked with "X" are inputs; the others are calculated.

Figure 3. Structure of the Model

Table 5. Illustrative Case (Costs in Millions of 1991 Dollars)

		80	81	82	83
Yearly Inputs					
O&MN ($M)		14,181	15,235	21,501	24,934
Procurement ($M)		24,646	32,637	34,328	40,736
TOA ($M)		38,827	47,872	55,829	65,672
Fleet cost ($M)		251,864	255,624	267,044	286,756
Flying hours (M)		1.48	1.87	1.84	1.84
Historical Factors					
B1 Ratio of spares O&MN to total O&MN	0.12				
B2 Ratio of spares Procurement to total Procurement	0.07				
R1 Ratio of NSF receipts from suppliers to spares TOA	0.92				
R2 Ratio of NSF spending on repair to spares TOA	0.12				
R3 Percentage of user budget purchased from NSF	76%				
R4 Percentage of HSC budget purchased from NSF	14%				
R5 Usage of ship spares per dollar of ship capital cost ($ per $)	0.00362				
R6 Usage of aircraft spares per aircraft flying hour ($ per hour)	871				
R7 Percentage of total spares usage by "others"	10%				
R8 Percentage of NSF sales made to the NIF	22%				
R9 Percentage of NSF sales made to Navy non-spare users	4%				
R10 Percentage of NSF sales made to other services and FMS	11%				
R11 Average administrative plus production lag for O&MN(years)	2				
R12 Average administrative plus production lag for Procurement(years)	3				
R13 Percentage of NSF O&MN plus Procurement sales made to O&M funds	88%				
R14 Percentage of NSF O&MN plus Procurement sales made to Procurement funds	12%				
Spares Budgets					
O&MN for spares ($M)		1,669	1,793	2,530	2,934
Procurement for spares ($M)		1,731	2,292	2,411	2,861
TOA for spares($M)		3,400	4,085	4,941	5,795
Inventory Flows ($M)					
NSF Inflows					
Receipts from suppliers due to TOA = TOA x R1		3,122	3,751	4,537	5,322
Purchases of repaired items from NIF = TOA x R2		421	506	612	718
Transfer of BP 81 from users			2,667		
Repricing of BP 81 transfer			751		
Transfer of BP 85 from user					
Repricing of BP 85 transfer					
Previously unrecorded inventory of BP 85					
Total		3,543	7,676	5,150	6,040
NSF Outflows					
Sales to Navy users directly = O&MN x R3		1,272	1,366	1,928	2,236
Sales to Navy users via HSC = Procurement x R4		247	327	344	408
Sales to the Industrial Fund = (NSF sales to users+HSC) x R8/(1-(R8+R9+R10))		528	589	790	920
Sales to Navy non-spare users = (NSF sales to users+HSC) x R9/(1-(R8+R9+R10))		97	108	145	169
Sales to other services and FMS = (NSF sales to users+HSC) x R10/(1-(R8+R9+R10))		263	293	393	458
Total		2,406	2,683	3,600	4,190
User Inflows					
Received from NSF directly = O&MN xR3		1,272	1,366	1,928	2,236
Received from NSF via HSC = Procurement x R4		247	327	344	408
Purchases from suppliers directly = O&MN x (1-R3)		397	427	602	698
Purchases from suppliers via HSC = Procurement (3rd prior year) x (1-R4)		1,484	1,966	2,068	1,484
Total		3,400	4,085	4,941	4,826
User Outflows					
Ship usage = Fleet cost x R5		912	926	967	1,039
Aircraft usage = Flying hours x R6		1,286	1,633	1,601	1,603
Other = (Ship usage+aircraft usage) x R7/(1-R7)		244	284	285	294
Transfer of BP 81 items to NSF			2,667		
Transfer of BP 85 items to NSF					
Total		2,443	5,510	2,853	2,935
Summary of Inventory Flows ($M)					
NSF		1,137	4,993	1,550	1,851
User		957	-1,425	2,088	1,891
Total		2,094	3,568	3,638	3,741

The yearly inventory changes calculated as in Table 5 would be used to update the yearly inventory levels (Figure 3). The beginning-of-year inventory for 1980 plus the change in inventory during 1980 equals the beginning-of-year inventory for 1981, etc.

Because the model estimates only changes in the inventory, the inventory for the first year of analysis must be supplied by the user. We chose the 1980 inventory level reported by NavCompt.

C. DATA CONSISTENCY

There are two issues concerning the consistency of the data. The first issue is whether the budget and VAMOSC usage data—the ultimate source and sink of the flow of spares inventory—are expressed in the same units. The answer is yes. They both deal with the full range of spares: initial and replenishment, consumable and repairable, and positioned at all echelons of supply (consumer retail, intermediate retail and wholesale in supply terms; organizational, intermediate and depot-level in maintenance terms). In addition, the budget and VAMOSC data both deal with the same kinds of resources: materials cost of consumables and repairables, plus labor cost of repairing repairables. Finally, they both use the same kinds of dollars, in that the budgets are used to purchase items at the "standard" prices, the sum of replacement cost (historical prices plus inflation) plus a variety of factors, such as second destination transportation and losses, that are included in a surcharge. (See Appendix A for a fuller discussion of stock fund pricing.)

The next question also has a satisfying answer: Is there a solid connection between the dollar inventories the model forecasts and the real resources that are related to readiness? If "real" means constant, as opposed to then-year dollars, the answer is yes. All costs are expressed in constant FY 1991 dollars. There is not, however, an exact link between constant-dollar inventories and physical stocks. For one thing, the surcharges have changed over time in the past, and will probably do so in the future. This would not affect future inventory predictions, however, if future budget projections are adjusted accordingly. Even if budgets are not adjusted, this would not vitiate the usefulness of the model, if we remember that its application is drawing out the overall implications of planning factors regarding spares budgets and the characteristics of the Fleet that uses the spares.

IV. VALIDATION OF THE MODEL

The validation exercise consists of using budget and Fleet data, along with the FY 1980-87 historical factors, to calculate the changes in inventory during FY 1980-87, and then comparing the resulting inventory levels with those reported by the Navy Comptroller for the period FY 1980-88. (The flow during FY 1987 is used in calculating the beginning-of-year inventory for FY 1988.) The NavCompt figures for FY 1980 were used as the starting inventories for the model. The results, shown graphically in Figures 4 through 6, indicate excellent agreement for Navy stock fund inventories but poor agreement for the user inventories. The remaining parts of this section amplify and discuss these results.

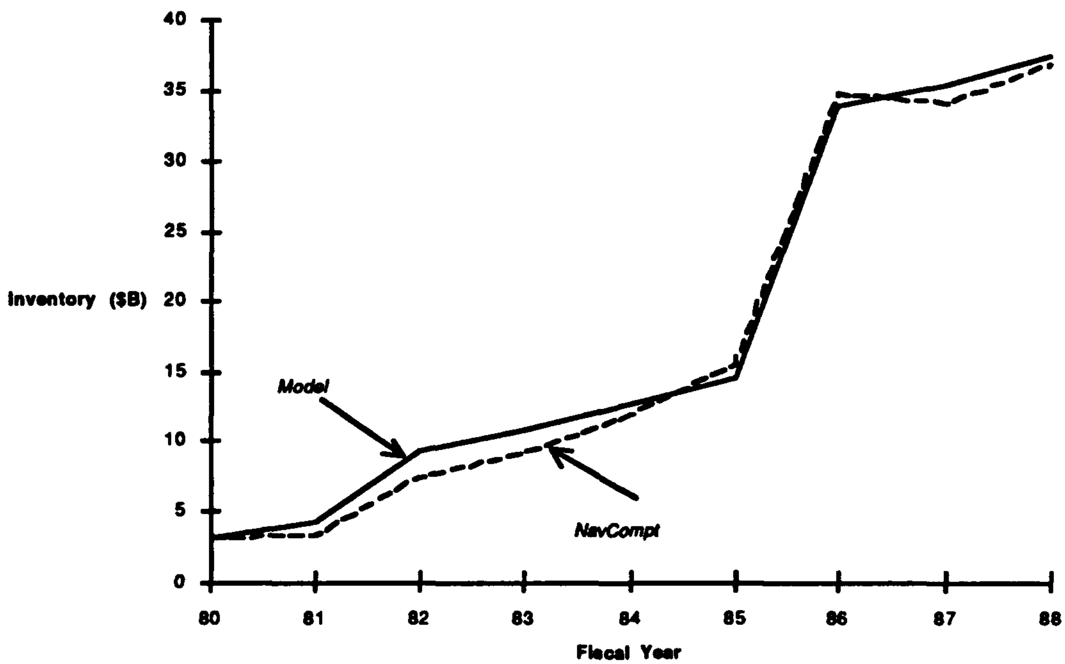


Figure 4. Navy Stock Fund Inventory

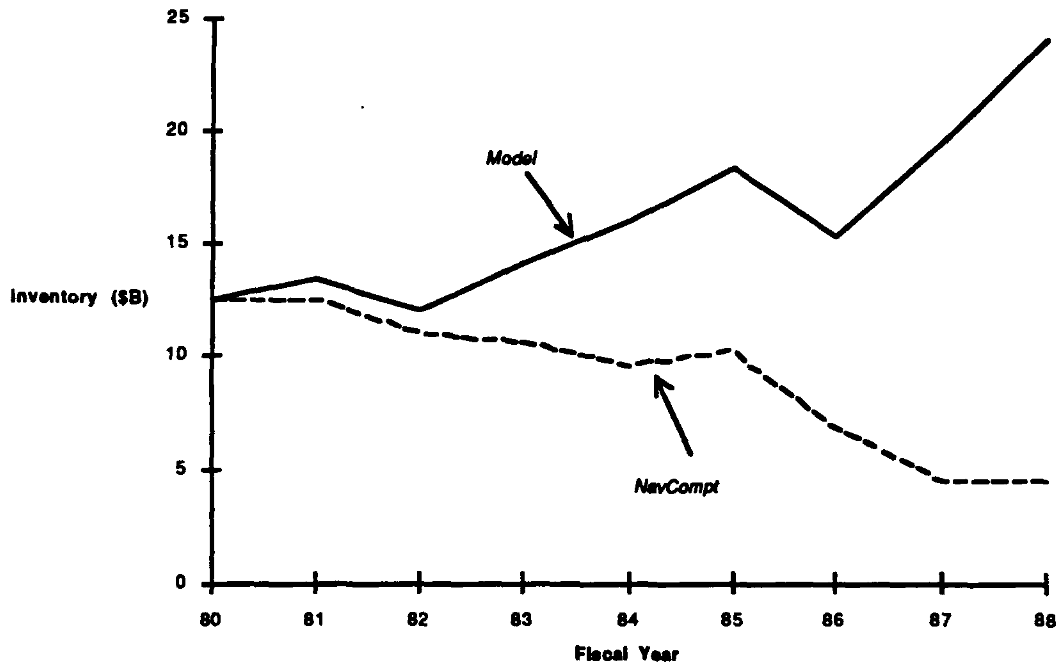


Figure 5. User Inventory

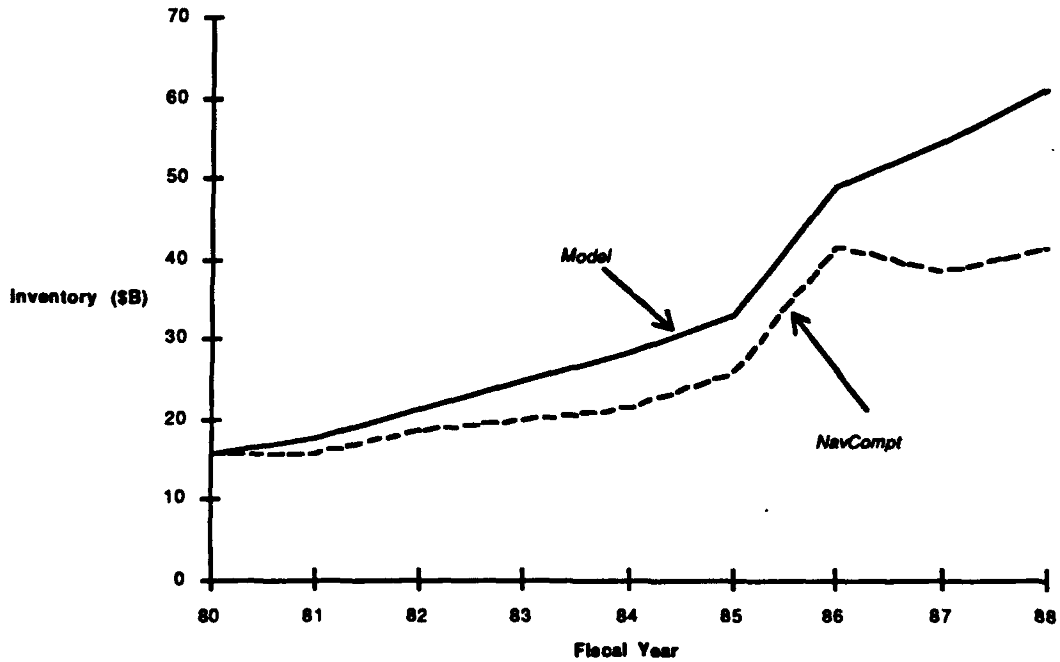


Figure 6. Total Inventory

A. ACCOUNTING CHANGES

Table 6 shows the calculation of the full change in inventory during FY 1980-87. The figures include several terms that were not computed from the model's flow equations. These are accounting changes that occurred during the period. Accounting changes could not be included in the model because they are one-time adjustments that are not systematically related to changes in spares budgets or other major planning assumptions. We obtained the figures from individuals who were part of the supply community when the changes were made, and who had some knowledge about the amounts of money that were involved.

Table 6. Calculated Change in Navy Spares Inventory During FY 1980-88

NSF Inflows	
Receipts from suppliers due to TOA	$40.9 billion
Receipts from suppliers due to capital augmentation	1.5
Purchases of repaired items from NIF	5.6
Accounting changes	
BP 81 transfer from users	2.7
BP 81 repricing	0.8
BP 85 transfer from users	6.6
BP 85 repricing	9.5
Previously unrecorded	1.8
Unanticipated receipts	0.0
Total	$69.3
NSF Outflows	
Sales to Navy users directly	$19.5 billion
Sales to Navy users via HSC	2.7
Sales to NIF	7.7
Sales to Navy non-spare users	1.4
Sales to other services and FMS	3.9
Total	$35.3
User Inflows	
Received from NSF directly	$19.5 billion
Received from NSF via HSC	2.7
Purchases from suppliers directly	6.1
Purchases from suppliers via HSC	16.4
Total	$44.8 billion
User Outflows	
Ship usage	$8.4 billion
Aircraft usage	12.8
Other Navy usage	2.4
Accounting changes	
BP 81 transfer to NSF	$2.7 billion
BP 85 transfer to NSF	6.6
Total	$32.8

The BP 81 and 85 transfers (outflows from user inventories and inflows to stock fund) occurred in 1981 and 1985, respectively, when ship and aircraft repairables were transferred from end-use to stock fund accounting. The repricing terms in the inflow to the stock fund are due to the fact that the cost of many repairables that had been purchased years ago and placed in the user inventory had not been adjusted for inflation until they were transferred from user inventory to stock fund. The final accounting change in the inflow to the stock fund is due to the fact that some of the aircraft repairables that were entered into the stock fund had previously been under no accounting system whatsoever.

B. COMPARISON OF MODEL AND NAVCOMPT STOCK FUND FIGURES

The fact that the model's calculations agree so closely with the NavCompt figures for the stock fund (Table 7 and Figure 4) offers strong validation of the model. The NavCompt figures for the stock fund are generally regarded as accurate: Stock fund activities are monitored by an automated financial accounting system, and the data are sent to NavCompt for publication in the Annual Inventory Report sent to Congress. The agreement between the model and NavCompt is partially explained by the fact that the model does not calculate everything from the ground up, but uses historical factors that were calculated from the actual data for the period. The agreement is not, however, the result of a mathematical identity. Evidence for this is the fact that, whereas a single set of planning factors is used, Figure 4 shows that the model agrees with the NavCompt figures equally well along the entire FY 1980-88 period. This suggests there is some underlying stability in the data, and that using the model with historical factors calculated from past data would provide "roughly right" forecasts for the future.

Table 7. Comparison of Model and NavCompt Inventory Changes During FY 1980-88 (Cost in Billions of FY 1991 Dollars)

	Calculated by model[a]	Reported by NavCompt
Stock Fund	34.0	33.9
User Inventory	12.0	- 7.9
Total	46.0	26.0

[a] From Table 6.

C. COMPARISON OF MODEL AND NAVCOMPT USER INVENTORY FIGURES

We do not have a complete explanation for the large disparity between the model and NavCompt figures for user inventory, as shown in Table 7 and Figure 5, but it is not clear that the fault lies with the model. First, the NavCompt figures for the user inventory may not be reliable. The inventory of items under end-use accounting (which we have called user inventories) are not monitored by an automated financial accounting system as are the stock fund inventories. Ships and the other operational activities certainly keep track of stockage levels so they know when to reorder. But there is no computer system that keeps track of the total value of the inventory in dollar terms. Rather, the inventories of user activities are roughly estimated by the Commanders-in-Chief of the Atlantic and Pacific Fleets from data such as Consolidated Shipboard Allowance Lists (COSALS), Aviation Consolidated Allowance Lists (AVCALS), and Consolidated Shore-Based Allowance Lists (COSBALS), and the Fleets send the estimates to NavCompt in annual letters. NavCompt included these estimates in the Annual Inventory Report up until 1985, and we used these figures. For the years 1986-87, when the Annual Inventory Report stopped reporting end-use inventories, we used the figures in the Fleet letters themselves. For simplicity, we refer to all the end-use data as the "NavCompt figures."

Another problem with the NavCompt figures for user inventories is that the precipitous drop violates the conventional wisdom that spares inventories rose during the Reagan years, 1980-88. The Fleet grew in size, support budgets rose, spares fill rates increased, and the number of casualty reports fell (improved), all suggesting an increase in inventories.

It has been suggested that procurement lags could help explain the fall in user inventories reported by NavCompt. The reasoning would be that increased funding for support may lead to new orders, but the deliveries do not come until later because of the procurement lags. This mechanism, however, might explain the lack of a rise in inventories, during periods of growing support budgets, but it could not explain the precipitous fall in the NavCompt data.

Pointing to problems with the NavCompt figures, however, does not prove that the model's calculations are exact. The model probably overestimates the increase in user inventory. First, the historical factor for aircraft spares usage per flying hour is probably too low. A 1983 audit by the VAMOSC-Air project manager, who is located at the Patuxent Naval Air Test Center in Patuxent, Maryland, found that the VAMOSC-Air database was at that time capturing only about one-third of all supply actions. The Navy is now undertaking a major review of this database to determine how to improve it, but it will take time to produce good historical data. We have tried to minimize problems by using the last two years of data, FY 1987-88, in calculating the historical factor for aircraft spares usage.

We also undertook a sensitivity analysis of aircraft usage, to see if the likely underestimation of it could help to explain the disparity between the model and NavCompt user inventories. (Usage has no effect on stock fund inventory.) Figure 7 shows that doubling the historical factor relating to aircraft usage (RG in Table 2) does, indeed, remove the disparity. This is a sizable increase in aircraft usage, but not extreme given the results of the 1983 audit. The truth probably lies between the top model curve and the NavCompt one in Figure 7 (perhaps nearer the model curve in view of the conventional wisdom regarding support during the Reagan years). We can certainly conclude from Figure 7 that obtaining better data on aircraft usage is an important ingredient in improving our ability to forecast spares inventories held by users.

The other problem with the model's estimate for user inventory concerns the estimate of "Other Navy Usage," one of the outflows from user inventories. Our figure that it is 10 percent of the total is a rough estimate by an analyst and retired Naval officer who has much experience in the Naval supply system. He states that there is little data on this variable, however, and that the figure could be higher. This, too, would lower the model's estimate of user inventory.

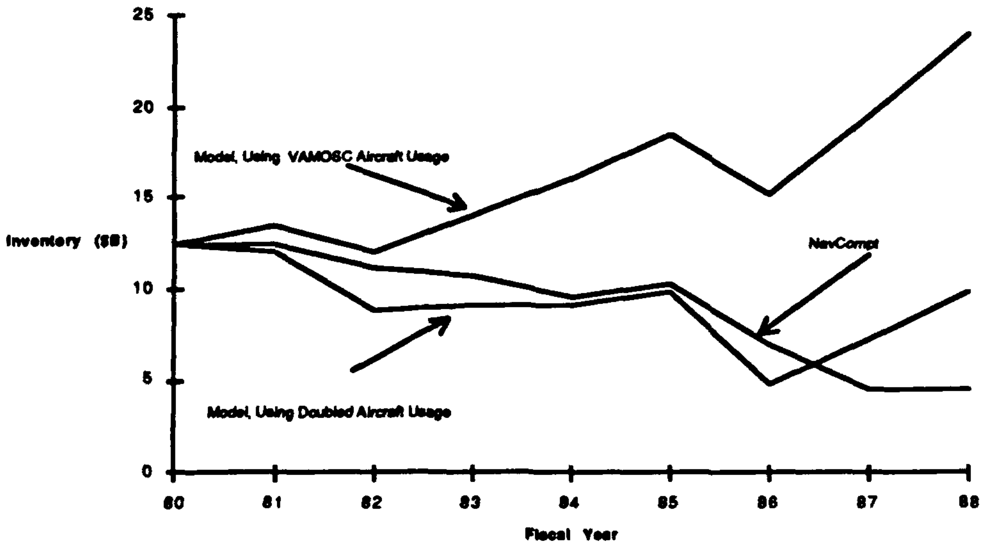


Figure 7. Effect of Aircraft Spares Usage in User Inventory

V. USE OF THE MODEL

This section discusses several issues concerning how the model would be used for forecasting: choice of budget and Fleet inputs, sensitivity to the choice of historical factors, and how to accomodate unanticipated budget changes.

A. CHOICE OF INPUTS

To use the model for forecasting, one could use the historical factors given in this report, and therefore have to assemble only four time-series of data: the O&MN and Procurement budgets, and the Fleet descriptions measured by ship capital value and aircraft flying hours. The user could get by with even less data by accepting our values of budget and Fleet for FY 1988 and estimating future values by applying percentage changes.

Figure 8 shows an illustrative forecast for FY 1991-97. For the budget inputs, we started with O&MN and Procurement for FY 1990 obtained from the FY 1992 President's Budget. For FY 1991 and beyond, we assumed an annual decrease of 3 percent. This is a real decrease; all dollar amounts in this report are in constant FY 1991 dollars. There is still a lot of uncertainty in the future defense budget, but a 3-percent real decrease is not atypical in current discussions. It yields, for example, the commonly-mentioned reduction of approximately $250 billion in nominal dollars relative to the pre-cut, FY 1989 estimates for the period FY 1991-97. The spares budgets were obtained from the total budgets using the historical ratios of 12 and 7 percent for O&MN and Procurement (B1 and B2 in Table 2).

The data for Fleet capital value and aircraft flying hours were similarly obtained: Figures for FY 1990 were obtained by scaling up figures for FY 1987 using recent changes in the total number of ships and aircraft, and figures for the succeeding years were computed by applying a 3-percent annual rate of decline. This is also not an atypical assumption, given current discussions on defense.

The FY 1990 values of inventory (NSF and user) were obtained by scaling up the values for FY 1988 that were calculated in the validation exercise. (The FY 1988 figures were increased by twice the change during the single year from FY 1987 to FY 1988.) We used the historical factors for 1980-87 instead of the more recent factors for 1987-88, on grounds that spares deliveries during the later period may have been atypically high, since they came at the end of a surge in orders resulting from a large buildup.

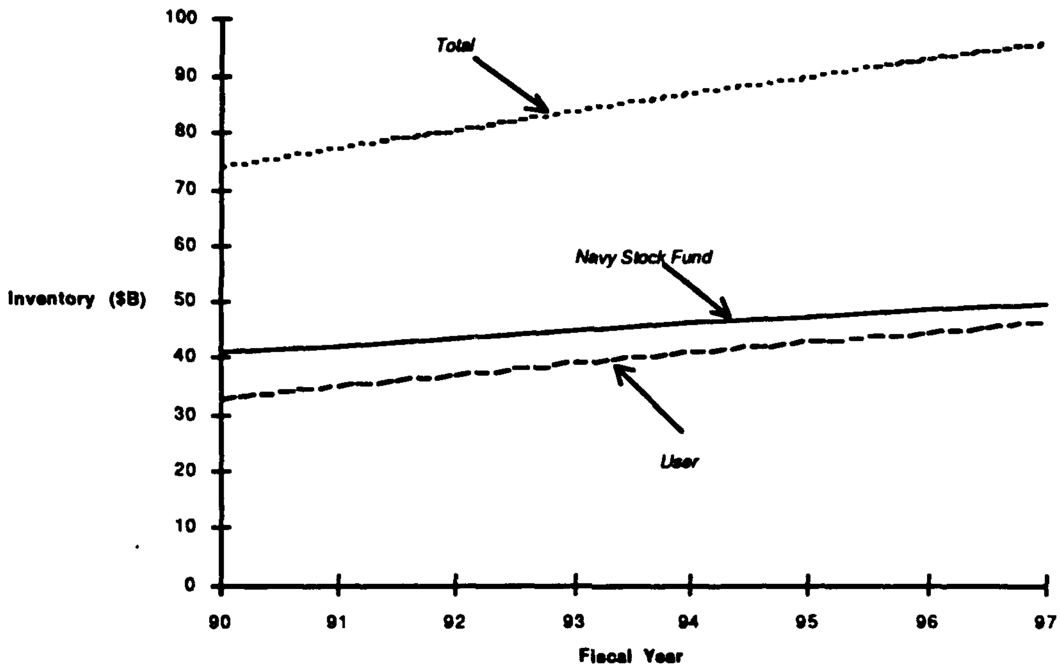


Figure 8. Inventory Forecast (Hypothetical)

Figure 8 predicts that total inventories would rise in the future, even if the budget and the ship and aircraft forces fall together. The reason is the use of historical factors from the Reagan years when inventories rose, so that even parallel reductions in budgets and forces lead to a rise in inventories.

B. SENSITIVITY TO THE HISTORICAL FACTORS

Having found that the model's predictions are heavily dependent on (albeit large) changes in aircraft spares usage, we were curious to see if the predictions are sensitive to perturbations in the historical factors taken as a whole. Large sensitivity would give us less confidence in using the model for forecasting.

For this exercise, we re-calculated inventory levels for the forecasting period using the second set of historical factors in Table 2, the ones evaluated for the last two years of data, FY 1987-88. The results, shown in Figure 9, show that he historical factors do matter, although both sets yield an upward trend in inventory level.

Analysts who want to use the model can, of course, choose any set of historical factors they wish. Our factors can be modified or eliminated altogether if the analyst has the ability to predict the effect of changing times and variations in the institutional setting.

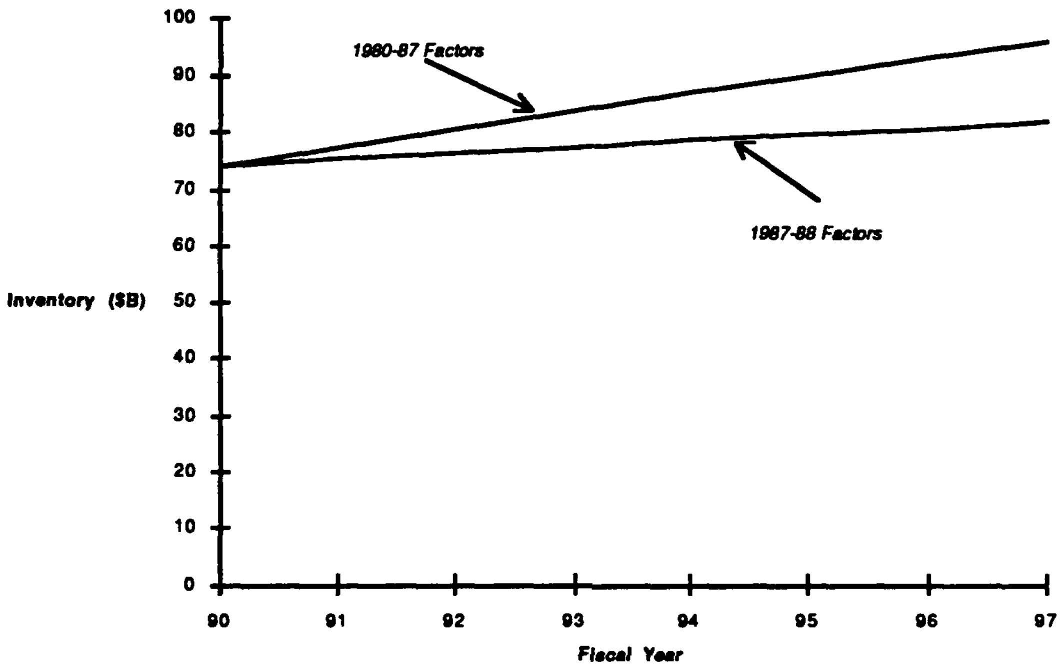


Figure 9. Sensitivity of Inventory to Historical Factors

C. LAGS AND UNANTICIPATED TOA

In Section II.C, we based the equation for stock fund purchases from suppliers on a major behavioral assumption, that the managers of the stock fund look ahead at future budgets and plan their orders so that deliveries will meet a certain percentage of the TOA. They can only do this, however, if the spares budgets are fully anticipated. This raises the question of what happens when an anticipated budget stream fails to materialize, either through increases or decreases. In this case, the procurement lags (administrative plus production) interfere with the stock fund's ability to place orders in time to meet the planned TOAs. This section deals with this case of unanticipated budget changes, where lags must be considered explicitly. We assumed the budget changes are increases for purposes of discussion, but the formalism holds equally well for budget decreases (negative increases).

"Unanticipated" changes are those that occur within the "lag period" from the present out to five years, the maximum lag in Navy purchases according to the data in Table 3. At least some of the orders to anticipate spares budgets during the lag period will already have been placed before the present year, and these items will be delivered even if the spares budget is cut in the meantime.

To handle unanticipated changes, we adopted a mechanism that retains the formal structure of the model, in which the spares budget (TOA) is viewed as deliveries. The mechanism involves adjusting the anticipated part of the spares budget by adding in the deliveries that would be produced by the unanticipated part (the "Unanticipated Receipts" referred to in Table 1). We derived an algorithm for calculating these deliveries by starting with an unanticipated change in the budget, determining when the orders would be placed (i.e., not until after the unanticipated change is assumed to be known), and then calculating the deliveries by taking explicit account of the procurement lags. Once these deliveries are added to the anticipated spares budget, the adjusted budget can once again be treated in the model as deliveries—those made in time to meet the demands of the anticipated TOA, plus the lag-constrained deliveries resulting from the unanticipated TOA. After developing the algorithm, we applied it to a hypothetical case showing how inventory levels adjust slower to unanticipated budget changes.

Assume that the Congress now (1991) grants a budget increase of $600 in O&MN for the future budget year 1994. This change is "unanticipated" because it occurs within the lag period. At the recent ratio of spares to total O&MN of 17 percent (B1 in the second column of Table 2), this implies an increase of approximately $100 in spares O&MN. Assume the simplified lag structure shown in Table 8: 10 percent of Navy spares take one year to obtain, given the administrative and production lead times, and so on. (This lag structure is not entirely hypothetical, having the same general structure as the actual lags for procurement funds in Table 4—rising to a peak in the third year and then subsiding.)

Table 8. Hypothetical Lag Structure

Lag (years)	Percentage of items
1	10
2	20
3	30
4	25
5	15

Given this lag structure, if the change in the budget for 1994 had been made several years ago, and were thus properly anticipated by stock fund managers, the Navy would have placed the orders shown at the top of Table 9, and would therefore have met the deliveries of $100 in 1994. The orders for items taking four and five years to procure would have been placed one and two years ago, in 1990 and 1989, respectively. Those items taking one and two years would have been ordered in 1993 and 1992 but not before, on the assumption that nothing would be gained from deliveries received before they were needed.

However, if the $100 increase in the budget for 1994 is not announced until now (1991), the pattern of orders would be as shown in the bottom of Table 9. The shorter-lag items could still be ordered as before, but since the 4-year and 5-year items could not be ordered until 1991 (the increase not being made until now), they would not be delivered in time to meet the 1994 demand.

Table 9. Hypothetical Deliveries Due to an Unanticipated Budget

	Orders					Deliveries		
	89	90	91	92	93	94	95	96
Anticipated Budget Increase								
1-year items					10	10		
2-year items				20		20		
3-year items			30			30		
4-year items		25				25		
5-year items	15					15		
Total deliveries						100		
Unanticipated Budget Increase								
1-year items					10	10		
2-year items				20		20		
3-year items			30			30		
4-year items			25				25	
5-year items			15					15
Total deliveries						60	25	15

The general picture for budget increases occurring in every year is shown in Table 10. The f's are the lag fractions: f_0 is the fraction of items with a 0-year lag (i.e., it can be delivered the year it is ordered), f_1 is the fraction with a 1-year lag, and so on. An unexpected budget increase of one dollar occurring now (1991) would lead to deliveries of f_0 dollars this year, plus f_1 dollars next year, and so on. The terms for the remaining years assume no benefit to ordering things for delivery before they are needed. Thus, the f_0 portion of an increased 1992 demand would be delivered in 1992 (along with the f_1

portion). It could have been ordered and delivered in 1991, but this would have served no purpose.

Table 10. General Delivery Pattern for Unanticipated Budget Increases

Year Receiving the Increase	Year of Delivery						
	91	92	93	94	95	96	97
1991	f_0	f_1	f_2	f_3	f_4	f_5	
1992		f_0+f_1	f_2	f_3	f_4	f_5	
1993			$f_0+f_1+f_2$	f_3	f_4	f_5	
1994				$f_0+...+f_3$	f_4	f_5	
1995					$f_0+...+f_4$	f_5	
1996						$f_0+...+f_5$	
1997							$f_0+...+f_5$

The terms in Table 10 can be easily applied to the case of unanticipated changes of different dollar amounts in different budget years. Suppose that the unanticipated changes (made in 1991) are \$100, \$200, \$300 and \$400 million for the budget years 1991 through 1994. Using the lag terms from Table 8, the total deliveries in 1994 would equal:

$$(\$100M + \$200M + \$300M) \times 30\% + \$400M \times (0\% + 10\% + 20\% + 30\%) = \$420M.$$

Note that since we are assuming that all deliveries can be made by the fifth year, the lags would not have to be considered for budget changes in the sixth year (1997) or beyond. (The sum of all the f's equals unity.)

Figure 10 illustrates how inventory levels adjust slower to unanticipated than to anticipated budget changes. The curves were calculated using the model along with the algorithm in Table 10 for unanticipated changes. The "No Cut" curve is the previously-calculated inventory forecast for 1990-97 from Figure 8. The other two curves assume that the spares budget is cut by \$2 billion in O&MN and \$1 billion in Procurement in FY 1992 and every year thereafter. The "Anticipated Cut" curve assumes the cut was made several years ago, in 1986 or earlier, and the "Unanticipated Cut" curve assumes the cut was made this year, FY 1991. Although the first order is placed in FY 1991, the inventory levels are not affected until FY 1993 because the first delivery takes a year under the lag structure we are using (from the 1980-87 historical factors in Table 3), and deliveries during a given year do not affect beginning-of-year inventory levels until the next year. As expected, inventory levels take longer to adjust to unanticipated changes.

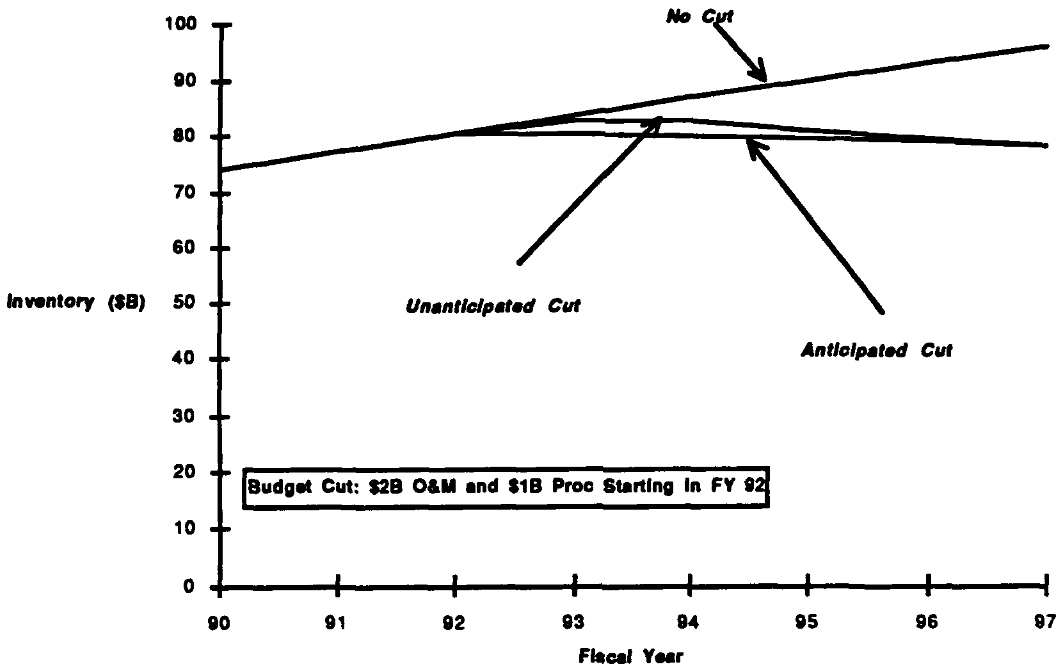


Figure 10. Lagged Response of Inventory to Unanticipated Budget Cut

D. SUMMARY

The model described in this report was designed at a high level of aggregation, to give defense analysts a convenient method for determining the implications, for future inventory levels, of budget variations and changes in the characteristics of the Fleet that determine spares usage. Stock fund and user inventories were modeled separately. Validating the model with past data proved at least partially successful, leading to close agreement with Navy Comptroller figures for inventories held by the Navy Stock Fund. The disparity in user inventories might be due mostly to the lack of automated data-gathering by NavCompt, and the underestimation of aircraft usage by the VAMOSC-Air database.

This research was sponsored by OSD as the initial project of a broad research program to develop the resources-to-readiness link for secondary items. The remaining work is therefore to extend the methodology by measuring the link between inventories and readiness, and applying the complete methodology to spares held by the other services as well as the Navy, and to other secondary items as well as spares.

APPENDIX A.

THE INVENTORY AND BUDGETING OF SECONDARY ITEMS

APPENDIX A.

THE INVENTORY AND BUDGETING OF SECONDARY ITEMS

A. INTRODUCTION

This appendix and the ones following it describe how the military services manage their secondary items. Secondary items are basic resources—spares, fuel, subsistence, medical and dental supplies, clothing, and office supplies—that support principal items such as ships, aircraft and weapon systems, as well as components of these systems such as radars, fire-control systems, and pumps.

Appendices B, C, and D discuss the Navy, Army, and Air Force management systems. This appendix introduces these discussions, and presents some basic material on secondary item funding that is common to all three services. The Navy is discussed first because it provides background for the Navy spares inventory model presented in the text, and also because the Navy has a stock fund in place for all spares, and the other two services are moving in that direction.

Although the appendices on the service systems differ somewhat in their treatment of the subject, they are all organized into five sections: an introduction (Section A), a discussion of the organizations, procedures, and data systems used in managing secondary items (Section B), a description of the sources and reliability of the data on secondary item inventories (Section C) and budgets (Section D), and a description of some of the models the services use to relate funding to inventory levels and measures of supply system effectiveness (Section E). Although the discussions focus on spares, many of the points are general and relate to the other secondary items as well.

Completeness is not the goal of these appendices. Although some details are presented, the intent is to present an overview for those new to the subject.

We use the term "spares" throughout to include both consumables and repairables (consumables are what are used to fix repairables), positioned at all echelons (consumer, intermediate, and wholesale), and funded by all methods (O&M or Procurement appropriation, or by revolving capital funds).

Important topics of DoD-wide applicability are treated specially as follows:

- Appendix B (Navy)—Sources of inventory data (Stratification Inventory Reports and the Annual inventory Report) and sources of budget data (the P-18 series procurement exhibits and the SF series stock fund exhibits).
- Appendix C (Army)—Stockage levels for various purposes.
- Appendix D (Air Force)—Categories for describing inventories.

B. SECONDARY ITEM FUNDING

Although the three services fund spares differently, they all use the mechanisms of congressional appropriation—using one of the procurement accounts or Operations and Maintenance (O&M)—or purchase by a stock fund.

1. Congressional Appropriation

The appropriation process starts when OSD transmits planning and programming guidance to the services, which the services follow in making detailed decisions on the forces, manpower, and funds required to meet the strategy and objectives established by the OSD guidance. These decisions are documented in the service's Program Objectives Memorandum (POM), which is submitted to OSD in May.

The POM is reviewed by the Joint Chiefs of Staff (JCS) and OSD, and OSD drafts issue papers that evaluate the proposals in the POM as they relate to the policy and planning guidance, and for balance among the four pillars of force structure, modernization, readiness and sustainability. The services then "reclama" (argue over some of the decisions) the issue papers, and the results of the debate between OSD and the services are reflected in decisions by the OSD Defense Resources Board (DRB). These decisions are reviewed by the Secretary of Defense, who makes the final decisions on the service programs. These decisions are described in the Program Decision Memorandum (PDM), which the Secretary of Defense signs in August as the basis for formulating the budget.

2. Stock Funds

The congressional appropriations process is a ponderous mechanism to use for funding secondary items, which are characterized by relatively low cost. In addition, the demand for secondary items is driven by the need to replenish major weapon systems and personnel, and to this extent the spending for secondary items is less discretionary than the spending for principal items. The services use stock funds to minimize these problems of inconvenience. A stock fund is a revolving capital fund, which is empowered to order and hold inventories of materiel to meet the needs of its customers. An industrial fund is another revolving capital fund that is used for funding the operation of industrial-type activities, such as depots and arsenals that manufacture and repair items.

The legal foundation for most defense financial management systems is contained in the provisions of Public Law 216. Especially relevant to the supply system is Section 405, which introduces working capital funds into the defense financial management scheme. The services' stock funds are established by the issuance of a DoD charter.

Stock funds use sales to customers (reimbursements) for buying new inventory and thus maintaining the fund's principal. The stock fund's total capital, or corpus, equals the value of inventories plus the amount of cash on hand and due in from customers. An important feature of the fund is that it acts to anticipate future needs, by planning orders early enough so that the deliveries, which can take years, will be in time to meet the services' requests for stock.

Although a stock fund uses its own cash to buy new stock, rather than "new money" (TOA, or Total Obligational Authority) obtained through Congressional appropriation, its operation is not unconstrained. First of all, the customers who buy from the stock fund use procurement and O&M funds, and these funds are obtained by congressional appropriation. Second, the fund must obtain Stock Fund Obligational Authority (SFOA) from the OSD Comptroller before buying new stock. SFOA is granted on a "sales replacement" basis. The stock fund is allowed to spend what it sold the previous year, plus an estimate of changes in projected sales.

There is an exception to the revolving capital nature of stock funds. Although such funds operate, most of the time, with a fixed capitalization initially obtained through congressional appropriation, they can go to Congress to increase the capitalization to anticipate changing conditions. The size of the Fleet may increase, as it did during the 1980s, major new weapons and equipment are introduced from time to time, existing weapons receive major upgrades and Service Life Extension Programs, and the tempo of operations may rise because of heightened emphasis on peacetime readiness or preparations for war. Such events can create a need for new stock significantly above last year's sales, a jump in total demands for its goods.

These new purchases cannot be funded, however, by increasing the prices the stock fund charges customers. DoD regulations have established stock funds as a convenient mechanism for maintaining business at the current level, not moving up to a new level. The stock fund can obtain the extra infusion of capital, a "capital augmentation," through congressional appropriation. Once the new capital is used to "buy in" the additional inventory, the stock fund maintains itself through its revolving funds.

3. Stock Fund Pricing

Stock funds are forbidden by regulation to make a profit, but are operated to simply break even over the long term. They therefore set prices to cover the long-run costs of doing business—so that revenue equals cost. Accordingly, stock funds compute prices, called "standard prices," by summing four terms:

- Historical cost.
- An allowance for inflation between the time of purchase and the present. (Historical cost plus the inflation allowance equals current replacement cost.)
- A surcharge to cover
  - second destination transportation (moving the item from where the contractor delivers it to places where it will be stored),
  - losses through obsolescence, fire, and pilferage, and
  - a "stabilization" allowance to allow for fluctuations throughout the year due to miscellaneous causes such as unanticipated inflation.
- The cost of operating the stock fund itself (overhead).

Surcharges typically vary from 10 percent to 25 percent of the prices net of surcharge. The overhead cost was covered by congressional appropriation in the past. The Navy decided just recently to include it in the surcharge (beginning in FY1991).

The standard prices are computed before each fiscal year, and are held constant throughout the year. (The stabilization allowance is intended to cover variability during the year.) The prices are approved by DoD during the budget review process, and customers of the stock fund are provided with pricing information by supply bulletins.

In summary, the three main financial features of stock fund operations—the use of standard prices, the recovery of overhead costs through appropriation or surcharge, and the granting of SFOA on a sales replacement basis—ensure that, apart from periods of rapid growth that require capital augmentation, the stock fund can maintain itself on a steady-state basis. It takes in enough to cover its long-run costs, and is able to spend what it takes in to purchase enough stock to replenish last year's sales.

4. Inventory Losses Through Obsolescence

Whether secondary items are funded through congressional appropriation or through a stock fund, there is a problem of inventory losses through obsolescence. Stockage can become useless when the equipment it is bought to support is withdrawn from service. Aircraft programs can be scaled back, weapon systems can be canceled, and tempo of operations can be cut back because of reductions in tensions. It can even happen that deliveries are obsolete the day they arrive. That this will occur some of the time is virtually guaranteed by long lead times orders. Some spares take half a decade between order and delivery, allowing plenty of time to make decisions on force levels that will eliminate the need for the spares by the time they are delivered. There are estimates, in fact, that as much as half of the Navy Stock Fund's inventory would not be needed through the budget year two years hence—"inactive" in current usage.

The existence of inapplicable inventory does not affect the financial viability of stock fund operations, since losses through obsolescence are covered by standard prices through the surcharge. However, the fact that customers must pay higher prices constitutes a dead-weight loss, since it means that the defense dollar buys less effectiveness.

How should we view losses through obsolescence? To some extent, long procurement lead times and changes in defense planning are inevitable. (Inevitable in the sense that the dollar and other opportunity costs of eliminating the losses would exceed the costs of the unneeded inventory.) On the other hand, it takes time to implement decisions on the principal items as well, and it is possible that closer coordination between decisions on principal and secondary items might save money. There are choices to consider, for example, between ordering many years of supply to save on unit costs, and maintaining smaller inventories on the shelf to minimize losses through obsolescence. Better planning might also help to eliminate sins of omission that we have ignored up to now: not ordering spares in time to support new forces during periods of build-up.

The description of the Navy supply system in Appendix B provides additional information on sources of stock fund data and other details of stock operations, including the important interaction of stock funds and industrial funds in repairing spares.

APPENDIX B.

NAVY INVENTORY AND BUDGETING OF SECONDARY ITEMS

APPENDIX B.

NAVY INVENTORY AND BUDGETING OF SECONDARY ITEMS

A. INTRODUCTION

This appendix contains four sections. The first describes the Navy's inventory management and budget process, with special attention to the secondary item requirements determination procedures and the budgeting and funding for these requirements. The next sections identify the sources of data on the inventory of secondary items, identify the sources of budget data, and finally describe some of the models used in budgeting, budget execution, and requirements determination

B. DISCUSSION

1. System Objectives

The inventory and budget structures for Navy secondary items has been set up according to Office of Secretary of Defense (OSD) guidance in three Department of Defense (DoD) instructions: DODI 4140.37, 4140.45 and 4140.7. The multiechelon support concept set up by this guidance was introduced by the Navy in the early 1980s under the Retail Stockage Policy (RIMSTOP) initiative, and is designed to meet established Navy Average Customer Waiting Time (ACWT) standards at lowest overall cost to the government.

The Navy uses two principal measures of effectiveness in judging the success of the supply system in supporting the operational forces: (1) the ACWT, which is the mean of the waiting time distribution, and (2) operational availability (A_O), which is the likelihood the system will be in an "up" condition at any point in time.

ACWT is the variable the Navy logistics management system uses for determining inventory requirements, developing budget requests, and deciding how to allocate funds in managing secondary items. ACWT goals have been established for critical, maintenance-related customer requirements.

A_O reflects both maintenance and supply considerations:

$$A_O = MTBF/(MTBF + MTTR + MLDT),$$

where

MTBF = mean time between failure (system reliability)

MTTR = mean time to repair (system maintainability)

MLDT = mean logistics delay time (system supportability).

MLDT is the determinant of most concern to supply managers. It is a broader concept than ACWT in that it captures the operational cost of such factors as the lack of technical publications, administrative delays, time spent waiting for parts, and lack of trained personnel. It provides the logistic manager with a more operational concept of waiting time then ACWT by itself.

2. Inventory Management Structure

Office of the Chief of Naval Operations (OPNAV) instruction 4140.41 specifies a three-tiered or three-echelon inventory structure:

- Retail consumer inventories are positioned at the retail level to support-single user activities such as ships, shore stations, and industrial activities.
- Retail intermediate inventories are positioned at the retail level to provide a resupply source for consumer-level activities in a specific geographic region.
- Wholesale inventories are managed by a single inventory manager and positioned to provide worldwide support to all retail outlets.

These inventories are managed by a variety of methods from manual cards to sophisticated computer systems. They are funded in any of four ways:

- Navy Stock Fund (NSF)
- Navy Industrial Fund (NIF)
- Navy Appropriated Purchases Account (APA)
- Operations and Maintenance, Navy (O&MN).

APA is a Navy designation for the four weapon procurement appropriations: SCN (Shipbuilding and Conversion, Navy), APN (Aircraft Procurement, Navy), WPN (Weapons Procurement, Navy) and OPN (Other Procurement, Navy).

Regardless of funding source, the goal of the inventory management system is to minimize the ACWT at all echelons of the integrated distribution network. For items in Issue Priority Group (IPG) I or II, OPNAV instruction 3140.12 sets ACWT goals of 125 hours for continental United States (CONUS) customers and 135 hours for non-CONUS customers. (IPG I, the most urgent category, signifies that an operational degradation will occur if the requirement is not met. IPG II signifies a potential problem.)

Given the understanding of the overall Navy multi-echelon inventory concept and the link to ACWT, we can now examine the structure of the Navy inventory system in more detail. Navy secondary item inventories can be characterized in a variety of ways:

- Location (afloat or ashore)
- Type (initial provisioning or replenishment)
- Intended use (War Reserve Material or Peacetime Operating Stocks)
- Make-up (consumable or repairable)
- Asset visibility by the wholesale inventory manager (visible or not)
- Inventory control system employed
- Analytical models used to evaluate alternative inventory management strategies
- Performance measures used to measure efficiency.

The OSD has established provisioning policies in a variety of DoD instructions: DODI 4140.42 for initial provisioning, 4140.39 for replenishment, 4140.37 for guidance for asset visibility, and 4140.47 for determining requirements for war reserve stocks.

Table B-1 describes the three basic levels of Navy inventory. The responsibility for inventory management ranges from centralized control of wholesale inventories to decentralized management of retail consumer inventories. Each level is intended to provide a specific support role. Further, the visibility of inventory assets is more limited in lower echelons in the system. The budget base, moreover, changes from a stratification-based budget (for wholesale inventories) to separate budgets based on historical aggregate totals (for consumer budgets). The three echelons of inventory are discussed in more detail in the subsections that follow, using Table B-1 as a guide.

a. Wholesale Level

Wholesale inventories are managed by two Inventory Control Points (ICPs): ship's parts by the Ship's Parts Control Center (SPCC) located in Mechanicsburg, Pennsylvania, and aviation parts by the Aviation Supply Office (ASO) located in Philadelphia, Pennsylvania. Together, these organizations monitor, on a daily basis, all wholesale assets in the entire Navy supply system through an automated system called Transaction Item Reporting (TIR).

Table B-1. Inventory Control Elements

Inventory level	Wholesale	Intermediate (retail)	Consumer (retail)
Inventory manager	Managed by ASO/SPCC	Managed by intermediate activity	Managed by local activity
Asset visibility	Line-item visibility	Line-item visibility for Navy-managed items	Selected line-item visibility for Navy-managed items
Budget base	Stratification-based budget	Stratification-based budget	Navy Stock Fund O&MN budgets developed by SPCC/ASO/FMSO type and fleet commanders
Support role	Fills requisitions from intermediate and consumer activities	Fills requisitions from assigned consumer activities	Supplies local material requirements

The wholesale inventories are stored primarily at seven Naval Supply Centers (NSCs) that are managed under an automated inventory control system called the Uniform Inventory Control Point (UICP) system. Inventory requirements are listed in the semi-annual Central Secondary Item Stratification (CSIS), which is completed in March and September of each year. The information in this document forms the basis for the wholesale secondary item budget submitted to the OSD. This line-item stratification process, which is described in detail in DODI 4140.24, uses file data and forecasts of demand to identify budget deficiencies. Analysts then project future usage during the stratification horizon, which varies from 12 to 36 months depending on the cycle and the year in question. By considering the number of assets on-hand and on-order, the analysts determine if there are any deficiencies or overages for each line item, and plan procurement or repair funding to remove the problem.

b. Intermediate Level

Intermediate items are managed by Naval Supply Centers (NSCs) and Naval Supply Depots (NSDs) ashore, and by replenishment and repair ships afloat (AFSs, ASs, ADs, etc.). The NSCs and NSDs are managed by the wholesale managers on a daily basis, and the afloat activities on a quarterly basis. (Some items used by the Navy are managed by the Defense Logistics Agency or other military services, and the Navy maintains no visibility for these items.)

The automated systems used in managing the intermediate-level inventories are the Uniform Automated Data Processing System for Stock Points (UADPS-SP) used for ashore inventories, and the Shipboard Uniform Automated Data Processing System (SUADPS) for the afloat stocks. Inventory requirements for Navy-managed items are determined using the CSIS process, and for non-Navy-managed items using the retail stratification process run by the Navy Fleet Material Support Office (FMSO), in Mechanicsburg, Pennsylvania.

c. Consumer Level

Consumer items are managed by the consumers themselves. The activities at the consumer level include some ships, the Naval bases and air stations, and Naval industrial activities such as Naval aviation depots, weapons stations, and shipyards. Navy ICPs have limited visibility of items at Naval air and weapons stations, but no central Navy visibility exists for non-Navy-managed items. A wide range of inventory control systems are used to help manage the consumer-level items. These include UADPS/SUADPS, the NAVSEA Management Information System, tailored automated systems for Naval Ammunition Depots (NADs) and weapons stations, locally-developed automated systems, and manual card systems. Inventory requirements are typically based on local projections instead of stratification. By way of exception, FMSO develops the requirements for non-Navy-managed consumer inventories held ashore in the Navy Stock Fund (NSF) at NSCs, NSDs, Naval air stations, Naval stations, etc., and afloat in the NSF.

3. Budget and Funding Structure

We turn now to the budgeting processes used in managing secondary items. Table B-2 summarizes the funding sources, which include the NSF, the Appropriation Purchases Account (APA), the NIF, and O&MN. Expense items (consumables) that are common to all the services are procured and managed by Integrated Material Managers such as the General Services Administration, the Defense Logistics Agency, and other military services. The Navy stores these items in some intermediate and consumer inventories. Consumables and repairables that are unique to the Navy are procured by Navy wholesale managers located at the Inventory Control Points. These items are purchased by the Navy Stock Fund and retained in the NSF inventory until bought by the end user with APA, NIF, or O&MN funds.

Finally, there are a few so-called "investment items" in the Navy secondary item inventory that are financed with APA funds and managed either by ICPs or one of the Hardware System Commands (HSCs): the Naval Sea Systems Command (NAVSEA), the Naval Air Systems Command (NAVAIR), the Space and Naval Warfare Systems Command (SPAWAR), and the Naval Facilities Engineering Command (NAVFAC).

Table B-2. Navy Budget Structure

Navy Stock Fund	Appropriation Purchases Account	Naval Industrial Fund	Operations and Maintenance, Navy
Revolving fund based on sales replacement	Used to "buy in" for future customer sale	Revolving fund	Expense account
Changes to corpus reflect base growth	Annual appropriation buys outfitting, allowance changes, selected HSC repairables	Finances secondary items to support depot-level repair	Funds most afloat inventories
No annual appropriation	Budget requirements by BA		"Buy out" funding from NSF
Budget requirements by BP			Annual appropriation
Semi-annual stratification used to construct budget			Suballocation at many levels

a. Navy Stock Fund

The Navy Stock Fund (NSF) is the principal source of funding for Navy secondary items. (See the general description of stock fund structure and pricing in Appendix A.) It is a revolving fund used to procure both consumable and repairable secondary items for storage at the various echelons in the Navy inventory structure. The NSF is operated by the Naval Supply Systems Command (NAVSUP) under P.L. 31 USC 1517 and other DoD directives.

The money the NSF spends come from internal funds, rather than from yearly congressional appropriations. (An exception will be covered later.) NSF spending is thus not routinely subjected to congressional review. The NSF is, however, required to obtain obligational authority from the OSD Comptroller (via the Navy Comptroller) on a form SF 1105. This stock fund obligational authority (SFOA), is granted by the Comptroller on a "sales replacement" basis: it grants the NSF enough authority to spend in a given year what the NSF took in the previous year, plus an allowance for estimated increases or decreases in projected sales. (NSF receipts are reported on an SF-6 form.)

For purposes of managing inventory and constructing budget requests, the Navy categorizes secondary items by a series of Budget Project: (BPs), as follows:

- BP 14—Ship consumables
- BP 28—DLA-furnished items
- BP 35—Aircraft consumables
- BP 81—Ship repairable
- BP 85—Aircraft repairables.

Using supply data such as assets on-hand and projected demand, the Navy ICPs compute inventory requirements of several types: initial provisioning requirements for new systems and equipment, stratification requirements for established items, war reserve and mobilization requirements, and any other special requirements. These requirements are combined with other financial data to develop the various exhibits used to defend the NSF budget submitted to OSD via NAVSUP headquarters and Op-41. A complete discussion of the structure and operation of the NSF is contained in the Navy Secondary Item Requirements and Budget Development Manual (NAVSUP Publication 514, Volumes II and III).

b. Appropriation Purchases Accounts

The Appropriation Purchases Accounts (APA) is the Navy's term for the sum of SCN, APN, WPN, and OPN accounts. These accounts are administered by the Hardware System Commands (HSCs) according to OSD guidance contained in DoD Directive 7110-1M. The accounts are used to fund three types of secondary items: (1) items of high value, classified items, and specially-controlled items not appropriate for NSF management, (2) initial provisioning spares for use when the new system or equipment is still supported by contractors, prior to the Navy assuming responsibility for support, and (3) items that are part of a "buy out" for existing or new systems or equipment that are included on Consolidated Shipboard Allowance Lists (COSALs), Aviation Consolidated Allowance Lists (AVCALs), or Consolidated Shore-Based Allowance Lists (COSBALs).

Inventory requirements are first generated by the HSCs based on estimates of need. These requirements are sent to the Navy ICPs for use in developing a coherent set of requirements for all secondary items. NAVSUP provides supply and budget policy guidance for this process. Using inputs from both the HSC and NAVSUP, together with supply data from Navy stockage activities, the ICPs develop requirements for initial spares, determine funding needs for procurement and repair, and use these projections as inputs in developing the APA budget request.

Within each major APA account, budget and funding data are broken out by Budget Activity (BA) codes. Several different BAs may have budget and funding data for secondary items in a given APA account. The budget documents for APA secondary items include a wide range of exhibits, many of which parallel the NSF exhibits mentioned earlier. The more important exhibits include the following:

- P-18, Spares and Repair Parts Operating Budget—includes the inventory on-hand and on-order, the requirements for new APA inventory, and the net funding to obtain this inventory, arranged by Budget Activity.
- P-18A, Initial Spares Requirements—includes the requirements for initial spares for both system stock and allowance stocks over time, arranged by Budget Activity.
- P-18B, Secondary Item Analysis and Computation of Peacetime Objectives—provides a more detailed breakdown of requirements for Peacetime Operating Stocks, based on P-18 data and arranged by Budget Activity.
- P-18C, Inventory Status and Transaction Statement—lists the inventories at the beginning of the year; the receipts, issues and other transactions that affect balances during the year; and inventories at the end of the year, arranged by Budget Activity.
- P-18D, Transition from Stratification to Budget—is the equivalent to the SF-3 report and indicates requirements for inventory, assets on-hand and on-order, and the need for new procurement and obligational authority to purchase the assets, arranged by Budget Activity.
- Op-35/35A, Material Rework Requirements: Transition from Stratification to Repair Budget—provides budget requirements for repair of APA material for those rework requirements that are not documented in Stratification Tables IV and V.
- NAVSUP Publication 514, Volume V—gives a complete description of the structure and management of these procurement accounts for secondary items.

c. Navy Industrial Fund

The NIF is a revolving fund used to finance the repairs and overhauls conducted by Naval shipyards and aviation maintenance depots. Most NIF funding goes to pay the personnel costs, overhead, and other operating costs of the repair and overhaul facilities. The remainder is used to pay for the secondary items, primarily consumables, that are used in the repairs and overhauls. The NIF buys these repair items from the NSF and holds them in inventory until they are charged to the customer, at which time the NIF capital stock (corpus) is replenished. The budget process for the NIF is much like that of the NSF, since both are revolving, non-appropriated funds.

d. Operations and Maintenance Account

The O&MN account is used by operating commands (ships and air stations), supporting shore stations, and intermediate-level repair sites to purchase items from the Navy Stock Fund. These commands and sites are the ultimate users of secondary items, and it is here that secondary items directly support the operational readiness and sustainability of the Fleet.

O&MN inventories are budgeted by the Type and Fleet Commanders and managed as line items within the overall O&MN budget. Items are categorized by Budget Element (BE). O&MN budget requirements are listed on Op-32 forms in Navy budget submissions.

During budget execution, the OPNAV issues expense allocations (spending limits) to the Fleet Commanders and other major claimants. The allocations are passed on to the Type Commanders who then establish Budget Operating Targets (OPTAR) for specific activities such as ships and air stations. OPTAR allocations may be revised during the year in order to support the quickly-changing needs of Naval forces. NavSO P3013-1 and -2 provide additional information on the structure and operation of O&MN accounts.

4. Data Problems

Some major problems arise when assessing the Navy's management of the supply system. First, good data on user inventories is lacking because of the lack of automated control and reporting. Neither the UADPS-SP nor the SUADPS are used for those inventories not controlled by the stock fund.

Second, the different types of funding—NSF, APA, NIF, and O&MN—are developed in separate channels, using possibly inconsistent assumptions. The actions of Op-41, however, bring some coherence into the process after the initial budget development. Op-41 has the responsibility to review and defend the Navy's budget for all secondary items during the entire process from the Program Objective Memorandum (POM) to execution. This includes translating the requirements for secondary items in the POM into needs for NSF or APA funding.

Even in this central control, however, there is a problem with the lack of data. Although the NSF budget submissions are typically well-documented, and secondary item requirements are usually supported by line-item stratification data, the requirements for APA funding are generally presented with much less detail and back-up. Most of Op-41's review effort for APA funding is done by working directly with the APA Budget Activity office. Further, the review and validation of secondary item requirements contained in Navy POM submissions are based on even less detailed data. The problem is even worse at the OSD level because much of the detailed information available to the Navy is not passed on.

The third information problem is that there exists no close link between inventories of secondary items and the steaming hours and flying hours they are intended to support. Finally, there is a large internal inconsistency between the timing lags in the process and the dynamics of Naval operations.

These data inadequacies create problems in the introduction of large weapon systems and equipment, where the acquisition and phase-in process may take several years. The size and timing of programs often change many times as a result of changes in program funding or priority. Because the NSF is the mechanism for acquiring initial support for these programs, the NSF must obtain the funding authority and initiate the procurement actions for initial provisioning well before the system is introduced.

In summary, it appears that the process for developing the Navy's budget for secondary items should be revised to provide more detailed support, and that the data available in the Navy to support these requirements should be routinely made available to the OSD.

5. Synthesis

We will conclude this overview by bringing together our discussion of the inventory structure and budgeting process for Navy secondary items. Peacetime Operating Stocks (POS) and War Reserve Stocks (WRS) are located at three levels of inventory afloat and ashore. These inventories are funded by the NSF, APA, NIF, and O&MN accounts. A variety of management systems are used to control and size these inventories, depending on the level, location, and funding source.

The various inventory levels and funding sources are interrelated. Wholesale inventories are sources of resupply for retail inventories, and the availability of material at each inventory level affects the availability at lower levels with time lags depending on the type of material and the levels involved. Some funds, specifically the "buy ins," are used to increase the stockage levels of items already carried by the NSF. Initial provisioning inventories at the retail level are usually financed by APA outfitting accounts, but the replenishment of these inventories are funded by the NSF or O&MN accounts. It is important to account for timing lags in evaluating these funding linkages.

Table B-3 shows the relative usage of the different funding sources using data for FY 1988. The important role of the NSF regarding both funding and inventory is obvious. Much of the NSF inventory are low demand items that are not expected to sell in the current year, but that are kept for "insurance." Overall, the system has a ratio of inventory to sales of about 3, meaning that we keep an average of three years of usage on hand. Note the difference between funds approved and funds expended. Approval means that Congress has granted DoD obligational authority—the authority to sign contracts and thus create obligations. Expenditure is two steps removed, coming only after the contracts are actually signed (which comes within a year or two) and the payments on these contracts are actually made by checks drawn on the U.S. Treasury (which can come much later after an obligation is signed).

Table B-3. Navy FY 1988 Funding and Inventory Levels (Costs in Millions of FY 1988 Dollars)

Budget Category	Funds Approved	Funds Expended	Inventories
Navy Stock Fund			
BP 14	$ 332		3,030
BP 28	1,691		2,140
BP 34	750		4,660
BP 81	882		8,420
BP 85	1,668		13,590
NSF Total	5,648	5,311	31,840
Navy Industrial Fund	1,150	1,150	1,613
Appropriate Procurement Accounts			
APN	1,447	1,422	
SCN	175	49	1,500
OPN	264	203	700
WPN	115	115	
Total APA	2,001	1,789	2,200
O&MN	4,052	3,998	2,660 (est)
Grand total	12,851	12,248	38,313

Although the inventory of Navy secondary items has been rising dramatically in dollar terms—it went from $19 billion to over $33 billion between during 1983-88 in FY 1991 dollars—much of this increase is due to changes in the accounting system. A lot of the increase is in ship and aircraft repairables, some of which had not been counted until BPs 81 and 85 were created in FY 1981 and FY 1985, respectively. Additionally, some of the increase is due to re-pricing old inventory that had been purchased as far back as 1970, and had been valued at historical rather than standard prices.

C. SOURCES OF INVENTORY DATA

The Navy's inventory data are based on records that reflect the stocks and flows of individual line items: the quantity of assets on-hand and on-order (backorders), the receipts and issues of items that constitute the sources of gains and losses of inventory, and the purpose and condition of the material. These records are kept, either manually or on computer, at each activity that stocks secondary items. The data are collected by different offices for different purposes, and gathered on different cycles using different data-collection methods with varying degrees of accuracy. There is no single source that gathers all the data, so each source provides only a partial picture of Navy secondary item inventories. All alternatives suffer from some deficiencies or limitations.

The two data sources that appear to be most appropriate for analyzing secondary items are the Stratification Inventory Reports and the Annual Inventory Report. We describe these reports and briefly evaluate them under the categories of completeness, accuracy, timeliness, and availability.

1. Stratification Inventory Reports

The Navy uses a "stratification" process to develop budget requirements for many secondary items. The process entails (1) generating inventory requirements, (2) identifying inventory that is available (both on-hand and on-order), and (3) computing, by subtraction, the amount of new procurement that is needed. Secondary items are classified (stratified) in a variety of ways for purposes of this calculation, some of the categories being serviceable and unserviceable, scheduled and unscheduled for repair, war reserve material, recurring and non-recurring demands, safety levels, and inventory to cover the repair pipeline, as well as the production and administrative lead times.

In carrying out the stratification, the three managers of secondary items (SPCC, ASO, and FMSO) each develop budget requirements by line item. (This process is governed by OSD guidance stated in DODI 4140.24, and Navy guidance stated in NAVSUPINST 4440.471 and 4440.165.) Stratification output is organized into a series of stratification tables, the most important of which are these:

- Table I. Central Secondary Item Stratification Budget—presents the basic stratification of the procurement budget stratification, which projects procurement requirements.
- Table II. Central Secondary Item Stratification-Readiness and Retention—lists beginning-of-year assets, and is the source of the Inventory Management Report of Material Assets (DD1138), an input to the Annual Inventory Report.

- Table III. Local Activity Item Stratification—covers most NSF inventories held at the retail, or unit level of the Navy supply system.
- Table IV. Central Secondary Item Stratification-Repair—lists repair funding requirements measured at standard prices (historical prices plus surcharge, the amount that customers are charged.

Stratified inventory data allows inventory managers to consider assets already on-hand or on-order as appropriate offsets in forecasting customer requirements. The data come from individual line-item records on the UICP that the inventory managers monitor on a daily basis. The variables that are reported include the value of assets on-hand and on-order, as well as the condition and purpose codes. For consumable items, only serviceable assets (those that work) are reported. For repairable items, both serviceable and unserviceable assets (those needing repair) are considered. The inventory items are also categorized by whether they are needed for current and projected requirements, or are inapplicable under the definitions contained in DODI 4140.24 and 4140.37. For those retail assets than are not managed by the Navy but held in the NSF, the inventory managers prepare a record called the Retail Asset Status Card (RASC), and submit it to SPCC, ASO or FMSO for incorporation in the stratification reports.

A deficiency with the stratified inventory data is that some inventories are omitted, particularly (1) inventories ashore and afloat that are expensed under O&MN funding, and (2) inventories that are held in the Naval Industrial Fund (NIF). Most other inventories are stratified by the cognizant ICPs, including: wholesale inventories; retail inventories of Navy-managed items held in NSCs, NSDs, NASs, weapons stations, and major shore stations that are managed by the NSF; other retail inventories of Navy-managed items maintained in the NSF (particularly in afloat inventories in SUADPS ships); and non-Navy-managed items that are held ashore and afloat in the NSF.

Because stratified data are used in constructing budget requirements, they undergo a significant review for accuracy. Retail data are reviewed by the Navy stock points, which are required to reconcile differences of more than 5 percent in the asset balances listed in inventory and financial records. Wholesale data are reviewed by the ICPs, which identify those items that have high on-hand or on-order asset balances that vary from established requirements. Further, on-site reviews are held at SPCC, ASO, and FMSO to further review inventory data before they are finally accepted for stratification.

Navy stratification data are available twice a year, at the end of March and September. The budget submission is based on the March stratification. The data at the Budget Project level are available in hard copy at the Naval Supply Systems Command

Headquarters (Sup 013) for FY 1970 onward. The data are also maintained in an automated system in OSD (Supply Policy) for the period since FY 1983. Further, DoD has been considering changes to DODI 4140.24 that will require the services to submit future stratification data in an automated format, so that this information can be directly inserted into automated databases maintained by the services and OSD.

2. Annual Inventory Report

OSD (Supply Policy) prepares an Annual Inventory Report (AIR) that lists the inventories of principal and secondary items held by the military services and the Defense Logistics Agency. This report, which is based on feeder reports prepared by various components of the supply system, is prepared in accordance with DODI 4140.18 and published by the Washington Headquarters Service. Although the AIR differs from the stratification reports in coverage and methods of estimation, the data (not shown) reveal the same dramatic growth in Navy secondary item inventories (from $18 to $30 billion during FY 1983-88.) Moreover, the AIR makes an even stronger case for the point that much of the growth is due to accounting changes, by showing that the number of line items has remained relatively constant over the period. The data also show that the decline in APA inventories during 1985-86 is a reflection of the movement of aviation repairables into the NSF over the period.

The purpose of the Annual Inventory Report is to document, for Congress, the current value of material inventories. The report is used by OSD to provide aggregate information on the levels of inventories and how these levels have changed over time. The report is not tied either to the budget process or to any operating system within the supply system.

The data in the AIR are compiled by the Naval Supply Systems Command Headquarters (Sup 013) from inputs supplied by thirteen supply activities, which obtain their inputs, in turn, from over 800 lower-level reports. The thirteen activities forward their data to NAVSUP in DD 1138, Inventory Report of Principal or Secondary Items. Data collection begins each October, and NAVSUP sends the report to Washington Headquarters Services in January. For those secondary item inventories that are stratified, the source of the data are the stratification reports generated in the late March stratification process.

The data for non-stratified items are provided by the designated coordinating activity based on Financial Inventory Reports (FIRs). NavCompt Volume II, Chapter 5 lists both direct reports and indirect reports of FIR data for the stores accounts. Much of these data are captured from financial records and reports published by the Navy Regional Finance Center and the Fleet Accounting and Disbursing Center (FAADC). (The FAADCs on each coast are the primary accounting activities for Fleet activities.) Financial inventory data are, in turn, obtained from the actual processing forms for supply transactions, which result in charges or credits to the various operating accounts used to fund material inventories throughout the Navy.

These Fleet stores accounting data are consolidated by the Navy Accounting and Finance Center (NAFC) located in Washington, D.C. The Navy Regional Finance Center (NRFC), also in Washington, consolidates the information for shore reporters.

The Annual Inventory Report is not a superficial job. It collects data from 800 separate activities, and surpasses the stratification reports by including unstratified, as well as stratified data. The point is not trivial, since unstratified items account for 12 percent of Navy inventories of secondary items. The AIR is limited, however, in neglecting inventories held in the NIF. In addition, some shipboard inventories have not been reported since 1986. DODI 4140.18 does not require the reporting of inventories held in combatant ships, and the only afloat inventories currently included in the AIR are those managed by the NSF—inventories on the larger mechanized ships, including aircraft carriers, repair ships such as ADs and ASs, and supply ships such as the AORs. The omission of NIF inventories is the AIR's only major deficiency in coverage, however, because the inventories on the smaller combatants, which are neglected, are relatively small. Inventories held by the smaller combatants are still available from NAFC Washington for the years following 1985, and can be used to supplement the data in the AIR for FY 1986 and later.

The data in the AIR is not "scrubbed" as thoroughly as the stratification data. A recent analysis by the Defense Analysis and Studies Office indicates that the data in the AIR is less than 85 percent accurate. Another problem with accuracy is that the dollar values for some of the inventory—the portion obtained through automated financial inventory systems—are taken straight from the actual transactions (receipts and issues of material, losses of inventory, etc.). The stratification inventory, by contrast, is valued at standard prices. Because of these problems with accuracy, the AIR is not regarded as a reliable source of inventory data, and is not used in budget preparation.

Much of the AIR data are nine months old by the time the report is distributed. (Much of the data for the AIR, which is published in January, are obtained from the late

March stratification.) AIR data for the Navy are available in hard copy dating back to the 1960s.

D. SOURCES OF BUDGET DATA

This section discusses the data used in preparing and executing the budget for Navy secondary items. We cover the sources of the data, the availability of time-series data, and the known deficiencies in the data. The discussion deals separately with the four funding accounts.

1. Navy Stock Fund

Data regarding budget preparation and execution for the Navy Stock Fund are included in the Department of the Navy Stock Fund Report, and also in the Presidential budget submitted by OSD. The report is comprised of a series of exhibits at the Budget Project and summary levels. The most important exhibits are:

- SF 1 Stock Fund Summary. POS inventories, both on-hand and in-transit, customer orders, net sales, obligation targets, total obligations, commitment targets, total targets, and deviations.
- SF 2/2A General Narrative Justification. Total net sales, both approved and requested, obligation and commitment targets, and POS and WRS.
- SF 3/3A Operating Budget Requirements. A detailed breakdown of inventory requirements and resources, funding requirements, commitment and obligation targets, and the specific components that make up total requirements. Inventory augmentation data are provided by SF 3A.
- SF 4 Inventory Status. A complete portrayal of NSF inventories on-hand and on-order, both POS and WRS, at the beginning and end of the year, and receipts, issues, returns, etc., during the year.
- SF 5 NSF Pricing Data. How the standard price is constructed, covering such topics as the surcharge, inflation rates, stabilization factors, and projected percentage changes in customer orders for various Budget Projects.
- SF 6 Reimbursable Issues. Summary of reimbursable issues for wholesale NSF assets by Budget Project and buyer accounts (SCN, APN, WPN, OPN, and O&MN).
- SF 8 Analysis of Fund Balance with the Treasury. A four-year portrayal of NSF transactions and balances, collections, disbursements, and cash at the end of the fiscal year.

- SF 10 Selected Obligation and Sales Data. A summary of NSF growth by NSF augmentation and war reserve, obligations, sales for spare parts, subsistence, clothing, medical and dental items, fuel, and other.

In addition to the annual data on NSF operations given in the Department of Navy Stock Fund Report, there are monthly data on NSF operations documented by the NAFC Washington on Statement 7. Budget and execution data are also available from the Revolving Funds Branch, Fiscal Management Division, NavCompt (Op-0821) for the period FY 1974 through FY 1988. These data are maintained on hard copy for the entire period, and selected data for recent fiscal years have been incorporated into a local PC information system called the Navy Headquarters Budgeting System.

2. Appropriation Purchases Accounts

There is no single source of budget and execution data for secondary items purchased by the APA procurement accounts. Each account is handled by different management information systems, and by different budget analysts within the Navy Comptroller's Office (NavCompt). Requirements for APA-budgeted items are transmitted to NavCompt, via the assigned Navy program manager (Op-41), on form P-18a for initial spares, and form P-18 for replenishment spares.

Summary budget data at the Budget Activity level are included in the Presidential Budget, and documented on the DoD P-40 exhibits submitted for each of the four procurement accounts. These data reflect the total budget approved for the past fiscal year, and include additional detail by initial vs. replenishment spares, by hardware systems command, and, in some cases, by program.

APA (as well as NSF) execution data, including both obligations and expenditures, are given in a series of reports and exhibits that also include inventory data. These documents are maintained by the program managers who are responsible for APA budgeting and execution for secondary items. APA execution data are also reported on a monthly basis on DD 1002, and these data are loaded directly into the Navy Standard Accounting and Reporting System (STARS). APA budget and expenditure data are available in hard copy from the Investment and Development Division of NavCompt (Op-0822). Data for Budget Activity WPN-5 are available back to FY 1973, for APN-6 back to FY 1974, for OPN-8 back to FY 1979, and for SCN 1-4 back to FY 1974. Budget and execution data for APA expenditures for all BAs are also maintained in the Navy Headquarters Budgeting System (NHBS) for FY 1982 and succeeding years.

3. Navy Industrial Fund

Information on the source of NIF budget data was not assembled.

4. Operations and Maintenance, Navy

O&MN budget requirements are identified in the Presidential budget submission by budget program, program element, and commodity category. Requirements for secondary item inventories are specifically included in Op-32 inputs in each budget submission.

The O&MN budget requirements are broken into the following major commodity categories:

- Fuel (both from Defense Fuel Supply Center and from local sources)
- Army Stock Fund material
- Army equipment (material purchased from the Army but not from the ASF)
- Air Force Stock Fund material
- Air Force equipment (material purchased from the Air Force but not from the AFSF)
- Defense Logistics Agency material
- General Services Administration material
- Navy Stock Fund material
- Navy equipment (material purchased from the Navy but not from the NSF)
- Local purchase material
- Other.

These data are maintained in hard copy form in Op-0821 back to FY 1980.

Actual O&MN transactions by user commands are captured through the standard Navy accounting process and reported in three data sources. The first is Visibility and Management of Operating and Support Costs (VAMOSC). VAMOSC-Ships and VAMOSC-Air summarize actual operating and support costs for spare parts, equipment and equipage, supplies, and many other cost categories. The data describe actual usage, as when an item is issued from shipboard stocks to the user, or when the ship purchases material for direct turnover to the user. The data do not, therefore, describe expenditures for shipboard inventories.

The first source of O&MN transactions is NAFC's collection of O&MN costs for secondary items. These data are compiled by NAFC from accounting records maintained in the FADCs, forwarded to Op-0821, and reported monthly on NC Form 2235. The data are entered in the NHBS database and are available on the same basis as APA expenditure data. Further, any movement of APA secondary items into O&MN inventories is reflected in the data because, although there is no actual accounting charge to the activity for these items, an administrative transaction is recorded based on the fund code cited. There is a deficiency in the use of this basic accounting data: expenditures for O&MN inventories (versus direct turnover requirements) cannot be easily isolated in the aggregate data.

The final source of O&MN transactions is the Navy Stock Fund Report. This report documents sales from the NSF to the O&MN account. Because the Navy manages both consumables and repairables in the NSF, NSF sales account for most O&MN purchases of secondary items. The report does not, of course, include APA issues to O&MN inventories. Moreover, some of the NSF sales reflected in the report are direct turnovers rather than addition to inventories. These transactions are probably relatively small.

Of these three sources of data on O&MN spending for secondary item inventories, the NAFC accounting data, which is represented in the NHBS database and available from NavCompt, are the most accurate and complete.

E. BUDGET AND PERFORMANCE MODELS

1. Types of Models

The Navy uses a variety of analytical models to manage secondary item inventories. Some models are extremely detailed simulations for individual ships, shore stations, and weapon systems. Most of these models require an "operating scenario" defined by such variables as the location of operations, the number of flying or steaming hours, sortie lengths and personnel staffing. At the opposite extreme are macro models that deal with the operation of large segments, or even the total Navy supply system. These models lack enough detail to guide planning for given operating sites, but offer a capability to analyze system-wide relationships.

In terms of function, the models are either of the "requirements" type (which calculate the inventory needed to meet specific funding or performance goals) or the "assessment" type (which start with inventories and assess the operational impact). Two performance measures often used by requirements models are the Fill Rate (the percentage of customer requisitions that are satisfied from available inventory) and the Mean Requisition Response Time (the average time it takes for customers to receive the material they request). A complete discussion of requirements models is given in the NAVSUP publication, "Inventory Management: A Guide to Requirements Determination in the Navy."

The analytical models also differ in their analytical approach, or methodology. Deterministic models employ point estimates (generally mean values) for their key inputs, and usually generate steady-state solutions. Simulation models, by contrast, use probability distributions for their inputs. They are thus more realistic, and allow the user to deal with variation over time, but they are also more data-intensive. (It takes more information to specify an entire distribution, rather than an average value.)

We will discuss the three major models the Navy uses for analyzing secondary item funding and inventories: the Computation and Research Evaluation System (CARES), the Variable Operating and Safety Level (VOSL) Analyzer, and the Budget and Readiness (BAR) model.

2. Computation and Research Evaluation System (CARES)

CARES can be operated in the assessment mode to take a budget and generate various measures of wholesale system material availability. The model also provides statistics on projected backorders, inventory levels (operating, safety, and lead time levels), procurement and repair workload, and item demand categories. The analyzer can deal with either a component of, or the entire wholesale inventory managed by a particular ICP. It allows the ICP to evaluate alternative budget execution strategies by their impact on material availability.

In the requirements mode, the user would start with a desired level of wholesale material availability and generate the budget required to reach it.

The inputs to the CARES model are data from inventory management files, which include actual assets, demands, lead times, and other inventory data at the individual line-item level. The model is a proven, easy-to-use analytical tool that is routinely used by the Navy. It runs on either a mainframe or minicomputer. Its major limitations are the assumption of a steady-state and the need to develop input data from actual ICP operating files. Also, because CARES deals only with the wholesale inventory and support level, its estimates do not directly relate to material availability, funding, or system performance at other levels in the Navy structure. Nor does it translate the output measures of material availability into operational impact. The Navy Fleet Material Support Office (FMSO), Code 93, maintains the CARES model and is the best source of information on its operation and use.

3. Variable Operating and Safety Level (VOSL) Analyzer

The VOSL Analyzer is the stock point equivalent of CARES. It allows a Navy stock point manager to develop funding requirements from desired goals regarding material availability, or to assess the impact of a given level of funding on material availability at the stock point.

The VOSL Analyzer uses actual stock point inventory records and related UADPS-SP file data. The model may be run for the entire inventory range of items, or for selected commodity groups. The analyzer allows the stock point to explore alternative execution strategies for dealing with any given level of funding, and provides supplemental operating statistics on workload, backorders, etc. The model is widely used by Navy stock points, runs on a mainframe, and requires the input of actual inventory management data for the given activity. Simplicity, good documentation, and accuracy are among the major strengths of the VOSL Analyzer. Its major limitations are that it requires data unique to a given stock point, and assumes steady-state operation. FMSO, Code 93 maintains the VOSL analyzer and is knowledgeable on the use of the model.

4. Budget and Readiness (BAR) Model

CARES and the VOSL Analyzer are "detail" models: they deal with specific operating requirements and activities, and require a mainframe or minicomputer. The Naval Supply Systems Command in 1986 directed FMSO to develop a simplified, multi-level model that could be run on a PC and provide "generally reasonable" macro-level answers to questions of funding and material availability.

The Budget and Readiness (BAR) model is the result of the FMSO effort. While sacrificing some accuracy, the BAR can provide quick answers (but not budget quality answers) to questions of budget and funding impact. It does not require a large amount of input data, but relies instead on predetermined relationships to link funding, material availability and customer waiting times. These relationships are derived by FMSO using the more detailed CARES model and the VOSL Analyzer.

The BAR model is currently used by NAVSUP headquarters for quick analysis of the impact of funding reductions. The user can quickly enter inputs using a computer display and menu prompts. The major strengths of the model are speed, simplicity, and its system orientation. It provides best-guess answers to what-if budgeting and readiness questions in hours rather than weeks. The program runs on an IBM PC, and has a well-documented users guide.

The major shortcoming of the model is that the imbedded relationships between funding, inventory, and material availability must be periodically updated by FMSO to ensure the model's validity. Moreover, the user must be willing to accept VOSL Analyzer projections for a "representative" stock point in the Navy system. Finally, BAR does not extend down to the shipboard or station level, but only to the lowest UADPS-SP stock point level. FMSO, Code 93, which developed the BAR model, maintains the model and is the best source of information on its structure and use.

APPENDIX C.

ARMY INVENTORY AND BUDGETING OF SECONDARY ITEMS

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ARMY INVENTORY AND BUDGETING OF SECONDARY ITEMS

A. INTRODUCTION

Managing the Army's inventory of secondary items is becoming a more complex task, due both to increases in size—the inventory rose in value from $6 to $15 billion during 1980-8 —and to gains in technology.

Secondary items include all the spares used in maintaining Army weapon systems, plus other support items such as medical and dental items, clothing and subsistence, general supplies, oils, lubricants, and fuels. This discussion focuses on spares inventories, which, according to the 1987 DoD Supply System Inventory Report, accounted for 86 percent of the Army inventory of secondary items in 1987.

This appendix contains sections describing: the Army's inventory management and budget process with special attention to the secondary item requirements determination procedures and the budgeting and funding for these requirements; the sources of inventory data on secondary items; the sources of budget data; some of the models used in budgeting, budget execution and requirements determination; and a brief summary of the report.

B. DISCUSSION

This section describes the Army's inventory system, the flow of materiel between wholesale and retail levels of inventory, and the flow of funds to pay for the acquired inventories.

The basic concepts governing the management of the Army's inventory of secondary items are found in two basic documents: AR 710-1, "Centralized Inventory Management of the Army Supply System," dated March 1, 1988, for wholesale inventory, and AR 710-2 for items below the wholesale level. AR 710-1 defines stockage categories, retention levels, procedures for financial management, operational and repair cycle procedures, hard targets for testing and range use, war reserves, and the automatic return program at the wholesale level. AR 710-2 establishes policies for the accountability and assignment of responsibility for property stored at supply support activities, and property that is already issued to operational units.

Major supply items that are part of the Army's Total Organizational Equipment (TOE) structure are called investment items, and are funded by procurement appropriations. Procurement appropriations are also used to fund items, such as aircraft engines, that are not part of the TOE but that are expensive and considered to be critical to missions. These items are managed like the TOE, or major end items. Most other items are normally consumed or expended at the field or base level. (Modification kits and ammunition are exceptions.) These are called expense items and are funded by the Army Stock Fund (ASF).

The Army Materiel Command (AMC) has the primary responsibility for managing the Army's secondary items. The AMC delegates day-to-day operation to the six Major Subordinate Commands (MSC), which provide inventory support for the secondary items assigned to them.

The MCSs are weapon producers as well as inventory managers: each MCS has the responsibility for acquiring and managing supply for a given range of items. Below the MSCs are the depots for storing wholesale stocks, arsenals, and other storage facilities for storing ammunition, intermediate-level facilities for storing items of general and direct support, and storage sites at the organizational or unit level for storing retail stocks.

Organizations at the intermediate, direct-support level maintain supplies with larger range and depth, in order to support the user units. In the Army structure, the supply function is related to the maintenance organization at the division level, where direct exchange of repairables and operational readiness flow is maintained.

The wholesale level of supply is located at a set of depots, ammunition arsenals, and storage facilities. The managers of the wholesale inventory are generally located at six National Inventory Control Points (NICPs), although a few are located at Army facilities designated by a NICP.

The Army uses performance criteria for measuring the effectiveness of the supply system at the various levels of supply. Some of these measures are described in the following sections.

1. Supply Performance and Measures of Effectiveness

In keeping with DODI 4140.39, the Army uses "time-weighted requisitions short" as the primary measure for determining safety levels and economic order quantities. However, there are other performance targets available for Army use to evaluate the effectiveness and efficiency of mission accomplishment. Many of these do not have an established/specific target designated by higher authority.

2. Requirements Determination

The procurement objective for secondary items is calculated by forecasting the inventory that is desired (the requirements objective) and subtracting the value of assets on-hand and on-order. The requirements objective is the sum of several items: the economic order quantity, the variable safety level, usage during the procurement lead time, usage during the repair lead time, and the protectable war reserve.

The economic order quantity (EOQ) and the variable safety level (VSL) are computed by an analytical model that minimizes the annual variable cost of supply. The EOQ is computed by accounting for procurement cost, inventory holding cost, and the cost of requisitions on backorder. The safety level is chosen to be between zero and three standard deviations of the usage during the procurement lead time. The computed values of EOQ and VSL may be overridden if there are significant price discounts, or if raising the procurement quantities attracts additional bidders and thus lowers the price through competition.

The procurement lead time is the sum of (1) the administrative lead time, between the initiation of a procurement directive and the award of a procurement contract, and (2) the production lead time, between the award of a procurement contract and the first month's delivery. These lead times are computed using a 20-year moving average of representative procurements. The repair lead time is the average time between when an unserviceable item is returned and when it is restored to a usable condition.

War reserves, for which the Army Material Command is the central manager, are inventory bought in peacetime to meet wartime requirements during the mobilization period. The mobilization period is defined to be the length of time it takes for production rates to catch up with usage rates for combat and training. It includes the War Materiel Production Capability (WMPC) and the War Reserve Materiel Requirement (WRMR), consisting of material prepositioned in CONUS and elsewhere. The WRMR, in turn, is the sum of the War Reserve Materiel Requirement Protectable (WRMRP) and the War Reserve

Materiel Requirement Balance (WRMRB). The WRMRP is that portion of WRMR that is on hand or has been funded and is protected (promptly replaced if issued during peacetime), and the WRMRB is the portion of the WRMR that has not been acquired or funded.

The WRMR is computed using data from the War Reserve Stockage List (WARSL), an automated file of data on major items and selected secondary items, lubricants, and subsistence. (The WARSL data are also used for mobilization studies.) Items are selected for inclusion in the WARSL based on their importance for the following tasks:

- Destroying the enemy and protecting battlefield personnel
- Maintaining the operational effectiveness of combat support forces
- Maintaining the combat operations of weapon systems
- Mobilizing and deploying Active or Reserve forces
- Contributing to the survival, protection,and evacuation of personnel
- Maintaining the combat capability of aircraft.

3. Demand

Demand for secondary items is often divided into recurring and nonrecurring demand. Recurring demand is the need for items in persistent use, and is measured in units of frequency (number of requests per unit of time). Nonrecurring demand, resulting from a one-time occurrence, is measured in units of quantity (size of request). Secondary items can also be grouped by the value of annual usage: (1) low dollar value (annual usage under $25,000), (2) medium dollar value (usage of $25,000-$100,000), (3) high dollar value (usage of $100,000-$1,000,000), and (4) very high dollar value (usage over $1,000,000).

Inventory managers periodically review the assignment of items to these groups, and request reassignment if the bounds are exceeded. Reassignment can also be done automatically, on the basis of data in the Material Management Decision (MMD) file.

Forecasting the future demand for an item is a necessary step in developing the requirements for future inventory and new procurement. Demand for old items is set equal to past usage, modified by anticipated changes in forces or operating tempo. The Army maintains usage data for at least six years, and the most recent two years are retained in an active database used in the demand computation process.

Demand is estimated differently for new items, which lack a history of prior field usage. The lack of data is greatest during the initial provisioning period, which begins when the item is first introduced, at either the first unit equipped (FUE) date or the initial operational capability (IOC) date, and ends no later than the termination of the demand development period (DDP), which usually comes 24 months after IOC. Demand during the beginning of this period is determined by "bottom up" engineering estimates, or by analogy—keying demand to the usage of old items thought to have a similar demand pattern.

By the time the initial provisioning period has ended (24 months after IOC), usage data have started coming in from the field, and these data are used along with the engineering and analogy factors. The weight given to the field data is increased by 25 percent each 6 months, so that the demand forecast is eventually based entirely on actual data.

Subordinate commanders may modify the weighting factors if they think it appropriate. In fact, many of the new high-technology items do not fail in the first 24 months, and some item managers have started waiting until long after IOC before they declare the end of initial provisioning and begin relying completely on field usage data.

4. Replenishment

Once the initial provisioning period is completed, the replenishment period begins. There are four different ways of estimating demand during this time:

- Use actual demands after the 24-month demand development period or earlier if actual demands are thought to be representative of future requirements.
- At the wholesale level, given a demand development period of IOC plus 6 months, and for items without demands during the demand development period, replenish at one of the following times:
  - the planned lead time requirement
  - the depot repair-cycle requirement for repairables
  - at a rate sufficient to maintain a 12-month stockage level used for a safety-level procurement requirement.
- For provisioned items beyond IOC plus 6 months, after actual recurring demands are received or additional end items are procured, use weighted average monthly demands and full requirements objectives.
- If no demands have been received by IOC plus four years, set retention levels at all on-hand plus on-order assets.

Inventory item managers for secondary items rely on the Requirements Determination and Execution System (RDES) for guidance in determining requirements. The RDES produces two main outputs: the Supply Control Study (SCS) used in managing low-value items at the NICP, and the Item Management Plan (IMP) used for medium and high-value items. These computer-generated guides list monthly demands and make supply recommendations that are then reviewed by the item managers. Item managers can request this information for 15 different customer areas, including Europe, Japan, and Southeast Asia.

The IMP lists the inventory position for the current and appropriation years, and data on demands, items returned, economic order quantities and variable safety levels for 3 budget out-years. The RDES is produced every 4 to 6 weeks, using supply policies and parameters in the MMD file, and program data file (PDF). The process is automated so that the RDES obtains the right data from the right file without manual intervention. The MMD file gives parameters for all weapons systems managed by the ICP. The PDF, whose purpose is to inform ICP managers about the effect of program changes on the factors used in forecasting demand, contains program data for all major end items that are managed or supported by the ICP. These data include such variables as flying hours, rounds fired, troop population, and miles traveled. The PDF records these data for 2 prior years, the base period, the current year, and up to 5 out-years.

5. Army Budget and Funding Concepts

Although the Army is part of DoD's Planning, Programming and Budgeting System (PPBS), it refers to its own system as the Planning, Programming, Budgeting and Execution System (PPBES). In the programming phase, OSD transmits planning and programming guidance to the Major Commands (MACOM), whose responsibility is to make detailed decisions on forces, manpower, and funds. These decisions are reviewed by the Army staff and used to construct the Army's Program Objectives Memorandum (POM), which is submitted to OSD. The POM, which is published in May, describes all aspects of the Army program: the acquisition and distribution of forces, and the manpower, materiel, equipment, and logistics support required to meet the strategy and objectives established by the OSD guidance.

The POM is reviewed by the Joint Chiefs of Staff (JCS) and OSD, and OSD drafts issue papers that evaluate the proposals in the POM as they relate to the policy and planning guidance. The issue papers also review the Army program for balance between the four pillars: force structure, modernization, readiness, and sustainability. The Army "reclamas" the issue papers, and the results of the debate between OSD and the Army are reflected in decisions by the OSD Defense Resources Board (DRB). These decisions are reviewed by the Secretary of Defense, who makes the final decisions on the Army program. These decisions are described in the Program Decision Memorandum (PDM), which the Secretary of Defense signs in August as the basis for formulating the budget.

a. Army Guidance

Army guidance is developed by the Department of the Army (DA) and issued to the Army staff and MACOM in four volumes. Volume I is the Army Plan. Volume II states the procedures for developing the program, and contains administrative instructions for use by MACOM and operating agencies in preparing their respective Program Analysis and Resource Review (PARR) documents. Volume III contains the Program Development Increment Packages (PDIPs); these packages, developed by the Major Command staffs and subordinate commands, link resources to overall goals and form the basis of the PARR. The PDIPs relating to supply list the supply retention levels. Volume IV contains the instructions of OSD for writing the POM.

The PARR presents the prioritized program of the Major Commands, allowing them a means of identifying and explaining their resource requirements to the DA. It highlights the resources needed to accomplish the Army's missions, and suggests command tradeoffs. A number of functional panels are established to review these PARRs at the DA level, including: Structuring, Training, Mobilizing and Deploying, Manning, Equipping and Sustaining, Providing Facilities, and Managing Information. Of particular concern for supply is the Equipping and Sustaining panel, which makes decisions concerning the budget for supply assets.

b. Levels of Supply Retention

Variable retention levels are quantities of supplies set aside for different purposes:

- Approved Force Acquisition Objective (AFAO)—supplies acquired in peacetime to equip and sustain U.S. forces (including the war reserve requirements), equip and sustain allied forces as required by OSD and FMS, and support other U.S. government departments and agencies.
- Approved Force Retention Stock (AFRS)—supplies in addition to the AFAO that are used to equip and support U.S. forces during the mobilization period (from the start of deployment until production equals wartime usage rates).

- Economic Retention Stock—supplies, in addition to the AFRS, that are more economical to retain for future peacetime issues than to replace by procurement, if the need arises.
- Contingency Retention Stock—supplies, in addition to the AFAO and AFRS, for which there is no quantifiable peacetime need, but that are more economical to retain for future peacetime issues than to replace by procurement. War reserve requirements, inactive end items, etc., are of this type.
- Numeric Retention Stock—supplies not needed to meet specific requirements, but retained in the supply system because disposal is not feasible or economical.
- Potential Excess—supplies that are not required, but retained while it is determined if disposal is necessary.

c. Army Stock Fund (ASF)

The Army Stock Fund, like all other DoD stock funds, was established by the issuance of a DoD charter. (See the general description of stock fund structure and pricing in Appendix A.) The ASF is used to manage common-usage items, mostly consumables, such as spares, clothing, subsistence, petroleum products, and medical and dental supplies. Users purchase items from the ASF with their operating accounts. The Army Industrial Fund (AIF), another working-capital fund, is used for financing the operation of industrial-type activities, such as depots and arsenals, which manufacture and repair items.

The ASF charges a single "standard" price that covers the item's historical costs, inflation, and other expenses included in a surcharge (cost of transportation, losses in handling and storage, etc.).

The ASF is managed by the Director, ASF who is also the deputy chief of staff for logistics (DCSLOG). The stock fund is organized into several divisions, each consisting of a home office and several branch offices. The home office, which is located at the major command headquarters, establishes policy and procedures. Examples of home offices are the Training and Doctrine Command (TRADOC), the Army Forces Command (FORSCOM), the Defense Supply Services Division, and AMC. The branch offices, which are located at installations subordinate to the major command, do the procuring, storing, and distributing (or issuing) of inventory to customers.

The AMC has the only wholesale stock fund division. Other wholesale sources outside the Army include the Defense Logistics Agency (DLA) and General Services Administration (GSA). In contrast to the AMC wholesale system, the TRADOC stock fund, for example, is under the retail stock fund concept and is directed by the installation commanders. The Defense Supply Services Division, another retail division, finances the purchases of supplies required by agencies located in the Washington, D.C. area. This division has been referred to as the Pentagon stock fund division.

Inventory acquisition programs of the AMC wholesale division and all retail divisions are limited by the amount of obligational authority established through the Office of Management and Budget (OMB) apportionment process. The application of the apportionment process by the OMB to the ASF is a control device used to preclude overbuying, which might ultimately jeopardize the integrity of the fund.

d. Retail Operations

An installation (or station) branch office is a separate corporate entity that is both a retail buyer and a seller. Movement of stock from depots or other wholesale supply sources such as GSA is treated as a sale to the station. When placing a requisition with a supplier, the station obligates its own acquisition or obligation authority, which is simply an annual dollar acquisition limitation on each station. In other words, the station supply officer, as a retailer, buys stocks of supplies from wholesalers using his acquisition authority and stock fund cash, and sells stock to consumers in return for consumer (i.e., appropriated) funds.

Under this system, the DoD, through the ASF director in DCSLOG, gives the retail stock fund divisions obligation and acquisition authority, plus an initial amount of operating cash. The retail stock fund has complete flexibility in distributing and using its annual acquisition and obligation authority and stock fund cash. For example, any branch office may choose to acquire and sell more petroleum products and general supplies than were originally programmed. To accomplish this, it can effect immediate reprogramming of acquisition and obligation authority without having to appeal for authority to a higher echelon of command. In addition, a home office has the authority to withdraw stock fund cash from one branch office and give it to another branch office if the situation dictates.

Station stock fund managers are in positions comparable to that of commodity managers at ICPs. They must prepare budget estimates that include forecasts of peacetime and mobilization inventory requirements, sales data, and other types of inventory transactions. A separate estimate is prepared for each major commodity or category, such as electronics supplies.

e. Army Industrial Fund (AIF)

The Army Industrial Fund is a revolving fund that provides working capital to finance industrial and commercial kinds of activities that provide common services to defense components. Each industrial fund activity operates under a charter that defines the scope of operations to be performed. These charters are approved by the Assistant Secretary of Defense (Comptroller). Two requisites for an activity to qualify for an industrial fund charter is that a buyer-seller relationship must exist, and that the activity must produce goods or services for more than one customer.

The Army has several AIF activity groups under two major commands that are designated as activity managers: the Army Materiel Command (AMC) and the Military Traffic Management Command (MTMC). There are three activity groups under AMC. The Army Armament, Munitions and Chemical Command (AMCCOM) activity group manufactures artillery, small arms, munitions, and major components for all military services. The arsenals also perform engineering, repair, renovation and product assurance in support of the services. AMCCOM is the single manager for conventional ammunition for DoD. These missions are carried out at the Pine Bluff, Rock Island, Rocky Mountain, and Watervliet arsenals, at the Crane Army ammunition activity, and at the McAlester Army ammunition plant.

The Army Depot System Command (DESCOM) activity group sustains fighting forces worldwide with depot-level supply and maintenance support. Depot supply operations include the receipt, storage, issue, and shipment of major end items and secondary items to worldwide units and customers. These operations are performed at the Anniston, Corpus Christi, Letterkenny, Lexington Blue Grass, New Cumberland, Red River, Sacramento, Seneca, Sharpe, Seirra, Tobyhanna, and Toole Depots, and at the Fort Wingate, Pueblo, Savanna, and Umatilla Depot activities. Depot maintenance includes tasks of conversion, renovation, modification, repair, inspection and testing, manufacture, fabrication, and reclamation of materiel, as well as provision of maintenance support services.

The Army Missile Command (MICOM) activity group performs various support tasks for missile systems and related projects: research, development, testing, engineering and design, procurement, production management and follow-up production, secondary item procurement, requirements determination, supply, maintenance management, new equipment training, target flight services, and product assurance. These tasks are accomplished by MICOM headquarters, Redstone Arsenal Support Activity, and the Test Measurement and Diagnostic Equipment Support Group.

The second activity manager, the MTMC, is the single DoD manager for traffic management, land transportation, common-user ocean terminals, and intermodal container management. It serves as DoD's transportation operating agency, is organized as a major Army command, and is jointly staffed by all services. The activity groups that accomplished this mission are MTMC headquarters, Eastern Area, Western Area, Transportation Engineering Agency, and Terminal Panama.

The AIF must have the capability to obtain new equipment from time to time, and items can be obtained either under DoD's Asset Capitalization Program using the industrial fund's own resources, or through direct congressional appropriation. Under the Asset Capitalization Program (ACP), the cost of the equipment is recovered over the long run by adding a depreciation expense to the surcharge included in the prices paid by customers. At present, however, the AIF supply operations have been using direct appropriation.

The DCSLOG is responsible for the Army Industrial Fund from a logistics point of view, and the Assistant Secretary of Army (Financial Management) has responsibility for the financial operations. The responsibility for operating the field activities lies with AMC and MTMC, and with the AIF commanders of each separate activity.

6. Weapon-System-Oriented Inventory System

As a related action on the funding of supply items, OSD has been asking the services to move in the direction of managing secondary items by weapon system. OSD hopes this will strengthen the link between materiel management and the performance of weapons. OSD(Installation and Logistics) directed the services to develop plans for the new management system in August 1985. The Army forwarded its plan to OSD in March 1986, and the plan was approved in April 1986.

In moving to a weapon-system-oriented approach, the services and DoD have identified five key areas and thirteen capabilities to meet the requirements of these areas:

- Operational availability (A_O) item information
  - Application file
- Requirements determination
  - Stock levels by weapon system
  - Multi-echelon optimization model

- Integration of initial and replenishment spares and repair parts

- Information systems
  - Asset visibility
  - Demand usage reporting
  - Interservice data exchange
  - Performance tracking
- Materiel management
  - Asset positioning
  - Redistribution
- Resource development and allocation
  - Develop PPBS
  - Balance resources
  - Budget execution.

The Army has been taking concrete steps toward a weapon-system-oriented management approach. An article in the September 1988 issue of *Army Logistician*, "Managing Secondary Items by Weapon System," describes 29 active projects that are moving in this direction. These comprise the first two phases of the Army's three-phase plan. One project concerns allocating resources based on operational availability rates. In 1986, the Army conducted a pilot test of this procedure, dealing with the secondary items for six weapon systems.

C. SOURCES OF INVENTORY DATA

There are two main sources of inventory data for Army secondary items. First is the historical demand profiles maintained by the inventory managers at the NICPs. This information is provided to the item managers through the Commodity Command Standard System (CCSS) of the Supply Management System (SMS). The Requirements Determination and Execution System (RDES) is the primary system within the CCSS; as mentioned earlier, the RDES is the major tool used by the item managers for determining the requirements of wholesale supply items.

The other source of inventory data is the collection of Army reporting systems, including the retail (stock fund) stratification report, that report on inventory of the retail stocks at the field level. Retail stocks include those at both the unit and supply support level.

The RDES inventory data for the low-dollar items is given in three main reports. The Line Item Action Report (LIAR) is a history of all items that have a recommended supply action processed by the LDV (Low-Dollar-Value) portion of RDES. The LIAR gives item managers a concise one-line picture of the current situation and the recommended supply action. The Commitment Obligation Procurement Report is a multi-item, summary display of data on the LDV report. It includes such information as actual demands and returns, as well as forecasted demand requirements. Other data include the inventory positions at the ends of the current, apportionment, and budget years, plus estimates of stock due out during these years.

The final report of RDES inventory data is the Demand Return Disposal File, which is a depository for all the demand, return and disposal histories of all the supply items managed or used by a National Inventory Control Point. From these records, management obtains information on the average demand rate for each item, the average monthly returns, and the quantity of disposals dropped. Finally, the Demand Depot Summary Report lists the total demands supplied by or credited to each depot. It does not give the total stock on-hand or back-ordered at each depot.

The medium- and high-dollar studies include quantitative data on recurring and nonrecurring demands, economic order quantities and safety levels, administrative and procurement lead times, stocks on-hand, due-out or due-in, receipts from repair and procurement, and supply actions resulting from monthly reviews of procurement obligations.

The final report of interest in this series is the Demand Return Disposal Summary, which displays, by customer area and by quarter, the past two years of total quantity demanded, the demand count, and the number of serviceable and unserviceable returns.

Stockage policy for the field is to "stock fast moving items forward and slower moving items in the rear." Stocks at the unit level are for day-to-day operations, and stocks at higher levels are to support customer units. For the unit level, there is a mandatory stockage list of authorized repair parts plus a demand-driven stockage list. The total of both these lists, referred to as the prescribed load list (PLL), is not to exceed 300 line items. There is one PLL for peacetime, and one for combat. The supply support activity can have additional items beyond mandatory and demand items on their authorized stock list (ASL), but each item must meet specific requirements for being placed on the ASL and each must have a requirements objective, which is the maximum quantity of the item authorized to be on hand and on order at any time.

The peacetime and combat PLLs are compiled alike, the only major differences being the number of days of supply, plus the fact that the combat PLL must be carried by organic transportation. The PLL is usually associated with the battalion level, and it holds the stock for the battalion's companies. There are generic PLLs for the different units, and these can be obtained from the Army through the Commander AMC Materiel Readiness Support Activity (MRSA) at Lexington, Kentucky. These PLLs would document what should be maintained for those units and would be composed of a list of mandatory parts, demand items, essential items, and other authorized non-demand items.

The supply-support level at the field contains additional supply items in the ASL. The ASL consists of items that have a high enough usage at a Supply Support Activity to warrant stockage. The stockage includes prepositioned war reserves, demand supported items, non-demand support for new items, insurance items, stock numeric items, and other stock (operational float items). These stocks are usually kept at the division level.

Stocks at the division level are also reported by the SIMS-X system, which implements the OSD directive concerning vertical management and critical supply management of selected secondary items. These are spares that are funded by the stock fund and procurement accounts. They are identified by Reportable Item Control Code (RICC) 8 *in the Army master data file*. The SIMS-X provides the wholesale item manager with a report of assets and requirements for selected items at the retail level that are supported by retail automated systems. The wholesale item manager has the authority, under the Materiel Returns Program, to redistribute SIMS-X items from those activities with excess holdings to those activities that need them more. In this manner, item managers can have better inventory control over total assets.

The criteria for an item to be in SIMS-X are: a supply class of 9, an automatic return code of C or U (on-hand assets are insufficient to prevent an out-of-stock position), an annual demand of $50,000 or more, and a recoverability code of D or L (depot repairable). It is estimated that over 85 percent of the dollar value of secondary items are covered by SIMS-X. The data on an item under the SIMS-X can be obtained from the NICP that manages the item. The RDES provides a line for the status of each location where the item is positioned.

A similar system to SIMS-X is the Aviation Intensive Management Item (AIMI) program. The purpose of the program is to provide responsive supply support for aircraft, allocate scarce resources to MACOM purchase items in critical supply, allow MACOM to participate in requirements determination and item allocations, track the location and status of selected aviation-related secondary items, reduce materiel requirements by choosing levels of supply that will reduce the repair cycle time, and authorizing premium transportation and direct shipments when efficient.

The items to be included in the AIMI are selected at semi-annual conferences that adopt delivery schedules and compile data on worldwide demand, assets on hand, scheduled procurement, and projected overhauls and rebuild schedules. At no time will any AIMI stock be allocated below installation level, and AIMI stock will be limited to a 30-day negotiated level. Stock over the current month's negotiated level plus the next month's negotiated level are considered excess stocks.

D. SOURCES OF BUDGET DATA

Stratification is the process the services use to relate requirements to current assets. The stratification report lists secondary items stratified by the purpose for which they are required, thus allowing the Army to better match assets to requirements, form estimates of readiness and sustainability, and prepare budget submissions.

The stratification process compares assets with requirements in a phased simulation of demands, procurement, repairs, etc. The four phases are the opening position (the date the stratification is performed), the current period (3 or 6 months in length), the apportionment year, and the budget year. The budget-year position serves as the basis for funding secondary items. The stratification report covers 21-30 months, depending on the stratification date. Army regulation AR 710-1 requires that budget stratification be accomplished at least four times a year, at the ends of June, September, December, and March.

Although the supply control study process and the stratification process are similar in concept, and use the same database, they differ in purpose. The stratification report deals with budget requirements (how much money is needed to operate the inventory system), and the supply control study deals with budget execution (how much to buy and when). The two reports also differ in planning horizon. The supply control study performs a continuous review of the forecast period and recommends a buy when needed. Each of the four quarterly stratification reports, on the other hand, looks as far ahead as 36 months. It simulates requirements levels and changes in inventory, and generates the funding requirements by adding up the dollar value of all the simulated buys.

The stratification report is run in phases. First is the initial processing, which produces the individual studies and the item management plan. Then comes a correction phase when item managers review the stratification studies to ensure that the best, current data are used. The system is then re-run with the corrections, followed by the final phase, consisting of review and analysis of the output.

Army data are listed according to the National Stock Number Master Data Record (NSNMDR). Each NICP maintains the history for the items under its control; each item is characterized by a National Stock Number. Various sorts of data can be obtained, for example, the dollar value of all stock fund items maintained at the Tank and Automotive Command. It is also possible to obtain data for a limited number of weapon systems at the same command. The variables would include the location (depot) of the materiel and its condition codes. In addition, the Army Materiel Category Structure Code is used in the management of inventories. The category groups and subgroups are the basis for data collection and reporting.

The quarterly stratification data are available from AMC in hard copy going back to 1981. Data for the retail level that is generated through the SIMS-X and AIMI systems are available at the NICPs. Using the NSNMDR, individual ICPs can tell where items are located and the quantity of the stock. For items not on the SIMS-X or AIMI system, the Materiel Readiness Support Activity in Lexington, Kentucky, maintains a current list of the prescribed load list (PLL) and authorized stock level for all activities. These data give the stock that is required and on hand at each field activity. Requests for these data should be made through the Materiel Readiness Support Activity. Stratification data is available through the Army stock fund reports on the retail inventories at each stock fund division. This information is maintained by OSD secondary item material codes, which relate to the Army commodity groups.

The availability of Army supply data is somewhat limited. There are quarterly stratification reports at the AMC, NICP, and major command level. These reports show the asset position at each level for the wholesale and retail levels.

E. BUDGET AND PERFORMANCE MODELS

1. Standard Initial Provisioning (SIF) model

Prior to 1965, there was no formal procedure for calculating the quantities of spares needed to support weapon systems and other end items during the provisioning period, the initial period after deployment. Each of the Army's commodity areas had developed independent approaches to provisioning. In 1965, the Army published a report that attempted to set down a standardized method of computing provisioning requirements. The process was not fully accepted, however, as it ignored many critical variables.

In 1974, DoD published DODI 4140.42, "Determination of Initial Requirements for Secondary Item Spare and Repair Parts." This instruction established a policy for computing the inventory levels of spares beginning with provisioning and continuing through the demand development period. The SIP model was the Army's response to this policy guidance. The model is a collection of 33 formulas and over 100 variables that are designed to compute provisioning requirements.

The basic formula in the SIP model calculates quantity from a product of (1) the failure rate, (2) the unit of operational time, and (3) the density, or number of items in use. The output of the SIP model is number of spares needed for support, for both initial issue and wholesale replenishment. The quantity for initial issue is the sum of needs for CONUS depot-level repair, below-depot-level repair, order and shipping time, operating level, safety levels below depot-level, and special requirements. Wholesale, initial issue and special requirement quantities are further rolled up into a total, worldwide requirement for spares.

2. Selected Essential Items Stockage for Availability Method (SESAME)

In designing the SIP model, the Army followed the specific guidance in DODI 4140.42 that stockage levels for most items should be based on anticipated demand, with severe restrictions imposed on "non-demand" items stocked using other criteria. The Army eventually discovered, however, that the computational methods did not lead to an adequate stockage level for many time-critical items. This led to the alternative criterion of sparing for operational availability, which has now become a DoD policy. The SESAME model is the part of the SIP model that provides the link between the availability of spares and the operational availability of the weapon system or other end item. Operational availability (A_O) is the percentage of total time that a piece of equipment is mission capable.

Basing provisioning on A_O means that the stockage level can no longer be based solely on satisfying the numerical demands of wholesale and retail customers, but must also consider other factors such as whether the item is needed to perform the mission, the appropriate level for the repair action to take place, the length of time required to conduct repair, and the time to order and ship replacement spares.

The SESAME model makes several assumptions: (1) there is no significant redundancy of components, (2) there is no gradual degradation of system performance, (3) components are not common to other weapons systems or other end items being supported by the same units, and (4) a failed item is sent to a repair facility for immediate repair.

The inputs for the SESAME model include order and shipping times, the densities of items supported, removal rates, replacement task descriptions, maintenance task descriptions, mean time between failures, mean time to repair, mean logistics delay time, the line-replaceable unit (LRU) designations, the non-LRU designations, and the unit price of the next higher assembly.

The SESAME model can be operated in either a requirements or budget mode. In the requirements mode, the model starts with a budget and produces a list of components and their stockage levels. In the budget mode, SESAME uses either of two methods to forecast future budgets. One method is an extrapolation procedure used when complete lists of components and critical component parameters are not available, as is sometimes the case early in the life of a system. The other method, called the stockage-list budget method, is used when the components have been identified and the data records are adequate.

In addition to producing budget forecasts and stock lists, the SESAME model also generates an essential repair parts stockage list. This list identifies, and gives the quantity of LRU units that do not meet the demand stockage criteria, but which are needed to keep the operational availability of the weapon system or end item at the level specified in the required operational capability.

3. Requirements Determination and Execution System (RDES)

The RDES is an automated system for use in determining the requirements of Army wholesale supply secondary items. It is not a budgeting system, but rather an execution system that provides item managers with the information they need to carry out their supply functions. The RDES obtains supply data from several sources: the demand return disposal file, the National Stock Number Master Data Record, the program data file, the materiel management decision file, and the "economic order quantity, variable safety level" (EOQ/VSL) model. Among the variables collected from these sources are current demand rates, customer requirements by major area, safety levels, administrative and procurement lead times, and reorder cycle times.

Using these data, the RDES predicts such outputs as the stock balance over time, the supply actions to be taken, and the costs of carrying out the actions. These outputs are calculated for the current year, the budget year, and several out-years. The information can be presented by item, or aggregated by classes of items. It will identify the locations of the demands, the customer areas, and the return and disposal of items by depot. The system is run monthly at each ICP, and the outputs are used in conjunction with the quarterly stratification report.

Two subsystems of the RDES are the One Two Three Effective Resupply (OTTER) system and the EOQ/VSL subsystem. The OTTER system creates automatic Procurement Work Directives (PWDs) after an item's asset position reaches the reorder point, and it does this more quickly than does the monthly run of RDES. This reduces the time to determine requirements and smooths out the flow of PWDs to the Procurement Directorate.

The EOQ/VSL subsystem computes variable safety levels and reorder cycles, and adjusts the computed levels by the minimum and maximum parameters from the materiel management file. The inputs of the EOQ/VSL subsystem can be changed to evaluate alternative provisioning programs and compute new supply levels.

The Army Logistics Management College at Fort Lee conducts a four-week course to keep item managers current on the RDES system.

F. SUMMARY

The Army's inventory management staff is organized into wholesale and retail divisions. There are six wholesale divisions, and they report to the Army Materiel Command. Each is a commodity-oriented Inventory Control Point called a Major Subordinate Command (MSC). The six MSCs are: Aviation System Command; Armament, Munitions and Chemical Command; Communications and Electronics Command; Tank and Automotive Command; Missile Command; and Troop Support Command. These MSCs manage all wholesale items, whether funded by either procurement accounts or stock funds.

The retail divisions are stock funds located at major commands and branch offices located at installations. These retail divisions purchase consumables and selected repairables from the other services, GSA, and DLA, with a small amount purchased locally.

The Army has a simple policy for funding secondary items. Items that cost over \$500 are funded by a procurement account (the particular account depending on the nature of the item), and by the stock fund if they do not cost over \$500 (i.e., they are consumables). Items that cost \$500 or less are funded by the stock fund regardless of their maintenance repair level, and the cost is charged to the user's account when issued.

The wholesale stocks managed by the ICPs are not co-located with the ICPs, but are held at 11 depots and 6 depot activities under the command of the Depot System Command, a subordinate of the Army Materiel Command. Items are generally acquired from the wholesale level through the Army's Direct Support System. Assets demanded by users are shipped directly from the wholesale depots to a central receiving point at the retail installation for pickup by the user. Customers using the Direct Support System have their funding and documentation processed by the stock fund division (actually, a sub-office of the stock fund division), rather then by the supply department at the installation (which stocks mostly non-repair part consumables). The Army instituted the Direct Support System to reduce the number of supply stockage points in the retail system.

Each of the Army's six NICPs produces a requirements determination and execution report each time an item breaches an established norm. The norm can be a dollar value, a change in operating tempo, a usage rate, a repair cycle time, etc. In addition, the RDES is run each month for all high-value items, and always before a quarterly stratification report. Each RDES run is made before the stratification report incorporates any changes in demand (both recurring and non-recurring), changes in Army materiel management decisions, or changes in operational tempo. The EOQ/VSL model is used to determine the required action for an individual item by the item manager.

The output of the RDES is used as the basic input into the quarterly stratification model. These data include: monthly demands, safety levels, administrative and production lead times, repair lead times, price of the item on the last procurement, stock on hand, stock due in from repair, stock due in from procurement, requirements objective, and information related to operating tempo. This information is at the item level for all wholesale items, and is aggregated for use in the stratification report.

APPENDIX D.

AIR FORCE INVENTORY AND BUDGETING OF SECONDARY ITEMS

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A. INTRODUCTION

This appendix summarizes how the Air Force manages secondary items. The next section discusses the inventory and budget structures, organizational structure, the requirements process, and measures of supply effectiveness. Succeeding sections focus on specific topics: the major sources of inventory data, the sources of budget data, and some of the models used to allocate secondary items and relate them to military capability.

B. DISCUSSION

1. Inventory Structure

The Air Force Supply Manual (67-1) establishes the basic framework for the entire Air Force supply process. It sets operating policies and procedures for both the base- and depot-level supply process. The Air Force Logistics Command (AFLC) has major responsibility for managing Air Force centrally procured items. AFLC manages all secondary items except those within the commissary, medical/dental, and Air Force Academy divisions of the stock fund. These divisions are managed by designated operating centers.

Base and other organizational commanders are responsible for accurate and timely reporting of usage, assets, and special requirements for use by AFLC. AFLC uses these data, along with those from contractors to determine supply requirements. Data for non-AFLC managed items are separately tracked and reported to the responsible operating center.

Air Force secondary item inventories are distinguished in different ways for different purposes:

- Expendable vs. nonexpendable (accountability)

- Replacement vs. consumption (requirements computation)
- Depot vs. base (distribution)
- Investment vs. expense (funding)
- Wholesale vs. retail (type of sales activity)
- Initial vs. replenishment (timing)
- Direct appropriations vs. revolving funds (management)
- Peacetime vs. wartime (type of operations).

a. Expendable vs. Nonexpendable

The Air Force makes this distinction for purposes of accountability. Expendable items are those that are either consumed during use or become a part of a higher assembly during periods of use. Repair components and fuel are typical examples. Expendables are issued on an "as needed" basis, and accountability stops when they are issued or attached to another item. Some expendables ("repairables") can be repaired and used again. They are kept on the books when they are turned in for repair, until the time they are reissued or condemned.

Nonexpendable items are "stand alone" end items such as vehicles, tools, and office equipment that are neither consumed nor lose their identity during use. They are usually issued by authorization or allowance documents, and the user is required to maintain accountability after issue.

b. Replacement vs. Consumption

The Air Force makes this distinction for the purpose of computing requirements. Replacement items are nonexpendable items that maintain their identity in use. They are also generally classified as principal items. Units are equipped with replacement items based on a predetermined table of allowances, and they can replace these items when they become worn or damaged.

Consumption items are also expendable (consumed in use or incorporated into other assemblies). These items are issued on an "as required" basis, with requirements based on past usage and a projection of this demand into the future, rather than on the basis of authorized allowances.

Consumption items are considered "recoverable" when it is economically efficient to repair them when they break. Repairing such items normally costs less than 75 percent of their acquisition cost. Recoverable items are also known as repairables, exchangeables, investment or nonconsumable items.

Consumption items can be further broken down into assemblies, repair parts, and consumable supplies. An assembly is a group of two or more parts that can be taken apart without destroying the assembly. Examples are pumps, motors and aircraft navigation instruments. Repair parts are individual pieces of an assembly used to make repairs or overhauls, examples being blades or valves. Consumable supplies are items consumed in use, such as fuel, paint, and ammunition. Consumables are also referred to as "expense items," "throw always," and "bits and pieces."

c. Depot vs. Base

The Air Force uses a two-level supply distribution system, in which inventory is stocked at either depots or operating locations (bases). The Air Force relies on a centralized "leveling" system to position inventory. Inventory is "pushed" out from depots to the operating locations where they are most likely to be used.

The Air Force's supply manager is the Air Force Logistics Command (AFLC) whose headquarters are at Wright-Patterson Air Force Base (AFB), Ohio. (There are plans to merge AFLC and Air Force Systems Command, but this has not happened yet.) Under AFLC are five depots, or Air Logistics Centers (ALCs), which serve as inventory control points (ICPs) for all secondary items except those for the commissary, medical/dental and Air Force Academy divisions. (Even for these items, the Air Force functions as the wholesale manager.) The depots are located at Tinker AFB, Oklahoma; Hill AFB, Utah; Kelly AFB, Texas; McClellan AFB, California; and Robins AFB, Georgia. A sixth ICP, a cryptological support center, is located at Kelly AFB, Texas.

The depots perform all the Air Force's major maintenance work, including repairs, overhauls, modifications, alterations, inspections with disassembly, and retrofitting. They do this through the Depot Maintenance Service (DMS), a division of the Air Force Industrial Fund (AFIF), discussed later. DMS is generally referred to as the Depot Maintenance Industrial Fund (DMIF).

There are currently about 200 bases or installations at the operational level, where inventory items are actually used. Inventory at these locations can be maintained within the supply system as part of the stock fund or as investment (repairable) items under the control of the base's supply officer. Base-level inventory can also be located in maintenance facilities at the organizational or intermediate level. Organizational maintenance includes relatively minor, routine tasks performed at the flight line, tasks such as removing and replacing small items, cleaning and servicing parts, and making minor adjustments. Intermediate-level maintenance includes the field or shop-level maintenance activities on base. These tasks, which require more highly-skilled personnel and more sophisticated and specialized tools and equipment than do organizational tasks, include larger adjustments, repair, extensive testing, and rebuilding of certain components.

Air Force weapon system maintenance primarily involves aircraft. Aircraft inventory items have a multi-indentured, or hierarchical component structure. The first, or assembly level are the line-replaceable units (LRUs), items that are normally removed and replaced at the flight line under organizational maintenance. LRUs are composed of shop-replaceable units (SRUs). These are items that are removed, repaired and replaced at intermediate or depot maintenance activities, and they also include the smaller consumable items (bits and pieces) used in the repair.

d. Investment vs. Expense

Investment items are those that are funded by the three Air Force procurement accounts: Aircraft Procurement, Air Force, Missile Procurement, Air Force, and Other Procurement, Air Force. These items include equipment repairable assemblies, and spares and repair parts that are centrally managed and designated as recoverable or repairable. Repairable spares are of two types, initial and replenishment, and are normally expendable at the depot level. Aircraft repairables are funded by Aircraft Procurement (appropriation symbol 3010), missiles by Missile Procurement (3020), and the remaining categories by Other Procurement (3080). The aircraft component accounts for almost 90 percent of all investment spares, and 72 percent of the total value of secondary items.

Repairable (investment) secondary items are funded by procurement accounts, and consumable (expense) items by the stock fund.

e. Wholesale vs. Retail

Inventory consists of those items for which the Air Force serves as the DoD wholesale manager, with responsibility for all purchases from private suppliers. Wholesale items are not transferred or sold directly to final customers, but are passed through intermediate points such as bases or industrially funded activities for further processing. Item managers at the depot or ICP retain the responsibility for managing wholesale inventory from "cradle to grave" to meet Air Force demands worldwide.

Retail inventory is stock held below the wholesale or depot level, either in the stock fund or in the hands of the final customer, including base-level organizations and field (intermediate) maintenance activities. Retail inventory is usually purchased from government wholesale activities. The Air Force's stock fund consists of five retail divisions that handle items for which other services or government agencies have been designated as the wholesale manager. These items are primarily held for sale to Operations and Maintenance (O&M) accounts and industrially funded customers.

f. Initial vs. Replenishment

Spares are individual pieces of an assembly or an end item that is used in the field or at depots to repair or overhaul a worn or damaged equipment. These items vary from consumable items such as bolts and washers funded by the stock fund to complex equipment such as navigational computers funded by the investment appropriations. Repairable spares are funded by procurement appropriations, and consumable spares by the stock fund.

Initial spares are the stocks that are bought to support new equipment during the first two years of operation. The spares for the first two years of the 10th squadron of F-15s, for example, are initial spares, even if this squadron was not created until many years after the first squadron. This terminology was first implemented in the FY 1987 Budget Estimate Submission. Previously, all spares purchased more than two years after the first deployment of the first squadron were called replenishment spares. Initial spares are funded by the three procurement appropriations.

Replenishment spares, which are funded by both the procurement appropriations and the stock fund, are those that provide continuing support for the system, after the initial period. In addition to normal resupply, replenishment includes purchases to increase stockage levels to meet higher usage rates, decisions to improve readiness, and redeployment of old end items. Requirements for replenishment spares are computed from demand rates established since the system was first deployed. Finally, all War Reserve Material is budgeted as replenishment spares, with the single exception of entire whole spare engines.

g. Direct Appropriations and Revolving Funds

Secondary items can be purchased from the private sector either by money appropriated by Congress, or by revolving funds belonging to working capital accounts. The Air Force operates two such funds, a stock fund and an industrial fund. The Air

Force's stock fund buys inventory from the private sector using its stock of cash on hand (working capital), and then sells these items to ultimate users in return for cash that the users have received from congressional appropriations. The proceeds from these sales are then used to replenish inventory, and the cycle repeats. (Working capital funds are originally "seeded," or set in motion, by congressional appropriation.)

The Air Force's industrial fund provides repair, instead of inventory. It buys labor and consumable parts from the stock fund (just like ultimate users), and employs these parts to repair repairables for other Air Force organizations (including the stock fund). The industrial fund charges these customers for the repair cost in order to maintain its stock of capital and replenish its stock of consumables.

h. Peacetime vs. Wartime

In addition to its normal revolving fund operations, which are self-sustaining, the Air Force Stock Fund also receives appropriated funds for Peacetime Operating Stock (POS) and War Reserve Materiel (WRM). Since 1983, Congress has appropriated money for enlarging POS due to the introduction of new weapon systems, modification of existing systems and increased levels of peacetime operations.

POS are that part of the inventory that supports the peacetime objectives of the Air Force: training combat forces, supporting day-to-day operations, and ensuring that weapon systems are ready for war. WRM includes almost the same categories of items as POS, but the stockage requirements are higher, being sized to support wartime activity levels.

WRM inventory is of two types, prepositioned and prestocked. Prepositioned stocks are in place before hostilities break out, and serve to support forces during the transition to wartime operations and during the first 30 days of combat. Prepositioned stocks are further divided into War Readiness Spares Kits (WRSK), which are air-transportable packages of spares and repair parts for use by units to be deployed, and Base Level Self-Sufficiency Spares (BLSS), which are spares and repair parts required, in addition to normal POS, to support non-deployed units fighting from their home bases.

Prestocked WRM, which is often called Other War Reserve Materiel (OWRM), are items that are stored at the depots for the purpose of augmenting WRSK, BLSS, and POS. In particular, OWRM is intended to sustain wartime operations until the rate of industrial production of supplies meets wartime goals. DoD's stated policy is to transition to industrial production rates within 60 days.

2. Air Force Stock Fund

The Air Force Stock Fund (AFSF) provides for the financial management, inventory control and distribution of consumable items of supply and low-cost equipment. (See the general description of stock fund structure and pricing in Appendix A.) These items are used to fix repairable investment spares and major end items of equipment. AFSF inventories also consist of non-repair items, including general and administrative supplies, fuel, subsistence, and medical supplies needed to maintain the readiness and sustainability of weapon systems and personnel.

The dollar value of stock fund inventory is calculated using "standard prices" that cover historical prices plus allowances for inflation and surcharges to cover second destination transportation and losses due to pilferage.

The AFSF is composed of several divisions:

- Systems Support Division
- General Support Division
- Fuels Division
- Medical-Dental Division
- Commissary
- Air Force Academy Cadet Store.

The Systems Support Division (SSD) buys and manages about 515,000 centrally procured expense (consumable) items for which the Air Force has been designated as the DoD Inventory Control Point (ICP). These items are purchased directly from contractors and consist of repair parts for aircraft, missiles, and their major components. AFLC is the designated manager for buying, storing, and issuing these parts. SSD is the only wholesale AFSF activity, the other five divisions being classified as retail activities. SSD operates under the vertical stock fund concept, in which assets remain under the ownership and control of the central AFLC item manager while they are in the stock fund, and are transferred at no cost between various organizations of the stock fund. No transaction is recorded until the items are sold to the ultimate customer. Since only wholesale activities are permitted to add a surcharge to sales prices, SSD is the only AFSF division that is consistently able to recoup all operating expenses. In FY 1987-89, the Air Force added surcharges of 13.4, 14.9, and 17.2 percent, respectively.

The General Support Division (GSD) is a retail division that buys and manages about 1.5 million expense type (consumable) items. Included are repair parts common to more than one weapon system, low cost equipment, administrative supplies, and general base operating supplies. AFLC is responsible for overall management. Inventory is purchased by base-level stock fund outlets from the General Services Administration (GSA), the Defense Logistics Agency (DLA), other services, and commercial sources. All items except those purchased locally must be sold at the same standard price the AFSF pays for other government activities. The Air Force must therefore absorb any gains or losses not covered by the standard price. Locally purchased items include a surcharge.

The Fuels Division is the retail activity that is responsible for the worldwide purchase and sale of bulk petroleum for Air Force aircraft, missiles, and ground transportation. Most fuel products are purchased from the Defense Fuel Supply Center (DFSC), which serves as the DoD wholesale manager. The Medical-Dental Division is a retail activity that manages about 62 thousand expense items through 115 outlets throughout the world. Most items are purchased from the Medical Division of the DLA Defense Stock Fund (DSF).

The Commissary Division is a retail activity that buys and sells subsistence items to military personnel and their dependents. Items purchased from the DSF Subsistence Division are sold at standard prices. The Air Force Commissary Service located at Kelly AFB, Texas, is responsible for centralized management of the 150 troop and resale outlets. Finally, the Air Force Academy Cadet Store Division is a retail activity that manages academic supplies, uniforms, athletic supplies, clothing, bedding, textbooks, and micro-computers for resale to the cadets.

3. Air Force Industrial Fund

The Air Force Industrial Fund (AFIF) is managed by Headquarters, Air Force, although operational control is delegated to the major commands and their subordinate units.

The AFIF has four separate operating activities:

- Depot Maintenance
- Airlift Service
- Laundry and Dry Cleaning Service
- San Antonio Real Property Maintenance Center.

The Depot Maintenance Industrial Fund (DMIF) overhauls and repairs aircraft, engines, missiles, and other major end items and components at all levels of support (organic, contract, and interservice depot maintenance). The DMIF's customers are primarily Air Force operational activities that pay for DMIF's services by O&M funds from the AFLC-managed Depot Purchased Equipment Maintenance (DPEM) account. DMIF reimbursements are based on standard prices. In FY 1989, about 50 percent of the DPEM funds were spent on fixing repairables, most of the remaining funds being spent on modifications.

We will not discuss the remaining categories of the industrial fun, because they relate to services rather than inventory. The remainder of this section deals exclusively with the repairables process: how inventory is valued in dollar terms, how requirements are determined, and what data are available to measure inventory and effectiveness.

4. Inventory Valuation and Requirements Determination

Repairable or investment spares, those funded by the procurement appropriations, account for approximately 80 percent of the secondary item inventory ($29.3 billion out of $36.4 billion on September 30, 1987). The dollar value of the inventory is calculated by pricing the physical inventory using the latest price paid for a particular class of items at the time of the inventory.

The basic guidance for determining the requirements of Air Force centrally-procured logistic support items (spares and repair parts, except engines) is contained in AFM 57-1, "Policies, Responsibilities, and Guidelines for Determining Materiel Requirements." The specific computational algorithms used for replenishment spares is defined by the Recoverable Consumption Item Requirements System (D041), described in AFLC 57-4, "Recoverable Consumption Item Requirements System."

The computation of requirements, described in the following four steps, is carried out quarterly by AFLC for 25 quarters into the future, plus an additional three-year retention period:

1. Calculating the past demand rate by dividing past usage by an appropriate measure of program size (flying hours, equipment months, engine overhauls, etc.)
2. Projecting future demand by multiplying the past demand rate by the projected future program size
3. Adding in allowances for required stock levels, WRM requirements, and other special needs
4. Computing net requirements by taking gross requirements, and subtracting available assets.

These requirements computed by the D041 process are generally considered to be recurring types of requirements built from standard programs. There are still other additive requirements not accounted for by this process that must be included in total requirements. These other items, frequently referred to as quantitative requirements, can be determined by other systems as in the case of due out to maintenance, WRM requirements, and the International Logistics Program. Finally, there are changes that the item managers may make based on their own knowledge and experience.

The requirements for initial spares are calculated differently, based on a percentage of recurring unit procurement cost. The percentages, or provisioning factors for entirely new systems are based on experience with existing systems of similar type, with adjustments for new features that will lead to new supply requirements. The goal of this calculation is a budget that is sufficient to fill the pipeline, including base repair, depot repair, and condemnations, and that allows for procurement lead time plus three months.

The preceding paragraphs deal with recoverable spares. Inventory and budget requirements for Air Force centrally-procured nonrecoverable repair parts (expense items maintained in the Systems Support Division of the Stock Fund) are calculated using the D062 Economic Order Quantity Requirement Computation System. The governing regulation for the D062 system is AFLCR 57-6, "Requirements Procedures for Economic Order Quantity (EOQ) Items."

The purpose of the D062 computations is to calculate a reorder level, the point at which the supply system initiates a buy action. The amount of the buy itself is found by calculating the EOQ, which is the most economical quantity to buy given the costs of procurement and ownership (storage, for example). The reorder level is calculated four times a month, using the following steps:

1. An average daily demand rate is calculated using both recurring and nonrecurring demand.
2. This rate is multiplied by the procurement lead time in days to get a lead time requirement.
3. The reorder level is calculated by adding in allowances for the depot supply level, backorders (unfilled orders), and WRM.

5. Inventory Measures of Effectiveness

A number of measures are used to assess the adequacy of secondary item requirements and funding. These effectiveness indicators are focused on either the supply or the operational system. None tells the whole story, and each has its value. The problem is that the different measures support different funding positions, and this leads to confusion as the calculated requirements and budgets pass upward through the various management and review levels. This results in frustration, extra work, and decisions being made for the wrong reasons.

Supply effectiveness is commonly measured using fill rates, backorder levels, and cannibalization rates. A fill rate is the percentage of time the supply system is able to satisfy customer demands with off-the-shelf inventory. Higher fill rate clearly means higher operational readiness and sustainability. Rates are calculated for both the wholesale and retail levels, and the current Air Force goal is 85 percent.

Backorders are the total dollar value of customer demands that have been ordered but not received. More backorders means lower readiness and sustainability. Cannibalization is removing parts from one end item to put into another, to make it operable. For aircraft, the rate is the number of cannibalizations per 1000 flying hours. A high cannibalization rate indicates a shortage of spare parts, and portends readiness and sustainability problems for the future.

Operational effectiveness, as opposed to supply effectiveness, is a direct measure of the ability to perform missions. An aircraft is fully mission capable if it can complete all mission requirements. Aircraft that can complete some, but not all mission requirements are partially mission capable, and all other aircraft are not mission capable due to supply, maintenance, or both .

6. Budget Structure

The budget structure for secondary items follows the same general pattern as the inventory structure, so much of the terminology will be applicable here. Congressional appropriations are the first major funding division. The principal titles in funding Air Force secondary items are the three Procurement accounts and one O&M account. Aircraft Procurement (3010) goes to fabricate, procure, and modify aircraft and their weapons, procure direct ground support equipment, construct aircraft industrial facilities, and procure investment spares, war consumables, and technical data. Missile Procurement (3020) covers the same sorts of procurement activities for missiles. Other Procurement (3080) goes for procuring weapon support materiel (munitions, vehicles, electronic and telecommunications equipment, and other base maintenance and support equipment), other industrial facilities, equipment and modifications, and investment spares. This includes installing and replacing equipment, mockups, technical data, and handbooks associated with end item equipment.

O&M (3400) finances daily base activities. This includes operating and maintaining aircraft, missiles, radars, base facilities, and hospitals, and supporting other operational activites such as intelligence, communications and training. O&M also includes funds for civilian pay, equipment maintenance, and aircraft fuel, oil, supplies, and equipment. It is the principal account that consumers use to buy expense items from the stock fund and the DMIF.

Congressional appropriations (called Total Obligational Authority, or TOA) grant DoD the right to incur obligations (sign contracts). The money must be actually obligated (contracts must be signed) within three years for procurement appropriations, and within one year for O&M and Military Personnel. Actual spending of the money, through writing checks on the U.S. Treasury, can last years in the future, without limit.

Revolving, or working capital funds, including the Air Force Stock and Industrial Funds (4921 and 4922), are a different funding mechanism. The funds are initially created by congressional appropriations, but the funds can then operate independently of Congress, selling stock and buying more with the sales income, or reimbursements indefinitely. This does not mean that revolving funds operate without controls. First, the activities that buy from the revolving funds must obtain *their* money from congressional authorization, and thus undergo the normal (and stringent) budget review process.

Second, although revolving funds do not need congressional TOA to purchase new stock, they do need authorization in the form of obligation and commitment authority granted by the Office of Management and Budget. A revolving fund is thus a vehicle to provide interim financing that is more flexible than congressional appropriation. The military services can place orders for goods and services in anticipation of future needs without waiting for these needs to actually occur (i.e., without waiting for stocks to run out) and then suffering shortages during the substantial administrative and procurement lead times.

There is an important exception to this picture. Although revolving fund purchases are covered by reimbursements from customers under the majority of normal operations, Congress has, since 1983, made direct appropriations to the stock fund to finance increased purchases of POS required by such factors as the introduction of new weapon systems, modifications of existing systems, and increased levels of peacetime operations to improve readiness. The stock fund also receives direct appropriations for WRM.

The next major subelement in procurement appropriations is the budget program activity. Each activity is described by a Budget Program Activity Code (BPAC). The first two digits of the BPAC indicate the types of work being done, such as weapon systems purchases, modifications, and industrial programs. The remaining positions of the code specify the weapon system.

There are two budget projects for secondary items within the Aircraft Procurement appropriation: BP16 (Initial Spares) and BP15 (Replenishment Spares). In the supporting documentation for these appropriations (called the P-1 exhibit), initial and replenishment spares are combined into a single line item for all aircraft spares. War Consumables are a separate line item.

To get an idea of the relative shares of these line items, the FY 1988 budget authority of $2,246 million for aircraft secondary items was composed of $1,910 million for replenishment spares, $307 million for initial spares ($463 million for total initial spares less $156 for spare engines, which are principal items), and $29 million for war consumables. The Missile Procurement appropriation included about $155 million for secondary items: $112 million for BP 26 (Initial Spares) and $43 million for BP 25 (Replenishment Spares).

The Other Procurement appropriation includes initial and replenishment spares not covered by the aircraft and missile appropriations. There is no major subelement or budget project breakout for initial and replenishment spares funded through Other Procurement, but these items are included as separate P-1 line items within other Other Procurement budget programs: 81 (Munitions), 82 (Vehicular Equipment), 83 (Electronic and Telecommunications Equipment), and 84 (Other Base Maintenance and Support Equipment). Total Other Procurement budget authority for secondary items in FY 1988 was about $236 million. The major contributor was Electronics and Telecommunications, whose budget of $224 million included $127 for initial spares and $97 for replenishment spares.

7. Budget Process

The budget process is the focal point for secondary item management and oversight within DoD. Repairables are purchased through the procurement appropriations, and consumables through the stock fund. Bases use O&M funds to purchase consumables from the stock fund, and depot-level organizations use O&M funds to buy repair services (parts and labor) from the industrial fund (DMIF). The DMIF, in turn, uses its own revolving funds to buy, from the stock fund, those consumable items it needs to make these repairs.

The budget process will be described first at the OSD level, and then at the Air Force level. The OSD Comptroller takes the lead in organizing the budget process. The Comptroller orchestrates the cycle from beginning to end. Other OSD offices, such as Program Analysis and Evaluation (PA&E) and Production and Logistics (P&L), have key supporting roles.

As previously noted, the success of the repairable system depends, to a large extent, on the availability of procurement funding (investment items), stock fund obligation authority (bits and pieces), and O&M funding (both depot and base-level maintenance). All the resources must be in place if the repair cycle is to be completed in a timely manner. However, each element is usually reviewed separately, particularly when changes are being made after the major commands submit their budgets to Air Force Headquarters and the Air Force submits its budget to OSD. This segmentation of the review process mirrors the segmentation of the budget offices in OSD and the services appropriations. Even related appropriations are reviewed at the managerial level without the benefit of a detailed integrated analysis. The logistics offices that support the budget process are similarly divided.

The main source of supporting documentation for the budget of secondary items are the exhibits that are submitted to Congress with the Budget Estimate Submission (BES). Using the information submitted in written documents and the hearing, the analyst prepares the draft Program Budget Decision (PBD) for OSD and service coordination and comment. There are no universal guidelines for the focus and extent of this budget review. How the process goes depends largely on the knowledge and experience of the particular analysts. Also, OSD does not have computer models to help them analyze budgets for secondary items. There is, however, an automated database that is maintained by the Assistant Secretary of Defense (Production and Logistics) that contains inventory and funding data from Air Force BESs dating back to 1983. This database is used to generate planning factors designed to assist in the analysis. The current system is not a forecasting tool and does not include any models.

Based on the PBD review, the Air Force constructs inputs to the POM. PA&E's influence in this process is similar to that enjoyed by the Comptroller in the budget process. While the POM and BES are similar in many respects, there does not appear to be any concerted effort by PA&E and the Comptroller to integrate the two systems. However, a lot of data on secondary items are generated in the process of making the POM and BES submissions, and it could improve efficiency to develop an integrated system in OSD and the services.

The OSD budget process just described is not identical to the process used by the Air Force level. The key Air Force organization in the Pentagon is not the Comptroller, but rather the Office of Deputy Chief of Staff for Logistics and Engineering (LE). The Air Force Comptroller acts in strictly a supporting role, to make sure that the formal budget system is being followed. Almost all the detailed analysis and justification of requirements are accomplished by the LE offices. The LE office uses several different computer models to help develop timely information for the budget and POM analyses. The Logistics Analysis Branch is responsible for the modeling efforts discussed later.

The LE focal point for both investment and stock fund secondary items is the Weapons Systems Programs Division. This office is organized by aircraft spares (separate analysts for initial and replenishment spares), missile spares, support equipment, and the stock fund. Another division, the Modification and O&M Programs Division, is responsible for all O&M funding, including the DPEM account.

8. Summary

The procurement and stock funds account for the "buy-in," the purchase of secondary items with Air Force funds. The base maintenance functions, organizational, and field activities account for part of the "buy-out," the reimbursement of stock fund consumables with base O&M funds. The GSD retail category supports the repair process, and the other retail entry consists of nonrepair items, including those maintained within the GSD. As we discussed previously, SSD items, although maintained in the supply system at the retail level, are transferred rather than sold from the depot. An SSD sale to the retail level is not recognized until the item is sold to the DMIF or a base customer. The DMIF accounts for the other part of the "buy-out" with its DMIF funds. DMIF, in turn, is reimbursed from the O&M DPEM account as repairs are completed.

Investment spares that are funded by the procurement appropriations are provided as free issues on an "as required" basis to either DMIF or base activities. When items become unserviceable at a base, they are replaced with an investment spare. If base maintenance can perform the repair, they purchase the necessary bits and pieces from the stock fund with base O&M dollars and make the repair. If the base cannot make the repair, the item is returned to the appropriate DMIF activity (depot) for repair. DMIF then buys the necessary parts from the stock fund, makes the needed repair and charges the O&M DPEM account a standard rate to cover operating expenses.

C. SOURCES OF INVENTORY DATA

The primary source of data on secondary item inventories is contained in the stratification process that identifies inventory requirements in a prescribed time or priority sequence. Stratification is a two-step process: (1) identifying total requirements for a particular item, and (2) subtracting available assets in order to obtain the amount required for purchase. Data obtained in this fashion are used to support the budget and apportionment processes, and they also serve as the primary basis for preparing the annual DoD Supply System Inventory Report described below.

This section deals with the stratification process and its output, and the annual inventory reporting system. We discuss the sources of the data, as well as their completeness, accuracy, and timeliness.

1. Stratification Inventory Data

The Air Force uses stratification as the basic foundation to identify budget requirements for all secondary items used *in the repair* process. In the stratification process, numerous inputs are used to estimate future demands for secondary items, determine the extent to which these demands can be handled by on-hand and on-order inventories, and thus evaluate the need for new procurement.

Inventory data on secondary items that are components of weapon systems are consolidated by AFLC on a quarterly basis. Repairable items are also accounted for on a daily basis through the Air Force Recoverable Assembly Management System (AFRAMS). These data serve as the basis for compiling the quarterly Stock Balance and Consumption Item Report, which lists worldwide assets at the current time, demand (usage) data for the preceding three-month period, data on items that are due out to maintenance, and the number of users. Consumable inventory levels for both SSD and GSD are contained in the Standard Base Supply System (SBSS) monthly reports, and reported to AFLC on a quarterly basis. SSD items at the wholesale (depot) level are reported through the Item Management Stock Control and Distribution System. All of the above data are accumulated by the activities using their automated line item inventory records. Inventory data from those systems are integrated into the D041 and D062 systems to calculate future requirements.

The stratification inventory is relatively complete in that it lists all items in the automated supply system inventory by budget project and stock fund division. It does not include, however, items that are shown in financial records but that have not yet been entered into the automated supply system. The amount of this unstratified inventory is relatively small, only 2.8 percent in the annual Air Force Inventory Report for 1987.

The only other items not included in stratification are stock fund consumable items (except War Reserve Materiel) that are already issued to user activities to include both depot and base organizations. These items represent work in process, which we assume to be small. It is difficult to obtain data on the amount of consumable bench stock maintained at the retail level in base maintenance organizations. This inventory is sized to local needs as stated by the Base Supply Office and the Base Maintenance Organizations. A rough estimate made by an experienced Air Force supply officer suggests that the dollar value of these items is less than 1 percent of total inventory.

Inventory data undergo a thorough review and validation prior to the final stratification, and the stratification report presents the most accurate consolidated inventory data available within the Air Force. Nevertheless, the accuracy of these data has often been criticized in formal audits by the General Accounting Office[1] and others. For example, the GAO noted that in FY 1987, the AFLC, using its own sampling procedures, reported an accuracy rate of 87.1 percent in measuring the value of inventory prior to its research, and a 93.9-percent rate after completing the research. The report stated that in FY 1986, the Air Force had to make adjustments amounting to $1 billion to balance its inventory books. This resulted in a gross monetary adjustment rate of 4.2 percent of the total inventory.

Stratification is performed quarterly. The March 31 and September 30 versions are more reliable, since they are the ones used to support the budget and apportionment processes, and analysts thus spend more time on them. The stratifications are time-consuming, however, so that the final stratification for the March 31 budget position is often not completed until around July 1 to allow inventory managers enough time for analysis and corrections. Even so, desired changes are sometimes left undone.

AFLC keeps stratification data on microfiche, dating back to the late 1970s and arranged by appropriation, budget project, and stock fund division.

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1 General Accounting Office, "Inventory Management Report: Air Force Inventory Accuracy Problems," GAO/NSIAD-88-133, May 1988.

2. Annual Inventory Report

DoD reports supply inventories to Congress annually. The Air Force inventory is reported by DD-M(A)1000, "Stratification Report of Principal and Secondary Items" prepared by AFLC. This "Annual Inventory Report" (AIR) has an issue date of September 30, but is actually based on the March 31 inventory data established in the stratification process. The sole purpose of the AIR is to satisfy congressional reporting requirements. Discussions with Air Force and OSD supply personnel failed to turn up any other uses of the report.

The data in the AIR are provided by the five Air Logistics Centers (ALCs) and the Air Force Stock Fund Division Managers. Their primary source of information is the March 31 stratification inventory, updated to include data that were not reported in time for the final stratification report. The managers also include data from the March 31 financial records on items that were in transit at the time, and which had thus not yet been inserted into the automated supply system inventory. Preparation of the AIR begins in September, and the final report is submitted to Air Force Headquarters around January. Air Force Headquarters reviews the data and forwards the report to the Washington Headquarters Service for inclusion in the DoD-wide report, which is usually completed in March. The inventory report is completed around July 1.

The AIR is more timely than the stratification report, since it reflects the March 31 inventory position. It also has the advantage of including the list of unstratified items, but it does not list consumable items that are used by depot or base maintenance activities, and does not break out inventories separately for the Systems Support and General Support divisions, which are managed separately. The AIR is also less accurate than the stratification report, since it does not undergo the same rigorous scrub within the Air Force. Moreover, it is less timely since it is not available until almost a year after the "as of" date. Copies of the AIR back to the mid-1960s are available from the Office of the Secretary of Defense (Production and Logistics).

In summary, although the AIR is readily available and more complete than the stratification inventory, accuracy is a major stumbling block. We could not get any reasonable assurances about the accuracy of the data prior to 1985. Also, it does not separate inventories for the Systems Support and General Support Divisions.

D. SOURCES OF BUDGET DATA

This section describes the various data that are used to analyze the budget for secondary items during budgeting, apportionment, and execution. The budget data for 1990-91, for example are contained in the Air Force Budget Estimate Submission that was sent to OSD in September 1988. Clearly, the budget process is critical because it determines how much funding will be available in various levels of aggregate categories. Financial execution is probably the most important phase in determining exactly how dollars are spent on spares and repair parts. For example, budget submissions for repairables require justification by individual weapon system. However, once the funds are appropriated and issued, the services can, within certain limits, buy any spares for weapon systems they want.

Both initial and replenishment spares are combined into one spares account by appropriation and P-1 line item. This flexibility to move money around within the spares accounts is important to the success of the repairable process. Most budget requirements are computed about two to three years ahead of time using a wide variety of data. These estimates change with additional experience as the budget-apportionment-execution cycle matures.

This section discusses the financial data used in constructing the budgets relating to procurement and O&M appropriations and stock fund operations. Our focus will be on procurement and the stock fund, since they finance most of the initial purchases of all Air Force secondary items.

1. Procurement Data

The OSD Comptroller maintains the automated database for constructing the Five Year Defense Program (FYDP) and the Procurement Annex. The database includes funding data for initial and replenishment spares for the aircraft and missile appropriations going back to 1972.

The current Air Force budget submission includes a separate backup book for Aircraft Replenishment Spares. The book contains budget requirements by major weapon system, for POS, WRSK/BLSS, and OWRM. Also included are such data as the number of Primary Aircraft Authorized, the flying-hour program, Mission Capable rates, and key logistics data such as cannibalization rates and repair turnaround time. While the data are valid and useful at the time of submission, they are time-sensitive due to the dynamics of the repair cycle and changes in demand rates.

2. Stock Fund

The most reliable budget and execution data available for the stock fund is in hard copy in the Air Force Headquarters budget office. Budget data for POS, WRM, and inventory augmentation, which are used in constructing the OSD Apportionment and Reapportionment Schedule (1105), are available back to 1977. Obligation data from 1977 through 1985 are available at the divisional level. Beginning in 1986, these data are also available by POS, WRM, and augmentation. The obligation data are available from the end-of-year accounting report, referred to as the Monthly Management Report. Also available in this report are data on sales, purchases, and inventory reported by division.

The Air Force also prepares an annual Stock Fund Justification Book to support the budget submission to Congress. The book summarizes, by division, the justification for requests for direct appropriations for the budget year and three years prior, broken out by peacetime augmentation (force modernization, modification, and readiness initiatives) and WRM. These books are available at least as far back as 1980.

There is also a more detailed justification book, kept by the OSD Comptroller, that contains all the standard budget exhibits required by OSD. The books back to 1985 are available from the Air Force budget office.

E. BUDGET AND PERFORMANCE MODELS

This section reviews the models used by the LE offices to support the POM, budget, and apportionment processes. These models are collectively referred to as the Logistics Capability Measurement System (LCMS).[2] The LMCS is constantly changing as existing models are improved and new models are developed.

In 1989, three primary models were in use to relate funding to readiness and sustainability: the Aircraft Availability Model, the Dynaview Model, and the Aircraft Sustainability Model.

1. Aircraft Availability Model (AAM)

The Aircraft Availability Model was first developed in 1972 by the Logistics Management Institute. It has received numerous improvements since that time, and Air Force Headquarters uses the latest version as a principal tool for determining the procurement funding of peacetime repairables (replenishment items) for all types of aircraft.

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2 "Logistics Capability Measurement System (LCMS)," AF/LEXY Working Note, undated.

AFLC is also using a modified version of AAM in the apportionment process, and is presently bringing still another version of the AAM into the D041 requirements determination process. The AAM can be run on either a mainframe or personal computer.

The AAM is a steady-state model. It assumes that consumables and maintenance are 100 percent available, takes a given flying program and performs a parametric analysis that relates the availability of repairables to readiness measured by an aircraft availability (AA) rate. The AA rate is defined as the percentage of aircraft that are not missing a repairable component. Even though the AA rate does not translate into an ultimate measure of readiness, as does the Mission Capable rate, it is an improvement over earlier, more traditional measures of supply effectiveness.

The AAM is a multiechelon model, in that it deals with the interdependent operation of the two levels of Air Force inventory—depot and base. It is also a multi-indenture model, in that it accounts for all component subsets of an assembly or component. Engines can be incorporated into the model by designating them as seperate LRUs. Finally, the model can be run with a buy vs. repair option. AAM computes the optimum mix of buy and repair to achieve the highest possible AA rate. The implications of such calculations fall on both the procurement and O&M appropriations.

The AAM uses three sources of data: (1) the D041 system for logistics data, such as the current and projected inventory of repairables, and the failure rates and repair times for specific items, (2) Air Force planning documents for data on aircraft inventory and flying hours, and (3) funding data for figures on budget project and target AA rates for specific types of aircraft.

For output, the AAM produces curves that relate increases in funding of repairables to increases in aircraft availability by type of aircraft, and also produces "shopping lists" to show buy options in priority sequence based upon cost and availability benefits.

The AAM, in its many versions and uses over the years, has proved to be an effective model for repairables and procurement funding. Incorporating consumables into the model would be worth considering for the future. A recent report by the Logistics Management Institute[3] concluded that AA rates are not very sensitive to normal fluctuations in SSD funding, because management has the flexibility to take corrective action in the

[3] Christopher H. Hanks, "The Influence of Systems Support Division Funding and Safety Levels on Aircraft Availability," Logistics Management Institute, October 1985.

short run. They recommended that SSD funding cuts of 15 percent or less should be ignored unless they occur in two consecutive years.

2. Dynaview Model

Dynaview is an outgrowth of RAND Corporation's Dyna-METRIC model, which was developed in the late 1970s to assess aircraft performance in wartime. The Dyna-METRIC model has undergone numerous changes over the past several years, and RAND published its latest version for AFLC in May 1988.[4] Although it was originally developed for mainframe use, Dynaview has been recently modified for PC application.

Dynaview is similar to the AAM in that it forecasts combat capability by type of aircraft during a prescribed wartime situation, given a specified number of repairables. The number of repairables is set equal to the sum of the number on-hand and on-order, plus the inventory that would result from a level of funding in the aircraft procurement replenishment account (BP 1500) chosen by the user.

Dynaview is a multiechelon and multi-indenture model, using depot and theater interrelationships to assess worldwide logistics support for aircraft components. The model also has the same limitations as the AAM in that it assumes that stock fund consumable items and maintenance are always available. Dynaview is not a "user friendly" model; the user must have computer experience.

The inputs for Dynaview regarding the wartime scenario and flying hour program are taken from the Air Force War and Mobilization Plan. Logistics data similar to those used in AAM are taken from the D041 system. Dynaview calculates the daily number of item failures, repairs and replacements during the scenario. Based on these calculations, the model predicts aircraft availability and sortie generation capability by type of aircraft.

The focus of Dynaview is on the results of funding, rather than identifying budget requirements. It also does not consider the availability of consumable items. The model is maintained by the Air Force Supply Directorate.

3. Aircraft Sustainability Model (ASM)

The ASM is the latest model developed by the Logistics Management Institute to estimate total funding requirements for prepositioned War Reserve Material, specifically,

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4 Isacson, Boren, Tsai, and Pyles, "Dyna-METRIC Version 4: Modeling Worldwide Logistics Support of Aircraft Components," The RAND Corporation, May 1988.

the WRSK and the BLSS. It is a multiechelon and multi-indenture model that combines the best features of AAM and Dynaview. It was designed, in fact, to replace Dynaview: it can run on a PC, requires less internal computer memory and storage, and runs much faster. It uses the same inputs as Dynaview, and produces curves that show tradeoffs between procurement funding and the probability that the aircraft would be able to achieve a target AA rate in its wartime mission.

The ASM measures aircraft sustainability by estimating AA targets for a given funding level for procurement of replenishment spares and a given wartime scenario. The model trades off repairing LRUs and SRUs to achieve the highest availability at the lowest cost. Dynaview repairs all SRUs to make an LRU available. The outputs include information to show tradeoffs between costs (procurement funding) and the probability that the aircraft would be able to achieve the target availaility rate to perform its wartime mission.

APPENDIX E.

REGRESSIONS FOR SHIP AND AIRCRAFT SPARES USAGE

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This appendix describes our efforts to construct cost-estimating relationships (CERs) for spares usage by Navy ships and aircraft. These CERs were used as a guide in constructing the historical factors for spares usage, part of the inventory model described in the text. The subsections that follow describe the analytic method used to construct the CERs, present the numerical results, and discuss their relation to the historical factors.

ANALYTIC METHOD

The CERs were obtained by applying regression analysis to past data. The ship data consist of variables for each of 97 ship classes for each year during 1979-88. The dependent variable is the total yearly expenditure on ship spares by all ships of the class. The explanatory variables are capital cost found by multiplying the lead ship procurement cost by the number of ships in the class (a measure of force size), total yearly steaming hours underway and in port (measures combining both force size and optempo), and shaft horsepower and displacement (individual ship characteristics). The data were obtained from the VAMOSC-Ships database and *Jane's Fighting Ships* (recent years), and all costs are in FY 1991 dollars.

The data for the aircraft analysis are variables for each of 133 type/model/series for each year during 1980-87. The dependent variable is total yearly expenditure on aircraft spares by all aircraft of the type/model/series, and the explanatory variables are capital cost found by multiplying unit procurement cost by the number of aircraft of the type/model/series (a measure of force size), and total yearly flying hours for the type/model/series (a measure combining force size and optempo). These data were all obtained from the VAMOSC-Air database.

The log-log specification is used throughout, and the results are expressed in the more familiar exponential form. The advantage of this specification is that the regression coefficients (exponents of the variables) estimate the elasticities of the relationship—the percentage change in the dependent variable resulting from a 1-percent change in each of the independent variables. Weighted regressions were used in the ship analysis. On the assumption that the error term of the regression equation has constant variance *per ship*, it will not have constant variance for the data points: ship classes with more ships will have smaller variance. Weighting each data point by the number of ships in the class produces the constant error term required by ordinary least squares estimation.

We tried all possible combinations of the variables, and looked for those that meet three criteria:

- The regression coefficients have the expected signs. Higher capital cost and higher optempo should both give higher spares usage. The latter point implies that the sign of steaming underway should be positive, and the sign of steaming in port negative. (Since ships on active duty often keep on some power when they are in port, more steaming in port means less steaming underway, and thus less optempo and spares usage.)
- The coefficients have t-statistics of at least 1.64 or higher, giving a level of statistical significance of 10 percent or better (a probability of 10 percent or less that a model with a zero coefficient could have produced the observed data).
- The value of R^2 exceeds .20, indicating that the regression explains more than 20 percent of the variability in the dependent variable.

The regressions that meet these criteria are shown in Tables E-1 (ships) and E-2 (aircraft). The values of the t-statistic are shown in parentheses underneath the coefficients, and the numbers of data points and values of R^2 are shown to the right of the equations. The terms are defined in notes to the tables.

DISCUSSION: SHIP USAGE

Equation (E-1) in Table E-1 shows that ship capital cost is the best single predictor of ship spares usage. The exponent (elasticity) of capital cost in Equation (E-1) shows that a 10-percent increase in this variable leads to a 4.8-percent increase in spares usage. Equation (E-2) is not intuitive, since it contains no variable that depends on the number of ships in the class. (Shaft horsepower is per ship, not the sum over the ships in the class.)

Equation (E-3) shows that we get an improved CER by combining shaft horsepower with steaming hours in port. (As mentioned earlier, a negative elasticity for steaming hours in port shows a positive effect of optempo on spares usage.) Although steaming hours is a function of both force size and optempo, it did not yield a good CER by itself.

Table E-1. Ship Regressions

(E-1)	$SPARES = .0693(CAP)^{.479}$	N=403	R^2=.308
	(13.4)		
(E-2)	$SPARES = .325(SHP)^{.399}$	N=426	R^2=.286
	(13.1)		
(E-3)	$SPARES = .230(SHP)^{.542}(STEAM\text{-}P)^{-.413}$	N=300	R^2=.477
	(15.9) (-9.4)		
(E-4)	$SPARES = .0616(CAP)^{.387}(SHP)^{.198}$	N=370	R^2=.356
	(10.5) (5.8)		
(E-5)	$SPARES = .0486(CAP)^{.396}(SHP)^{.284}(STEAM\text{-}P)^{-.204}$	N=256	R^2=.463
	(7.3) (5.6) (-4.0)		
(E-6)	$SPARES = .210(DISP)^{.0547}(SHP)^{.540}(STEAM\text{-}P)^{-.427}$	N=300	R^2=.485
	(2.08) (16.0) (-9.6)		

Notes: SPARES = yearly expenditure on spares (per class); CAP = capital cost (per class; number of ships times unit procurement cost); STEAM-P = yearly steaming hours in port (per class); SHP = shaft horsepower (per ship); and DISP = displacement (per ship).

Table E-2. Aircraft Regressions

(E-7)	$SPARES = 779(CAP)^{1.156}$	N=169	R^2=.408
	(13.1)		
(E-8)	$SPARES = .664(FLYING)^{.888}$	N=682	R2=.216
	(13.7)		
(E-9)	$SPARES = 1.104(CAP)^{1.143}(FLYING)^{.609}$	N=169	R2=.463
	(11.1) (4.1)		

Notes: SPARES = yearly expenditure on spares (per type/model/series); CAP = capital cost (per type/model/series; number of aircraft times unit procurement cost); and FLYING = yearly flying hours (per type/model/series).

These results suggest that we might obtain an even higher R^2 by combining the measures of force size, optempo and ship characteristics, but the expectation is not realized. Equations (E-5) and (E-6) show little or no improvement in predictive power over Equation (E-3). (The fact that Equation (E-5) has a lower R^2 than Equation (E-3) does not violate the theorem that adding more explanatory variables must increase R^2, or at least not reduce it; because of missing data, Equation (E-5) involves fewer data points, and is thus derived from a different data set.)

DISCUSSION: AIRCRAFT USAGE

Table E-2 shows that aircraft capital cost is the best single predictor of aircraft spares usage, just as it was for ship spares. In this case, however, we can obtain improved predictability by adding in optempo measured by flying hours.

RELATION OF REGRESSION RESULTS TO CER USED IN TEXT

The regressions in Table E-1 and E-2 were used as a guide in constructing the historical factors for spares usage in the main text of this report. We keyed the usage of ship spares to capital cost because Equation (E-1) shows it to be the best single predictor, and simplicity was a major goal in designing the inventory model. Moreover, it is not difficult to project future values of ship capital cost, since ship force levels and unit procurement costs are readily available in planning documents.

We did not use Equation (E-1) itself, however, for the historical factor. On the assumption that the most recent data are the most reliable, we formed the historical factor—dollars of ship spares usage per dollar of capital cost—from usage figures from the last edition of VAMOSC-Ships that we were able to obtain, for the year 1989. However, anyone who wishes to use the inventory model for forecasting can use any of the CERs in Table E-1 in lieu of the historical factor we chose.

Similar considerations entered into the construction of the historical factor for aircraft spares usage. The data reliability problem is especially bad in the case of aircraft (see the discussion of the VAMOSC-Air database in section IV.C. of the text). This put even the choice of the single best variable into question. We decided to use flying hours instead of capital cost, since past studies have found flying hours to be a good indicator of aircraft spares usage. To minimize the reliability problem with VAMOSC-Air, we constructed the historical factor—dollars of aircraft spares usage per flying hour—from usage data from the two most recent editions of VAMOSC-Air we were able to obtain, for the years 1986-87. People in the Naval Air Systems Command told us that the most recent editions of VAMOSC-Air had received some scrubbing.

As with ship spares, any user of the inventory model could substitute any of the CERs in Table E-2 for the historical factor we chose.

ABBREVIATIONS

ABBREVIATIONS

AA	aircraft availability
AAM	Aircraft Availability Model
ACWT	Average Consumer Waiting Time
AFAO	Approved Force Acquisition Objective
AFB	Air Force Base
AFIF	Air Force Industrial Fund
AFLC	Air Force Logistics Command
AFRAMS	Air Force Recoverable Assembly Management System
AFRS	Approved Force Retention Stock
AIF	Army Industrial Fund
AIMI	Aviation Intensive Management Item
AIR	Annual Inventory Report
ALC	Air Logistic Center
AMC	Army Materiel Command
AMCCOM	Armament, Munitions and Chemical Command
A_o	Operational Availability
APA	Appropriation Purchases Accounts
APN	Aircraft Procurement, Navy
ASF	Army Stock Fund
ASL	authorized stock list
ASM	Aircraft Sustainability Model
ASO	Aviation Supply Office
AVCALS	Aviation Consolidated Allowance Lists
BA	Budget Activity
BAR	Budget and Readiness
BE	Budget Element
BES	Budget Estimate Submission
BLSS	Base Level Self-Sufficiency Spares
BP	Budget Project
BPAC	Budget Program Activity Code
CARES	Computation and Research Evaluation System

CCSS	Commodity Command Standard System
CONUS	continental United States
COSALS	Consolidated Shipboard Allowance Lists
COSBALS	Consolidated Shore-Based Allowance Lists
CSIS	Central Secondary Item Stratification
DA	Department of the Army
DCSLOG	deputy chief of staff for logistics
DDP	demand development period
DESCOM	Depot System Command
DFSC	Defense Fuel Supply Center
DLA	Defense Logistics Agency
DMIF	Depot Maintenance Industrial Fund
DMS	Depot Maintenance Service
DoD	Department of Defense
DODI	Department of Defense Instruction
DPEM	Depot Purchased Equipment Maintenance
DRB	Defense Resources Board
DSF	Defense Stock Fund
EOQ	economic order quantity
FAADC	Fleet Accounting and Disbursing Center
FIR	Financial Inventory Report
FMS	foreign military sales
FMSO	Fleet Material Support Office
FORSCOM	Forces Command
FUE	first unit equipped
GSA	General Services Administration
GSD	General Support Division
HSC	Hardware Systems Command
ICP	Inventory Control Point
IDA	Institute for Defense Analyses
IFOA	Industrial Fund Obligational Authority
IMP	Item Management Plan
IOC	initial operational capability
IPG	Issue Priority Group
JCS	Joint Chiefs of Staff
LCMS	Logistics Capability Measurement System

LDV	low-dollar value
LE	Logistics and Engineering
LIAR	Line Item Action Report
LRU	line-replaceable unit
MACOM	Major Commands
MICOM	Missile Command
MLDT	mean logistics delay time
MMD	Materiel Management Decision
MRSA	Materiel Readiness Support Activity
MSC	Major Subordinate Command
MTBF	mean time between failure
MTMC	Military Traffic Management Command
MTTR	mean time to repair
NAD	Naval Ammunition Depot
NAFC	Navy Accounting and Finance Center
NAVAIR	Naval Air Systems Command
NavCompt	Navy Comptroller
NAVFAC	Naval Facilities Engineering Command
NAVSEA	Naval Sea Systems Command
NAVSUP	Naval Supply Systems Command
NHBS	Navy Headquarters Budgeting System
NICP	National Inventory Control Point
NIF	Navy Industrial Fund
NRFC	Navy Regional Finance Center
NSC	Naval Supply Center
NSD	Naval Supply Depot
NSF	Navy Stock Fund
NSNMDR	National Stock Number Master Data Record
O&M	Operations and Maintenance
O&MN	Operations and Maintenance, Navy
OMB	Office of Management and Budget
OPN	Other Procurement, Navy
OPNAV	Office of the Chief of Naval Operations
OPTAR	Operating Target
Optempo	operating tempo
OSD	Office of the Secretary of Defense

OTTER	One Two Three Effective Resupply
OWRM	Other War Reserve Materiel
P&L	Production and Logistics
PA&E	Program Analysis and Evaluation
PARR	Program Analysis and Resource Review
PBD	Program Budget Decision
PDF	program data file
PDIP	Program Development Increment Packages
PDM	Program Decision Memorandum
PLL	prescribed load list
POM	Program Objectives Memorandum
POS	Peacetime Operating Stocks
PPBES	Planning, Programming, Budgeting and Execution System
PPBS	Planning, Programming and Budgeting System
PWD	Procurement Work Directives
RASC	Retail Asset Status Card
RDES	Requirements Determination and Execution System
RICC	Reportable Item Control Code
RIMSTOP	Retail Stockage Policy
SBSS	Standard Base Supply System
SCN	Shipbuilding and Conversion, Navy
SCS	Supply Control Study
SESAME	Selected Essential Items Stockage for Availability Method
SFOA	Stock Fund Obligational Authority
SIF	Standard Initial Provisioning
SMS	Supply Management System
SPCC	Ship's Parts Control Center
SRU	shop-replaceable unit
SSD	Systems Support Division
STARS	Standard Accounting and Reporting System
SUADPS	Shipboard Uniform Automated Data Processing System
TIR	Transaction Item Reporting
TOA	Total Obligational Authority
TOE	Total Organizational Equipment
TRADOC	Training and Doctrine Command
UADPS-SP	Uniform Automated Data Processing System for Stock Points

UICP	Uniform Inventory Control Point
VAMOSC	Visibility and Management of Operating and Support Costs
VOSL	Variable Operating and Safety Level
VSL	variable safety level
WARSL	War Reserve Stockage List
WMPC	War Materiel Production Capability
WPN	Weapons Procurement, Navy
WRM	War Reserve Materiel
WRMR	War Reserve Materiel Requirement
WRMRB	War Reserve Material Requirement Balance
WRMRP	War Reserve Materiel Requirement Protectable
WRS	War Reserve Stocks
WRSK	War Readiness Spares Kit