AD-A032 144 CONTROL ANALYSIS CORP PALO ALTO CALIF F/G 15/5
AN EVALUATION OF THE AREA SUPPORT/WHOLESALE MANAGEMENT CONCEPT --ETC(U)
DEC 74 M A CRANE, Z F LANSDOWNE, R C MOREY N00014-72-C-0266
UNCLASSIFIED 266-13 NL

1 OF 2
AD A032144

AD A032144

See FC

control analysis corporation

KCB

DDC
OCT 18 1976
C

headquarters - 800 welch road - palo alto, california - 94304
telephone (415) 326-2100

washington office - 8809 maxwell drive - potomac, maryland - 20854
telephone (301) 299-8488

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

Prepared for the

NAVY SUPPLY SYSTEMS COMMAND

File Copy
(173 pages)
(1)

Report No. 266-13

DRAFT

AN EVALUATION OF THE AREA SUPPORT/WHOLESALE MANAGEMENT CONCEPT FOR RESUPPLY OF CURRENT RETAIL INVENTORY

Investigators:

M.A. Crane
Z.F. Lansdowne
R.C. Morey
D.P. Snyder

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

DDC
DRAFTED
OCT 18 1976
RECEIVED
C

December 1974

CONTROL ANALYSIS CORPORATION
800 Welch Road
Palo Alto, California 94304

This research was supported under Office of Naval Research Contract N00014-72-C-0266(NR-347-022)

Reproduction in whole or in part is permitted for any purpose of the United States Government

TABLE OF CONTENTS

ACCESSION for
NTIS White Section
DDC Buff Section
UNANNOUNCED
JUSTIFICATION
BY
DISTRIBUTION/AVAILABILITY CODES
Dist. AVAIL. and/or SPECIAL
A

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF FIGURES AND TABLES

Figure No.

Table No.

LIST OF FIGURES AND TABLES (continued)

LIST OF FIGURES AND TABLES (continued)

1.0 INTRODUCTION AND SUMMARY

1.1 Background

This study, performed over the past five months, compares the costs and service level effectiveness associated with several alternative resupply systems. Each of these alternative systems, characterized by more emphasis on centralization, is compared to the decentralized scheme currently in use at several Naval Supply Centers. These centralized schemes all employ the notion of an Area Naval Support Center[1] and are motivated by the belief that replacing of the current "pull"/retail system by a vertically-managed "push"/wholesale system will offer considerable economies, both in the inventory and personnel areas. Indeed advocates of an Area Naval Support Center with area wide visibility capabilities have argued that such a Center would give rise to:

1) improved and more uniform service to the activities it supports because of the allocation and redistribution strategies that could then be employed;
2) substantial inventory savings, both one time and on a recurring basis, that would be available due to the elimination of duplicate safety stocks, and from the reduction in in-transit stock due to the elimination

---

[1] For convenience in this report, we shall use the abbreviation NSC to refer to the Area Naval Support Center. Use of this abbreviation is not intended to imply that the Support Center would necessarily be located at the site of the current Naval Supply Center. In fact, it might be located at the Naval Supply Center, at one of the major area activities, or perhaps at an entirely new site. Also in this report, NSC will sometimes include the Servmarts and sometimes not, and the correct interpretation will be clear from the context. Finally, "Main Supply" will sometimes be used to refer to the NSC exclusive of the Servmarts.

of certain material handling delays;

3) substantial personnel and computer savings arising from the fact that presently each individual activity, supported by a Naval Supply Center, must maintain its own staff and computers to prepare requisitions and manage its inventory; the Area Naval Support Center would centralize such activities;

4) lower handling costs since much double handling of stock at the DSA/GSA/ICP depots would be eliminated in favor of more emphasis on prepositioning at the Area Naval Support Center.

On the other hand, critics of the Support Center concept have pointed out the increased transaction reporting capabilities required to make such a concept viable as well as their apprehensions concerning the resulting transportation costs and the service level impacts.

1.2 Scope

To help resolve the issues of Section 1.1 and determine if future study efforts are warranted, the goal of this study was to evaluate the cost-effectiveness of the concept as it applies to the retail-managed 9 cog items. This class of items, currently resupplied from DSA or GSA depots[1], or in some cases directly from the vendor, is generally characterized as relatively fast moving and includes such categories as construction, medical, electronics, industrial and general.[2] This class of items, in contrast to the

---

[1] DSA material represent 88% of the retail-managed items and 79% of the value, GSA material representing the balance.

[2] Note that the DSA wholesale items of clothing and provisions are not included in this category.

Navy-managed items, was chosen for initial study since it represents, at NSC-San Diego for example, 65% of the supply operations costs, 72% of the issues, and 47% of the line items stocked. In addition if the cost-effectiveness of the concept, premised in large part on anticipated inventory savings, could be demonstrated for a class of items comprising only 8% of the inventory value and 15% of the dollar sales at NSC-San Diego, then the potential for the concept will have been strengthened.

To insure the realism of the study, actual demand and cost data experienced for NSC-San Diego for FY74 was used to provide a concrete benchmark for the present configuration as well as to provide a credible set of demands and service requirements to be met by any proposed alternative. It was assumed the push mode and area wide visibility would be applied to seven major activities supported by NSC-San Diego, namely Naval Air Station (North Island), Naval Air Station (Miramar), PWC (Public Works Center), Naval Hospital, Naval Air Rework Facility, Naval Shipyard (Long Beach), and the Development and Training Center, as well as the eleven Servmarts currently supported by NSC-SD; the other activities and ships would continue to requisition and function as presently.[1]

The major cost elements that were of interest included peacetime inventory holding costs (including a prorated share of DSA's and GSA's costs), in-transit inventory cost (from DSA/GSA to NSC and from NSC to the activities/Servmarts), transportation

---

[1] These seven activities and eleven Servmarts account for about 90% of all the short-originated transactions occurring at NSC-San Diego.

costs (from DSA/GSA to NSC and from NSC to the activities/ Servmarts), receiving costs (receipt control, receiving operations, etc. for receipts at DSA/GSA, NSC, and at the activities/ Servmarts), issue costs (including requisition processing, packing, bin and bulk issue and loading, at DSA/GSA and at NSC), transshipment (including receiving, receipt control and loading), overhead, and land and building. To concretely delineate the scope of the study these costs, in support of NSC-San Diego for the retail-managed items, amount annually on a system basis (i.e. a prorated share of DSA/GSA's expense, NSC and activities) to $27.6 Million and on a Navy basis (i.e. NSC, 11 Servmarts and 7 major activities) to $11.1 Million. In addition there is a peacetime system wide inventory of about $48 Million involved and a Navy inventory of about $16 Million.

1.3 General Approach

The key data inputs available included financial reports (i.e. Operating Budget Expense Report) for NSC-San Diego, Master Item Stock Record (MISR) tapes for the activities in question, samples of DSA/GSA order quantities, reorder points, and lead-times, NSC's FY74 9 cog receipts and issues reports, samples of bills of lading, etc. With these inputs the basic approach was to build and exercise for each scenario four separate models, one for each type of resupply configuration presently supporting San Diego demands. These four resupply configurations correspond to four classes of items, namely:

1) that class of items which are currently shipped directly to Main Supply from a DSA or GSA depot; this large class is generally made up of those items which because of their

movement or lack of bulk do not warrant direct shipment from the vendor, but instead are shipped first from the vendor, taken into the DSA/GSA depots and then ultimately shipped to NSC.

Within this subclass, separate submodels were needed depending on whether or not the item resupplied in this manner was also carried at the activity level;

2) that class of itmes, which because of their bulk, proximity and commodity class qualified for direct shipment from the vendor to Main Supply. Again it was necessary to separate out those items which were also carried at the activity level;

3) that class of items shipped directly to the activities or Servmarts from the DSA or GSA depots; these items are not carried at Main Supply and for the most pat are carried only at one or two activities;

4) that class of items shipped directly to the activities or Servmarts from the vendor.

For each of these classes of items a ten percent sample of items drawn from the MISR tapes was used to obtain the appropriate mix regarding the ten VAD (value of annual demand) categories in use at NSC-San Diego; the mathematical models were then exercised by VAD category using the average item characteristics for that VAD category. Hence the sequence of tasks followed were briefly to establish benchmarks for costs and service of the present system, develop the scenarios to be examined, (in each scenario the level of service was constrained so that the resulting cost comparisons

would be meaningful), develop the ordering and distribution rules for each scenario, compute the new leadtimes (averages as well as variabilities), estimate changes in number of requisitions, material handling, inventory, transportation, etc., and finally estimate changes in the costs due to the above.

Finally it should be stressed that the thrust of the effort was not directed toward a comprehensive costing of the increased transaction reporting capabilities needed to make the Area Support Concept viable nor toward assessing the management information processing savings that should be available at the activity level due to centralization of these functions at the Naval Support Center. Such calculations were not possible in this study since the activities' detailed financial reports were not available. However some effort was expended to obtain very approximate estimates regarding the annual equipment lease costs that might be involved in the transaction reporting upgrading, so as to provide some basis for objectively assessing the operating costs savings.

1.4 Overview of Scenarios Analyzed

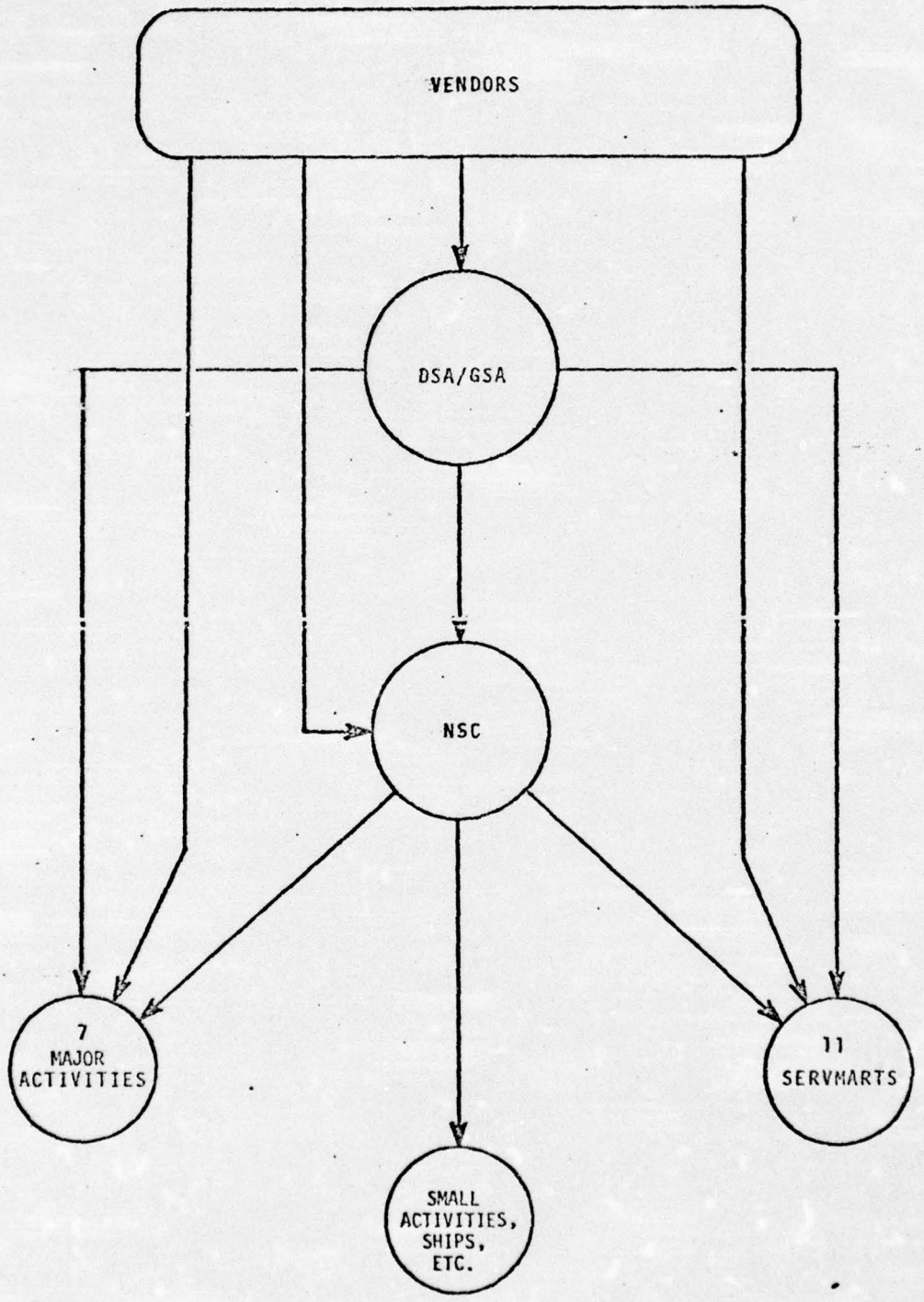
This study compares the current "pull" system against three alternatives, referred to as 1) Total Push System, 2) Local Push/Expanded Range and 3) Local Push/Current Range. The salient characteristics of each system are summarized in the following Subsections and compared in Table 1-1.

1.4.1 Current Pull System

Under the Current Pull System depicted in Figure 1-1, each activity/Servmart pulls (requisitions) material on an individual basis from higher supply echelons, and none,

FIGURE 1-1

CURRENT PULL SYSTEM*



* All customers pull from all higher supply echelons.

including NSC, has area wide visibility. Requisitions from activities for items which NSC does not stock result in direct shipments to the activity. There are a variety of replenishment policies in use with a wide variety of service levels resulting. In addition note that some material is being shipped directly from vendors to NSC, some from vendors to DSA/GSA depots to NSC to activities, some from DSA/GSA depots to activities, etc. In this system also transfer of ownership from DSA/GSA to the Navy occurs when material is requisitioned by a Navy installation, be it NSC or the activities.

1.4.2 Total Push Scenario (Basic Scenario)

In the proposed Total Push System shown in Figure 1-2, note that the DSA/GSA depots no longer take deliveries from vendors into stock but instead serve as a staging point for transshipments directly to the Naval Support Center.[1] Also note that the Support Center carries all items, even those which were previously carried in the area only by the activities. The Support Center now has areawide asset visibility through a daily transaction reporting information system and pushes all material, using a group reorder point[2], to Servmarts and major activities

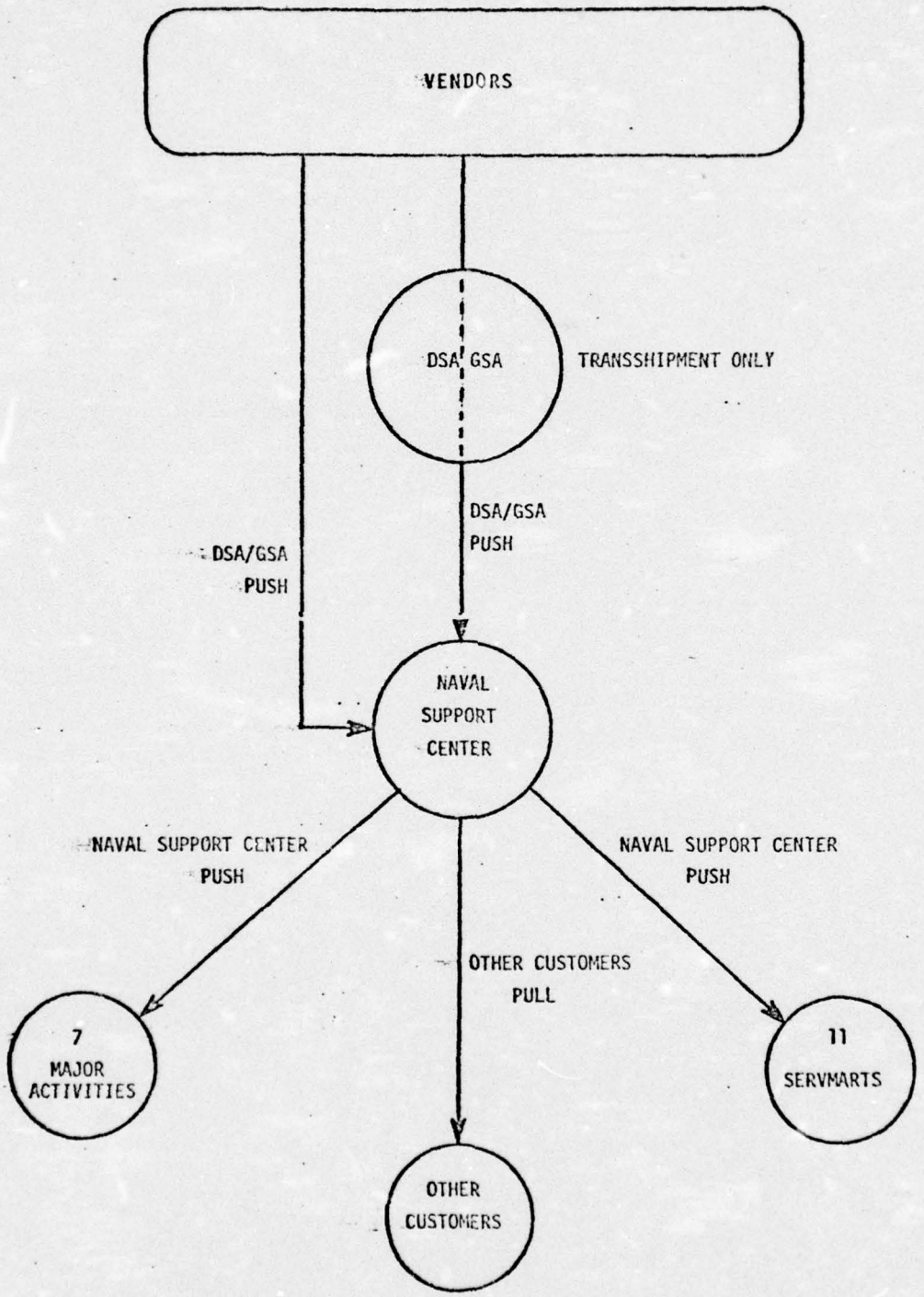
---

[1] Those vendor shipments currently going directly to NSC or the activities would continue as at present. No doubt in practice some of the shipments for which it is being assumed transshipments would take place would be more efficiently accomplished by direct shipment, avoiding the DSA/GSA depot completely, however, to determine which of those would qualify would require a level of detail outside the scope of this study. Hence, this factor tends to underestimate the actual savings that might result.

[2] A group reorder point for an item is one in which NSC pushed stock to the activity level on a simultaneous basis (as opposed to individual reorder points) which is triggered by the event that the total inventory level at the activities and Servmarts falls below some pre-determined level. Hence, there is a need for the activity to have enough safety stock to cover this random replenishment period. See Section 2.0 for details.

FIGURE 1-2

TOTAL PUSH SYSTEM



(other minor activities and ships continue as before to requisition material). In addition at the next higher echelon DSA/GSA now has visibility of the entire San Diego Area's stock level and pushes material to the Support Center; note that all material passes through the Support Center. Also stock ownership is retained by DSA/GSA, even when material is at the Support Center or the activity level; it changes ownership when it is requisitioned by the ultimate individual user. However the Navy manages (and pays for) the operations at the Support Center and at the activity levels. See Section 2.0 for the details.

1.4.3 Local Push/Expanded Range Scenario (Excursion from Total Push Scenario)

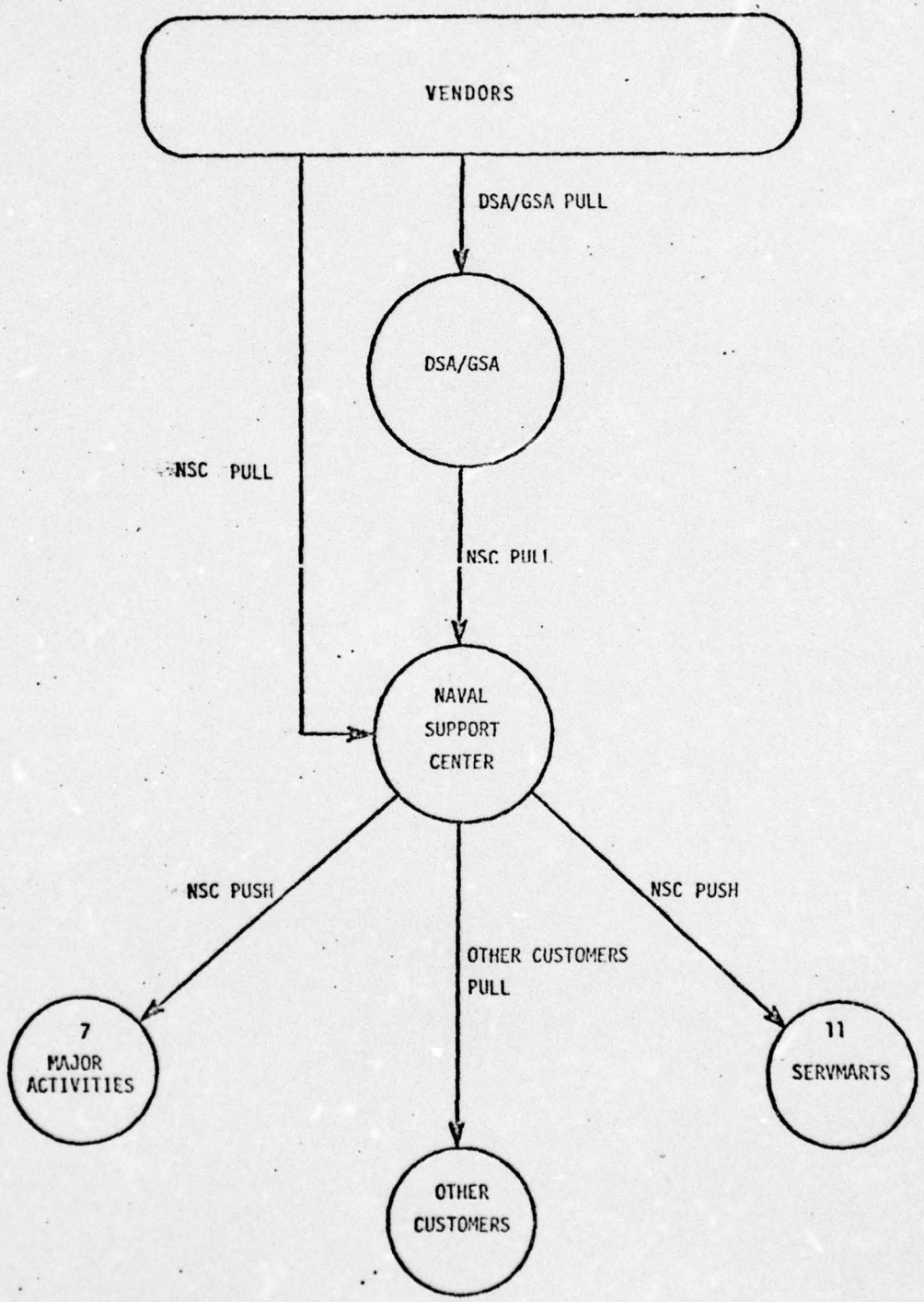
Under the proposed Local Push/Expanded Range alternative shown in Figure 1-3, the DSA/GSA echelon continues to operate as in the current system, processing the Support Center's requisitions and taking inventory into stock from the vendors. However, as in the total push scenario the NSC again has the complete range of material carried in the area and has visibility of Servmart and major activity stock levels. All replenishment of these activities is by pushing from NSC. This scenario does not depend upon a change in the DSA/GSA operations for its implementation.

1.4.4 Local Push/Current Range Scenario (Excursion from Total Push Scenario)

The proposed Local Push/Current Range System includes the concept of areawide asset visibility by a NSC, but

FIGURE 1-3

LOCAL PUSH/EXPANDED RANGE



does not call for expanding the current range of stock at the NSC. Figure 1-4 shows that DSA/GSA continues[1] to operate as under the Current Pull System. The NSC initiates orders from DSA/GSA for all items not carried at the NSC in behalf of Servmarts and major activities, indicating shipment directly to the appropriate activity. Such items are pushed by NSC to these activities. The key difference between the two local push scenarios is that in the latter one not all material passes through the NSC; in fact for those items presently not carried at NSC, generally characterized by being carried at only one or two activities, it appears advantageous to continue to have them shipped directly to the activity, thereby avoiding the double handling that would be incurred if it went through the NSC.

1.5 Summary of Findings

Table 1-2 depicts the key results obtained. Note that the basic scenario, i.e., the total push scenario, results in a total annual system-wide savings (in suport of San Diego-area demand) of 9.7% ($2.7M) and a Navy-wide savings of 18.6% ($2.1M). Also note alternatively that a one-time system-wide reduction in inventory of $10.276 Million, i.e., about a 21% reduction,

---

[1] Other scenarios that might be of interest includes one that might be termed a Total Push/Current Range scenario in which DSA/GSA pushes as in the basic scenario but the Support Center does not stock the complete range of material but rather transships those items not stocked at the Center to the activities; other variations include the cases where the activities continue to requisition directly on DSA for those items stocked only at the activity levels, or the case in which DSA contains detailed asset information for each item by activity not carried at the ASC and pushes to that activity directly for that class of items. These excursions have not been examined in detail.

FIGURE 1-4

LOCAL PUSH/CURRENT RANGE

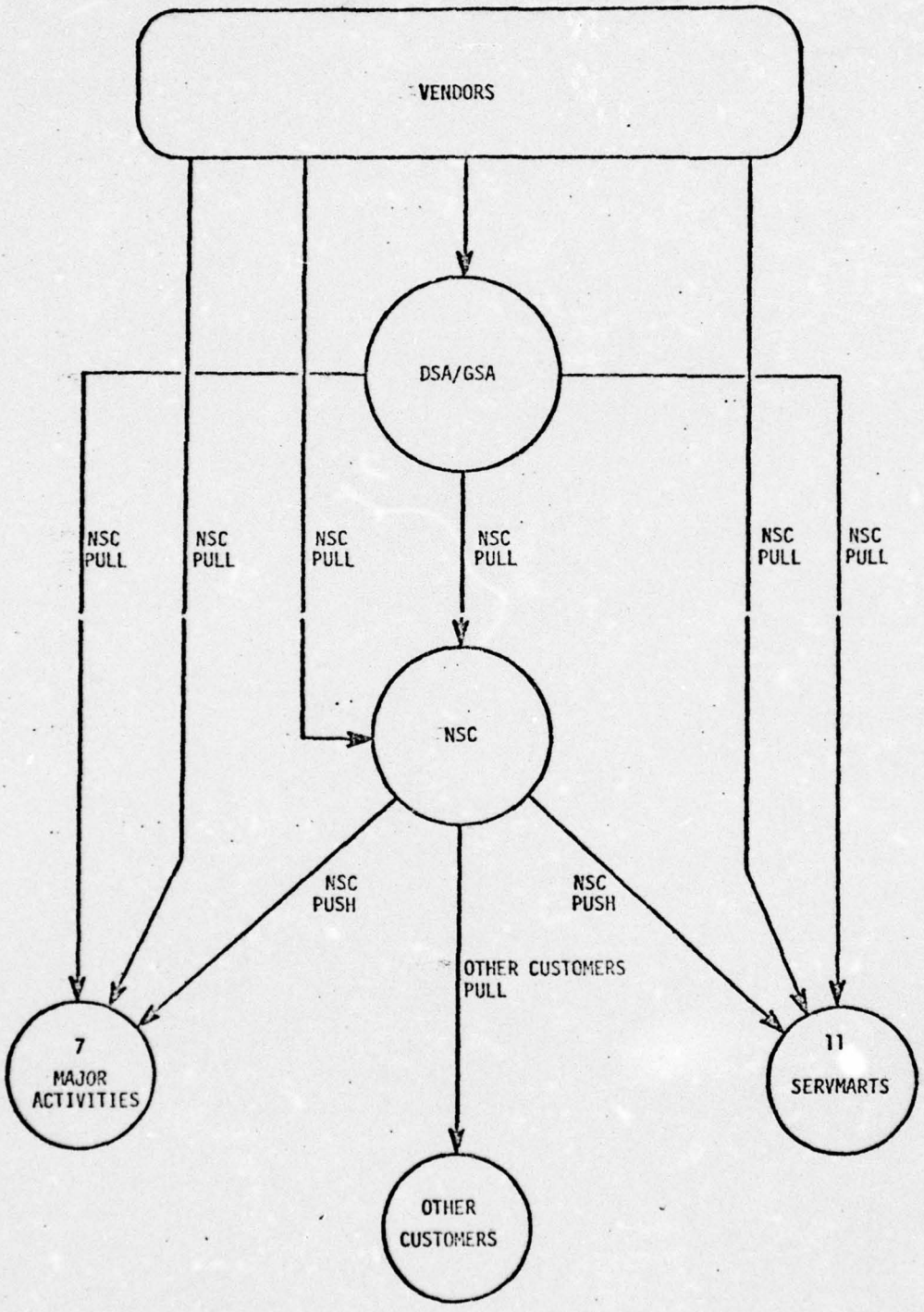


TABLE 1-1 CHARACTERISTICS OF INVENTORY SYSTEMS

SYSTEM	TYPE OF ITEM	VISIBILITY OF STOCK BY NSC[1]	VISIBILITY OF STOCK BY DSA/GSA	ORDERING RULES FOR RESUPPLYING MAIN SUPPLY	ORDERING RULES FOR RESUPPLYING ACTIVITIES/SERVMARTS	ORDER QUANTITIES FOR RESUPPLYING MAIN SUPPLY	ORDER QUANTITIES FOR RESUPPLYING ACTIVITIES/SERVMARTS
Current Pull	1a. Ordered by Main Supply from DSA/GSA	1a. Main Supply Stock	1a. None	1a. Pulled from DSA/GSA with Individual reorder pt.	1a. Pulled from Main Supply with Individual reorder pt.	1a. Current Main Supply Quantity	1a. Current Activity/ Servmart Quantity
	1b. Ordered by Activity/Servmart from DSA/GSA	1b. None	1b. None	1b. not applicable	1b. Pulled from DSA/GSA with Individual reorder pt.	1b. not applicable	1b. Current Activity/ Servmart Quantity
	2a. Ordered by Main Supply from Vendor	2a. Main Supply Stock	2a. None	2a. Pulled from Vendor with Individual reorder pt.	2a. Pulled from Main Supply with Individual reorder pt.	2a. Current Main Supply Quantity	2a. Current Activity/ Servmart Quantity
	2b. Ordered by Activity/Servmart from Vendor	2b. None	2b. None	2b. not applicable	2b. Pulled from Vendor with Individual reorder pt.	2b. not applicable	2b. Current Activity/ Servmart Quantity
Total Push	1. Sent from Vendors, Transshipped at DSA/GSA and sent to M. Supply	1. Detailed Area-wide Stock	1. Total Area-wide Stock	1. Pushed by DSA/GSA with Group reorder pt.	1. Pushed by NSC with Group reorder pt.	1. Current DSA/GSA Quantity	1. Current Activity/ Servmart Quantity
	2. Sent from Vendors Directly to Main Supply	2. Detailed Area-wide Stock	2. Total Area-wide Stock	2. Pushed by IM with Individual reorder pt.	2. Pushed by NSC with Group reorder pt.	2. Current Main Supply Quantity	2. Current Activity/ Servmart Quantity
Local Push/ Expanded Range	1. Ordered by NSC from DSA/GSA and sent to Main Supply	1. Detailed Area-wide Stock	1. None	1. Pulled from DSA/GSA with Individual reorder pt.	1. Pushed by NSC with Group reorder pt.	1. Current Main Supply Quantity	1. Current Activity/ Servmart Quantity
	2. Ordered by NSC from Vendor and sent to Main Supply	2. Detailed Area-wide Stock	2. None	2. Pulled from Vendor with Individual reorder pt.	2. Pushed by NSC with Group reorder pt.	2. Current Main Supply Quantity	2. Current Activity/ Servmart Quantity
Local Push/ Current Range	1a. Ordered by NSC from DSA/GSA and sent directly to Main Sup.	1a. Detailed Area-wide Stock	1a. None	1a. Pulled by NSC from DSA/GSA with Individual reorder pt.	1a. Pushed by NSC with Group reorder pt.	1a. Current Main Supply Quantity	1a. Current Activity/ Servmart Quantity
	1b. Ordered by NSC from DSA/GSA and sent directly to Activity/ Servmart	1b. Detailed Area-wide Stock	1b. None	1b. not applicable	1b. Pulled by NSC from DSA/GSA with Group reorder pt.	1b. not applicable	1b. Current Main Supply Quantity (for imputed VAD category)
	2a. Ordered by NSC from Vendor and sent directly to Main Supply	2a. Detailed Area-wide Stock	2a. None	2a. Pulled by NSC from Vendor with Individual reorder pt.	2a. Pushed by NSC with Group reorder pt.	2a. Current Main Supply Quantity	2a. Current Activity/ Servmart Quantity
	2b. Ordered by NSC from Vendor and sent directly to Activity/ Servmart	2b. Detailed Area-wide Stock	2b. None	2b. not applicable	2b. Pulled by NSC from Vendor with Group reorder pt.	2b. not applicable	2b. Current Main Supply Quantity (for imputed VAD category)

[1] NSC refers to the Naval Supply Center in current system and Naval Support Center in proposed systems.

TABLE 1-2

COMPARISON OF ANNUAL COSTS AND SAVINGS UNDER ALTERNATIVE SYSTEMS[1]

(In millions of dollars)

ANNUAL COSTS	Current Pull	Total Push	Local Push/ Expanded Range	Local Push/ Current Range
1. DSA/GSA (prorated for San Diego demand)[2]	$16.485M	$15.862M	$16.441M	$16.476M
2. NSC (including Servmarts)	8.093M	7.928M	10.097M	9.096M
3. Major Activities	2.987M	1.096M	1.096M	1.106M
4. Total Navy (2+3)	11.080M	9.024M	11.193M	10.202M
5. Total System (1+2+3)	27.565M	24.886M	27.634M	26.678M
ANNUAL SAVINGS (compared to Current Pull System)				
1. DSA/GSA (prorated to NSC-San Diego)	-	$.623M (3.8%)	$ .044M (0.3%)	$ .009M (.06%)
2. NSC (including Servmarts)	-	.165M (2.0%)	-2.004M (-24.8%)	-1.003M (-12.4%)
3. Major Activities	-	1.891M (63.3%)	1.891M (63.3%)	1.881M (63.0%)
4. Total Navy (2+3)[3]	-	2.056M (18.6%)	- .113M (-1.0%)	.878M (7.9%)
5. Total System (1+2+3)[4]	-	2.679M (9.7%)	- .069M (-0.3%)	.887M (3.2%)

---

1 Does not include savings related to centralization of management information processing functions at the Area Support Center nor does it take into account the additional costs associated with the increased transaction reporting capability requirement, estimated to be very roughly at about $.3M per year. Also the savings are stated only for the NSC-San Diego operation and do not address the savings to be achieved if the Area Support Concept were extended simultaneously to other NSC's.

2 An estimate of DSA/GSA's expenses in support of NSC-San Diego was obtained by prorating DSA/GSA's total expense on the basis of the fraction of their sales to San Diego Navy customers.

3 Included are annual savings in on-hand and in-transit inventory holding costs in the three proposed systems which could be viewed, alternatively, as one-time reductions in inventory of $16.590M, $3.152M, and $3.229M, respectively.

4 Alternatively the savings in on-hand and in-transit yearly inventory costs can be equated to a one-time reduction in inventory of $10.276M, $3.152M, $3.229M, respectively.

is available and that a one-time reduction in Navy inventory value of $16.59M is possible. Also, note that if the Area Support Concept were to be implemented without a change in DSA's or GSA's operations, then of the two excursions investigated the so-called "local Push/Current Range" alternative is preferable, yielding an annual system system-wide savings of 3.2% ($.9M) and a Navy-wide savings of 7.9% ($.9M). Alternatively, this represents a one-time reduction in inventory value of $3.229M for a system-wide inventory reduction of about 7%, and a Navy inventory reduction of 20%. The Local Push/Expanded Range Scenario does not fare particularly well since it entails a great deal of increased double handling at the Support Center (for those items not presently carried there) with no substantial offsetting benefits. See Section 7 for the detailed changes in financial accounts.

As was mentioned in the "Scope" Section of 1.2 and pointed out in Table 1-2 the savings calculated do not take into account those related to centralization of the management information-processing functions at the Area Support Center nor do they take into account the increased costs due to the additional transaction-reporting capabilities required. This was due to the fact that detailed financial accounting data at the activity level was not available at the time of the study and that the construction of a set of design specifications for the transaction-reporting system required was outside the scope of the effort. However, to shed some insights as to order of magnitude of the transaction-reporting costs that might be involved, a

preliminary analysis was performed based largely on experience gained with the automated cash register experiments at NSC-Charleston. Using their equipment configurations (see Section 8 for details) and lease costs obtained from National Cash Register, a rough estimate of the annual costs for equipment, transmission and file updating is $.295M. To assess the potential net impact of this increased transaction-reporting capability, it is helpful to note that the estimated total management information-processing costs for support of NSC-San Diego is about $2M (or about 7% of the total). Hence, it is clear that, if centralization of the MIS operation at the Support Center results in a reduction of personnel and data-processing costs of only 15%, then the net cost impact of the change in the MIS processing and transaction-reporting will be negligible; if centralization brings about more than a 15% reduction (which is likely) then a net savings from this account will also result. At any rate, it should be stressed that, even without taking into account the gains of centralization in the MIS area, the annual operating savings obtained in the inventory and material handling accounts are an order of magnitude larger than the increased transaction-reporting costs to be incurred.

Another key area of concern in this study was the consideration of service levels. As described in detail in Section 4 the basic approach in costing out the various alternatives was to constrain the area-wide service level to be that presently enjoyed by the activities. The idea here is that since the Naval Support Center has area-wide visibility, as well as rapid communication

with each of the major activities and Servmarts, an item which is not in stock (NIS) at one activity might be available from another activity. Hence, essentially the same level of service as now provided can be realized with a lower inventory. The measure of service used was the fraction of demand satisfied without a backlog.

Another way of appreciating the impact of the area-wide visibility/redistribution capability is to compare the gain in service to be achieved if the current inventory levels were utilized in conjunction with the new concept. Using MISR tapes and NSC's Master Servmart file, one can empirically measure the increase in service, by item and by location, that results if the area-wide visibility/redistribution concept were applied to the inventory levels now present. The measure of service used here is the fraction of items which are not in an NIS condition. Such a comparison is shown in Table 1-3 where one notes that at the North Island Naval Air Station, for example, 89% of the retail-managed items which had demand in the last year were not in an NIS condition as of December 1973; on the other hand, if the area-wide visibility/redistribution capability were available, the service measure would increase to 96%.

The remainder of the report is organized into seven additional sections, addressing the detailed assumptions used and presenting the detailed findings. The key sections are Section 2, dealing with detailed descriptions of the scenarios and Section 7, providing detailed cost estimates, by account and by support echelon, aggregated in a variety of ways. In

TABLE 1-3

THE IMPACT OF AREA-WIDE ASSET VISIBILITY AND REDISTRIBUTION ON SERVICE LEVELS IF PRESENT INVENTORY LEVELS RETAINED

Location	Current Service Level[1]	Service Level With Area-Wide Visibility[2]
NSC-SD	78.8%	89.8%
DATC	64.6%	85.0%
NSLB	90.6%	96.6%
NARF	90.6%	95.5%
NAS-NI	89.0%	96.0%
NAS-MIR	78.4%	88.2%
PWC	86.3%	97.4%
HOSP	100.0%	100.0%
Servmart NSC-SD Naval Station	90.4%	98.3%
Servmart NSC-SD	72.2%	98.1%
Servmart NAB	79.8%	99.0%
Servmart NAS-NI	81.3%	98.5%
Servmart Long Beach Annex	89.7%	98.6%
Servmart Imperial Beach	81.2%	97.4%
Servmart Pt. Loma	85.9%	98.4%
Servmart Miramar Main	89.0%	99.0%
Servmart Miramar Auto	87.5%	93.8%
Servmart NTC	81.2%	98.0%
Servmart NELC	82.4%	96.8%

1. The measure of service shown is the fraction of items which are not NIS. Items with zero demand are excluded from the calculation.

2. With area-wide visibility, an item is NIS if and only if it is NIS at every location in the area.

addition, there are five technical appendices dealing with the mathematics and modeling used for inventory calculations, demand coefficient of variation calculations, lead times, etc., as well as a simulation model useful in gaining insight into the complex interactions between DSA/GSA, NSC, and the activities/Servmarts.

2.0 DETAILED SPECIFICATION OF ALTERNATIVE INVENTORY SYSTEMS

2.1 Range Of Stock At NSC

In the total Push and the Local Push/Expanded Range systems, the range of stock at the Area Naval Support Center includes all items currently carried at NSC, the 11 Servmarts, and the 7 major activities. In the Local Push/Current Range system, the range is identical to the current range at NSC.

2.2 Range of Stock at Activities and Servmarts

In each of the alternative push systems, the range of stock at the activities and Servmarts is identical to that in the current system.

2.3 Transshipment of Material Through DSA/GSA

In the Total Push system, it is assumed that material currently stocked at DSA/GSA depots will be transshipped through those depots rather than shipped directly to San Diego from the vendors. To ship directly from the vendors to NSC would most likely result in increased transportation costs due to smaller quantities. However, for certain items which are manufactured near San Diego or which are sent in large quantities to San Diego, direct shipment might well result in lower transportation and handling costs. Hence, the assumption that all material is transshipped through DSA/GSA may be viewed as conservative in the sense that the total savings of the Total Push system will be underestimated.

2.4 DSA/GSA Transportation Costs

For each of the alternative push systems, it is assumed that the DSA/GSA transportation costs are the same as the current costs, based on assumptions of an equivalent amount of material being shipped to the San Diego area with equivalent cost rates. It is felt that these assumptions result in an over-estimate for the alternative transportation costs for the following reasons:

1. In the Total Push system, it is likely that some transportation costs could be avoided by direct shipment from vendors to NSC, especially from vendors in close proximity to San Diego.
2. In the Total Push system, there will be an increase in shipment size for material shipped to NSC. This may result in fewer costly parcel post shipments as well as more advantageous common carrier rates.
3. In the Total Push and the Local Push/Expanded Range systems, certain items which were shipped directly to activities and Servmarts in the current system are now shipped to NSC, perhaps facilitating more economic transportation rates.

2.5 Priority

Lead times, transit times, and service levels are computed based on assumptions of standard priority requisitioning.

2.6 Area-Wide Service Level

In each of the three alternative push systems, the Area Naval Support Center has area-wide asset visibility, as well as rapid communication with each of the Servmarts and major activities. Consequently, if a customer demands an item which is not-in-stock (NIS) at a particular activity but which is in-stock at another location in the area, the requisition may be satisfied from that other location. Hence, the same area-wide inventory as currently can result in an increased level of service. Alternatively, the same level of service may be achieved with a lower inventory.

In the alternative push systems, an area-wide service level is defined in terms of the availability of stock somewhere in the San Diego area. In Section 4, the area-wide service level is compared to the current individual activity service levels, assuming the same inventory values on-hand. In Section 6.1, inventory savings are computed assuming that the area-wide service level in the the push system is constrained to equal the current activity service levels.

2.7 Analysis by VAD Category

There are approximately 77,000 different 9 cog line items carried either at main supply, the Servmarts, or activities. Associated with each of these line items are various statistics, such as mean demand, standard deviation of demand, average on-hand inventory, service level, etc. It would be infeasible to perform separate analysis for each of these line items. Fortunately, these items can

be categorized into groups that share common characteristics. Main supply uses VOSL rules* for making its reordering decisions. These rules group all items into ten VAD (value of annual demand) categories, and all items within a VAD category have the same reorder quantity in months supply. The items at main supply are allocated to these categories on the basis of their VAD: unit price times twelve months demand. Table 2-1 gives the dollar ranges of each VAD category, and these ranges vary for different cogs. For example, VAD category J corresponds to the range $.01 - $35.43 for cogs 9Z and 9N, corresponds to the range $.01 - $72.95 for 9L, corresponds to the range $.01 - $109.61 for 9G, etc. Table 2-1 also gives the reorder quantity in months supply for each VAD category. For example, the reorder quantity is 1.0 months for all items in VAD category A, 1.5 months for VAD category B, 2.0 months for VAD category C, etc.

In addition to the classification by VAD category, items were also classified in our analysis into three types: items carried only at main supply; items carried both at main supply and at least one activity and/or Servmart; and items not carried at main supply. Certain average statistics were estimated for each VAD category and type of item. When computing the average on-hand inventory in the San Diego area (see Section 6.1 and Appendix B), our approach was to compute this inventory for a typical item within each VAD category and type classification, and this typical item would have the average statistics for all

---

* Variable Operating and Safety Level Requisitions Short Model, FMSO, July 1971.

TABLE 2-1 - DEFINITIONS OF VAD CATEGORIES AT MAIN SUPPLY FOR 9 COG ITEMS

VAD Category	ORDER QUANTITY (Months' Supply)	9Z, 9N		9C		9G		9Q		9L	
		Low	High	Low	High	Low	High	Low	High	Low	High
A	1.0	$2268.53	∞	$4669.78	∞	$7015.92	∞	$12612.61	∞	$14279.25	∞
B	1.5	1111.57	$2268.52	2288.19	$4669.77	3437.80	$7015.91	6180.17	$12612.60	6996.82	$14279.24
C	2.0	681.50	1111.56	1361.70	2288.18	2045.84	3437.79	3677.83	6180.16	4163.82	6996.81
D	2.5	439.18	681.49	904.06	1361.69	1358.28	2045.83	2441.80	3677.82	2764.46	4163.81
E	3.0	277.89	439.17	572.04	904.05	859.45	1358.27	1545.04	2441.79	1749.20	2764.45
F	4.0	165.37	277.88	340.42	572.03	511.46	859.44	919.45	1545.03	1040.95	1749.19
G	5.0	109.79	165.36	226.01	340.41	339.57	511.45	610.45	919.44	691.11	1040.94
H	6.0	69.47	109.78	143.01	226.00	214.85	339.56	386.26	610.44	437.40	691.10
I	8.0	35.44	69.46	72.95	143.00	109.62	214.85	197.07	386.25	223.11	437.39
J	12.0	.01	35.43	.01	72.95	.01	109.61	.01	197.06	.01	223.10

SOURCE: These VAD ranges for each type of item were computed by FMSC on their Mechanicsburg computer. These date were then forwarded to NSC-SD in February 1974.

items within that classification. Table B-1 in Appendix B illustrates this approach. The two left-hand columns in this table provide the VAD category and type classification, while the remaining columns give the statistics for that classification. After the average on-hand inventories for each VAD category and type were computed, then these values are summed to obtain the total on-hand inventory for each alternative system.

Note that the VAD category classification always refers to the classification used at main supply. For an item not carried at main supply, a VAD category was assigned to that item in the following way: the total area-wide (over all activities and Servmarts carrying that item) value of annual demand was computed, and then Table 2-1 was used to assign the appropriate category based upon the area-wide VAD for that item.

2.8 Ordering Rules

This section discusses the ordering rules for the alternative inventory systems: Current Pull; Total Push; Local Push/Expanded Range; and Local Push/Current Range. These rules are summarized in Table 2-2.

2.8.1 Current Pull System

In the current system, there are four broad classes of items in the San Diego area: (1a) items sent from DSA/GSA depots to main supply; (1b) items sent from DSA/GSA depots to activities and Servmarts; (2a) items sent from vendors to main supply; and (2b) items sent from vendors to activities and Servmarts. An activity or Servmart submits a requisition to main supply for

TABLE 2-2 CHARACTERISTICS OF INVENTORY SYSTEMS

SYSTEM	TYPE OF ITEM	VISIBILITY OF STOCK BY NSC[1]	VISIBILITY OF STOCK BY IM	ORDERING RULES FOR RESUPPLYING MAIN SUPPLY[2]	ORDERING RULES FOR RESUPPLYING ACTIVITIES/SERVMARTS	ORDER QUANTITIES FOR RESUPPLYING MAIN SUPPLY[2]	ORDER QUANTITIES FOR RESUPPLYING ACTIVITIES/SERVMARTS
Current Pull	1a. Ordered by Main Supply from DSA/GSA	1a. Main Supply Stock	1a. None	1a. Pulled from DSA/GSA with Individual Trigger	1a. Pulled from Main Supply with Individual Trigger	1a. Current Main Supply Quantity	1a. Current Activity/ Servmart Quantity
	1b. Ordered by Activity/Servmart from DSA/GSA	1b. None	1b. None	1b. --	1b. Pulled from DSA/GSA with Individual Trigger	1b. --	1b. Current Activity/ Servmart Quantity
	2a. Ordered by Main Supply from Vendor	2a. Main Supply Stock	2a. None	2a. Pulled from Vendor with Individual Trigger	2a. Pulled from Main Supply with Individual Trigger	2a. Current Main Supply Quantity	2a. Current Activity/ Servmart Quantity
	2b. Ordered by Activity/Servmart from Vendor	2b. None	2b. None	2b. --	2b. Pulled from Vendor with Individual Trigger	2b. --	2b. Current Activity/ Servmart Quantity
Total Push	1. Sent from Vendors, Transshipped at DSA/GSA and sent to M. Supply	1. Detailed Area-wide Stock	1. Total Area-wide Stock	1. Pushed by IM with Group Trigger	1. Pushed by NSC with Group Trigger	1. Current DSA/GSA Quantity	1. Current Activity/ Servmart Quantity
	2. Sent from Vendors Directly to Main Supply	2. Detailed Area-wide Stock	2. Total Area-wide Stock	2. Pushed by IM with Individual Trigger	2. Pushed by NSC with Group Trigger	2. Current Main Supply Quantity	2. Current Activity/ Servmart Quantity
Local Push/ Expanded Range	1. Ordered by NSC from DSA/GSA and sent to Main Supply	1. Detailed Area-wide Stock	1. None	1. Pulled from DSA/GSA with Individual Trigger	1. Pushed by NSC with Group Trigger	1. Current Main Supply Quantity	1. Current Activity/ Servmart Quantity
	2. Ordered by NSC from Vendor and sent to Main Supply	2. Detailed Area-wide Stock	2. None	2. Pulled from Vendor with Individual Trigger	2. Pushed by NSC with Group Trigger	2. Current Main Supply Quantity	2. Current Activity/ Servmart Quantity
Local Push/ Current Range	1a. Ordered by NSC from DSA/GSA and sent directly to Main Sup.	1a. Detailed Area-wide Stock	1a. None	1a. Pulled by NSC from DSA/GSA with Individual Trigger	1a. Pushed by NSC with Group Trigger	1a. Current Main Supply Quantity	1a. Current Activity/ Servmart Quantity
	1b. Ordered by NSC from DSA/GSA and sent directly to Activity/ Servmart	1b. Detailed Area-wide Stock	1b. None	1b. --	1b. Pulled by NSC from DSA/GSA with Group Trigger	1b. --	1b. Current Main Supply Quantity (for imputed VAD category)
	2a. Ordered by NSC from Vendor and sent directly to Main Supply	2a. Detailed Area-wide Stock	2a. None	2a. Pulled by NSC from Vendor with Individual Trigger	2a. Pushed by NSC with Group Trigger	2a. Current Main Supply Quantity	2a. Current Activity/ Servmart Quantity
	2b. Ordered by NSC from Vendor and sent directly to Activity/ Servmart	2b. Detailed Area-wide Stock	2b. None	2b. --	2b. Pulled by NSC from Vendor with Group Trigger	2b. --	2b. Current Main Supply Quantity (for Imputed VAD category)

[1] NSC refers to the Naval Supply Center in current system and Naval Support Center in proposed systems.

[2] Main Supply refers to the wholesale echelon in any of the systems.

those items carried at main supply. Thus, the current system has either one echelon, two echelons, or three echelons, depending upon the item: one echelon for items (2b) sent directly to activities and Servmarts from vendors; two echelons for items (2a) sent to activities and Servmarts from main supply, which in turn receives supplies from vendors; two echelons for items (1b) sent to activities and Servmarts from DSA/GSA depots, which in turn orders from vendors; and three echelons for items (1a) sent to activities and Servmarts from main supply, which in turn orders from DSA/GSA depots, which in turn orders from vendors. In all cases, supplies are pulled from a higher echelon to a lower echelon by the lower echelon submitting a requisition to the higher echelon. In all cases, a reorder point-reorder quantity model (refer to Appendix B.3) is used by the echelon submitting the requisition. These ordering rules are based upon the parameters (RP_{ij}, Q_{ij}) which may vary for different items at different facilities: whenever the available inventory (on-hand plus on-order) for item i at facility j falls to the reorder point RP_{ij}, then Q_{ij} months' supply of item i is ordered from the appropriate supply point.

2.8.2 Total Push System

In the Total Push system, the inventory manager (IM) knows the total area-wide stock in San Diego (including stock at main supply, Servmarts, and activities) and pushes stock to San Diego when needed. Table 2-2 indicates that for the Total Push system, there are two classes of items: (1) items sent from vendors, transshipped at DSA/GSA depots, and then sent to main supply; and (2) items sent from vendors directly to main supply.

In this system, activities and Servmarts receive all their supplies from main supply. No stock is warehoused at DSA/GSA.

First, consider the ordering rules for resupplying main supply with items coming directly from vendors. These items are the same as the ones that are currently being received directly from vendors (types 2.a and 2.b of Current Pull). The IM sends a requisition to a vendor whenever the area-wide stock at San Diego reaches its reorder point, and the reorder quantity is the same as in the current system. In other words, the reorder point-reorder quantity model is still being used for items coming directly from vendors, although the reorder point may be different; however, these rules are applied to the area-wide stock in San Diego, rather than just to the main supply stock as in the current system. This area-wide visibility will result in savings in safety stock requirements in San Diego, due to the reduction in variance of lead time demand.

Next, consider the reordering rules for resupplying main supply with items being transshipped at DSA/GSA depots. These items are the same as the ones currently being sent from DSA/GSA depots (types 1.a and 1.b of Current Pull). In the current system, the DSA/GSA depots represent another echelon of inventory with its own reordering rules. In the Total Push System, it is assumed that vendors continue to send their shipments of these items to DSA/GSA depots in the same quantities; but when these shipments reach a depot, they are not entered into stock, but are immediately divided (using the latest demand data) and sent to the various NSC's. Thus, all NSC's in the nation are resupplied at the same

time, and the stock which was formerly at the DSA/GSA echelon is now prepositioned at the NSC's. Because all NSC's in the nation are resupplied at the same time, it is necessary to use a group reordering rule called the base stock system (refer to Appendix B.2). A base stock level BSL_{ij} is specified for the i^{th} item at the j^{th} NSC. At the beginning of each day (or at the beginning of any review period), the available inventory of an item at an NSC is subtracted from its base stock level: the difference is "the amount to be ordered". Whenever the sum of "the amounts to be ordered" for an item over all NSC's equals a prespecified order quantity, then a shipment in that quantity is ordered from an appropriate commercial vendor. This approach has the following advantagous features:

a) The order quantity for each item purchased from vendors can be made to be the same as in the current system. This implies that the purchasing cost (with respect to quantity discounts) is the same as in the current system. This also implies that the average order quantity sent to main supply in San Diego is the current DSA/GSA order quantity in months' supply.

b) Because shipments are made in the same quantities between vendors and DSA/GSA depots, the transportation, packing, and handling costs between these points are the same as in the current system.

c) No inventory holding costs are incurred at DSA/GSA, as stock is allocated and shipped to the NSC's as soon as it reaches DSA/GSA from the vendors.

d) When shipments are divided for further distribution at a DSA/GSA depot, the latest demand data from the NSC's are used to make this allocation. This procedure minimizes safety stock requirements at the NSC's.

Next, consider the ordering rules for resupplying the activities and Servmarts. In the Total Push system, NSC has detailed visibility of the asset positions at these facilities and pushes stock from main supply to these facilities when needed. Because of its area-wide visibility, it is both feasible and desirable for NSC to use a group reordering rule when sending out supplies. Again, this group reordering rule is the base stock system. In other words, supplies for an item are sent simultaneously to all Servmarts and activities, as opposed to having an individual rule in which each activity would be resupplied independently of other activities. The advantages to having a group rule are: it minimizes handling costs at main supply; and it facilitates a rationing scheme in which any shortages can be spread evenly over all activities and Servmarts. We assume that the reorder quantity (in months' supply) for any item is the weighted average of the individual order quantities currently being employed by the various activities and Servmarts. In summary, the following are the differences between the Current Pull and Total Push systems with regard to resupplying the Servmarts and activities:

a) In the Total Push system, all shipments to Servmarts and activities come from main supply; however, some shipments come from DSA/GSA and vendors in the case of Current Pull.

b) In the Total Push system, the shipments are pushed to Servmarts and activities, while they are pulled in the current system. Having a push system minimizes the lead time between main supply and the destination facilities.

c) In the Total Push system, a group reordering rule is used, so that all activities and Servmarts are resupplied at the same time. However, individual rules are used in the current system.

2.8.3 Local Push/Expanded Range

In the Local Push/Expanded Range case, DSA/GSA retains their current warehousing function. The Servmarts and activities are resupplied in the same manner as in the Total Push system; however, main supply pulls stock from vendors and DSA/GSA. Table 2-2 indicates that there are two broad classes of items in Local Push/Expanded Range: (1) items ordered by NSC from DSA/GSA and sent to main supply; and (2) items ordered by NSC from vendors and sent to main supply. No items are sent directly to activities or Servmarts from vendors or DSA/GSA; thus, activities and Servmarts receive all their supplies from main supply.

We will discuss only the ordering rules for resupplying main supply, as the rules for activities and Servmarts are the same as in Total Push. NSC, in this case, uses the reorder point-reorder quantity model for both classes of items and sends a requisition either to DSA/GSA or to a vendor whenever the area-wide stock at San Diego reaches its reorder point. The reorder quantity is specified according to the VOSL rules [9] at main supply in the current system. There are two important differences between this system and the Current Pull system with regard to reordering

at main supply:

a) In the Local Push/Expanded Range system, the reordering rules refer to the area-wide stock, while the rules in Current Pull only refer to stock at main supply. Having this area-wide visibility reduces the variance of lead time demand and hence safety stock requirements.

b) The range of items at main supply in Local Push/Expanded Range system is expanded to include all items in the San Diego area, including items only stocked at activities and Servmarts in the current system.

2.8.4 Local Push/Current Range

Table 2-2 indicates that there are four classes of items in the Local Push/Current Range system: (1a) Items ordered by NSC from DSA/GSA and sent directly to main supply; (1b) Items ordered by NSC from DSA/GSA and sent directly to activities and Servmarts; (2a) Items ordered by NSC from vendors and sent directly to main supply; and (2b) Items ordered by NSC from vendors and sent directly to activities and Servmarts.

First, consider the ordering rules for resupplying main supply: item classes 1a and 2a. In this case, NSC uses the reorder point-reorder quantity model and sends a requisition either to DSA/GSA or to a vendor whenever the area-wide stock at San Diego reaches its reorder point. Thus, these are the same rules that are used for resupplying main supply in Local Push/Expanded Range.

Next, consider the ordering rules for resupplying activities and Servmarts with items coming directly from vendors and DSA/GSA: item classes 1b and 2b. In this case, NSC uses a group reorder-

ing rule called the base stock system (refer to Section 2.8.2 or Appendix B.2). The order quantity is determined in the following way: the total area-wide value of annual demand for an item (over all activities and Servmarts) is computed first; the corresponding VAD category at main supply is identified, using Table 2-1; and the current main supply order quantity corresponding to that VAD category is then used. Note that this quantity refers to the total order size over all facilities. However, the vendor or DSA/GSA depot makes separate shipments in appropriate amounts directly to the various activities and Servmarts, without storage or transshipment at main supply. Nevertheless, all activities and Servmarts are resupplied simultaneously, as a consequence of the group trigger in the base stock system.

And finally, consider the ordering rules for resupplying activities with items stocked at main supply: item classes 1a and 2a. As these are handled in exactly the same way that is done in the Total Push system, refer to Section 2.8.2 for a description of those rules.

2.9 Variability of Demand

In most cases, our data tapes were incomplete, and we did not have access to actual standard deviation estimates of the demand for most items at most facilities. Thus, the standard deviation estimates that we used were computed with a theoretical formula based upon FAD (frequency of annual demand) data, which were available at main supply and at all major activities; however, it was necessary to impute the FAD for items at Servmarts (refer to Section E.2.3). This formula was based upon the assumption that customers would arrive at a facility according to the Poisson

process (i.e., the arrivals would be random over time) and that the purchase quantity for an item would be the same for all customers at a particular facility. Let FAD_{ij} be the frequency of annual demand for item i at facility j (either main supply, an activity, or a Servmart), and let AQD_{ij} be the average quarterly demand for item i at facility j. The foregoing assumptions imply that the standard deviation of quarterly demand for item i at facility j is given by

$$AQD_{ij} \, (4/FAD_{ij})^{1/2} \; ;$$

and the coefficient of variations (ratio of standard deviation to mean demand) is given by

$$(4/FAD_{ij})^{1/2} \; .$$

3.0 LEAD TIMES AND TRANSIT TIMES

The lead time is defined as the time between when a facility (main supply, Servmart, or activity) reaches its reorder point for an item and when the replenishment order arrives and is in stock. The transit time is defined as that portion of the lead time which is initiated by the transaction at the issuing facility.

Table 3-1 provides the estimated lead times and Table 3-2 provides the estimated transit times for the alternative systems. These estimates are given both in months and in years. The sources for these estimates are indicated within the footnotes to these tables. Most of these estimates are based upon October 1974 samples of: issues from DSA to main supply; issues from main supply to activities and Servmarts; and items at DSA. Estimates for the standard deviation of these lead times are given in Appendix B.1, and these are incorporated into the service and inventory level analyses in that Appendix.

TABLE 3-1

ESTIMATED LEAD TIMES

(figure without parentheses in months; figure with parentheses in years)

	Current Pull	Total Push	Local Push/ Expanded Range	Local Push/ Current Range
Vendor to DSA/GSA	8.12[b] (.677)	--	8.12 (.677)	8.12 (.677)
Vender to NSC thru DSA/GSA	--	8.59[c] (.716)	--	--
Vendor to NSC direct	1.13[a] (.094)	1.13 (.094)	1.13 (.094)	1.13 (.094)
Vendor to Major Activities	1.13 (.094)	--	--	1.13 (.094)
Vendor to Servmarts	1.13 (.094)	--	--	1.13 (.094)
DSA/GSA to NSC	1.13 (.094)	--	1.13 (.094)	1.13 (.094)
DSA/GSA to Major Activities	1.13 (.094)	--	--	1.13 (.094)
DSA/GSA to Servmarts	1.13 (.094)	--	--	1.13 (.094)
NSC to Major Activities	.33[d] (.028)	.13[e] (.011)	.13 (.011)	.13 (.011)
NSC to Servmarts	.33 (.028)	.13 (.011)	.13 (.011)	.13 (.011)
NSC to direct Customers	.33 (.028)	.13 (.011)	.13 (.011)	.13 (.011)

---

a Based upon June 1974 FMSO Report 4422

b Based upon an Oct. 1974 sample of DSA items

c Computed as the lead time from vendor to DSA/GSA, plus transit time from DSA/GSA to NSC, less a correction for reduced handling at DSA/GSA

d Average lead time according to an Oct. 1974 sample of issues from main supply

e Average transit time according to an Oct. 1974 sample of issues from main supply

TABLE 3-2

ESTIMATED TRANSIT TIMES

(figure without parentheses in months; figure with parentheses in years)

	Current Pull	Total Push	Local Push/ Expanded Range	Local Push/ Current Range
Vendor to NSC thru DSA/GSA	--	.48[a] (.040)	--	--
DSA/GSA to NSC	.63[b] (.053)	--	.63 (.053)	.63 (.053)
DSA/GSA to Major Activities	.63 (.053)	--	--	.63 (.053)
DSA/GSA to Servmarts	.63 (.053)	--	--	.63 (.053)
NSC to Major Activities	.13[c] (.011)	.13 (.011)	.13 (.011)	.13 (.011)
NSC to Servmarts	.13 (.011)	.13 (.011)	.13 (.011)	.13 (.011)
NSC to direct Customers	.13 (.011)	.13 (.011)	.13 (.011)	.13 (.011)

---

a Only includes portion under DSA/GSA ownership. Computed as the transit time from DSA/GSA to NSC, less a correction for reduced handling at DSA/GSA.

b Based upon an Oct. 1974 sample of issues from DSA/GSA to NSC.

c Average transit time according to an October 1974 sample of issues from main supply.

4.0 SERVICE LEVELS

In this section, we compare service levels using the following measure of service. An item is said to be not-in-stock (NIS) if the on-hand inventory level for the item is zero. Then one meaningful definition of service level is the fraction of items which are not NIS.

In each of the three alternative Push systems, the Area Naval Support Center has area-wide asset visibility, as well as rapid communication with each of the Servmarts and major activities. Consequently, if a customer demands an item which is NIS at a particular activity but which is in-stock at another activity, the requisition may be filled from that other activity. Hence, the same area-wide inventory as currently can result in an increased level of service. Alternatively, the same level of service may be achieved with a lower inventory.

In the alternative Push systems we define an item at an activity to be NIS if and only if it is NIS at every location in the area (in keeping with the above discussion). Using MISR tapes and NSC's Master Servmart File, the new service levels may be compared with the current service level. Such a comparison is shown in Table 4-1, where we have empirically measured service levels assuming that inventory values, by item and location, are the same in the current system as with area-wide visibility. It is apparent that there is a significant improvement in service resulting from area-wide visibility. This is of course because many items which are NIS at a particular activity are not NIS when one considers area-wide availability.

Thus, for example, the current service level at NAS-NI is 89.0%, whereas area-wide visibility results in a new service level of 96.0%. That is, 96.0% of items which have demand at NAS-NI are available either at NSC-SD, at least one of the 7 major activities, or at least one of the 11 Servmarts. However, only 89.0% are actually available at NAS-NI.

In the analysis which follows in subsequent sections of this report, we shall adopt the alternative approach of keeping service levels constant and computing the resulting decrease in on-hand inventory levels. For this purpose, we shall find it convenient to define the service level as the fraction of demand satisfied without a backlog. See Section 6.1 and Appendix B.1 for details.

TABLE 4-1

THE IMPACT OF AREA-WIDE ASSET VISIBILITY AND REDISTRIBUTION ON SERVICE LEVELS IF PRESENT INVENTORY LEVELS RETAINED

Location	Current Service Level[1]	Service Level With Area-Wide Visibility[2]
NSC-SD	78.8%	89.8%
DATC	64.6%	85.0%
NSLB	90.6%	96.6%
NARF	90.6%	95.5%
NAS-NI	89.0%	96.0%
NAS-MIR	78.4%	88.2%
PWC	86.3%	97.4%
HOSP	100.0%	100.0%
Servmart NSC-SD Naval Station	90.4%	98.3%
Servmart NSC-SD	72.2%	98.1%
Servmart NAB	79.8%	99.0%
Servmart NAS-NI	81.3%	98.5%
Servmart Long Beach Annex	89.7%	98.6%
Servmart Imperial Beach	81.2%	97.4%
Servmart Pt. Loma	85.9%	98.4%
Servmart Miramar Main	89.0%	99.0%
Servmart Miramar Auto	87.5%	93.8%
Servmart NTC	81.2%	98.0%
Servmart NELC	82.4%	96.8%

1. The measure of service shown is the fraction of items which are not NIS. Items with zero demand are excluded from the calculation.

2. With area-wide visibility, an item is NIS if and only if it is NIS at every location in the area.

5.0 ISSUES, RECEIPTS, AND DOLLAR DEMAND

Before estimating costs for each of the alternative systems, it is necessary to estimate changes in the flow of dollar demand and transactions (issues and receipts). These estimates are given in Tables 5-1 and 5-2, respectively. The reader is referred to Appendix A for details of the calculations.

Table 5-1 shows the dollar demand flow for each of the four systems. To illustrate the table, in the current system, the seven major activities place a total annual dollar demand of $15.437 million on NSC stock, $6.341 million on DSA/GSA stock and $.196 million on the vendors or a total of $21.974 million. In the total push and local push/expanded range systems, NSC will carry all items demanded by activities, so that the entire $21.974 million demand will be placed on NSC stock. In the local push/current range system, the range at NSC is the same as currently, so that demands by the activities are allocated as currently. The analysis of Servmart demand in analagous.

Table 5-2 shows flow of transactions (issues and receipts) in each of the four alternatives. The most significant changes to be noted are:

1. In the second and third systems, the increased range at NSC results in increased issues from NSC to activities and Servmarts, at the same time eliminating direct issues from vendors and DSA/GSA to activities and Servmarts.
2. In the second system, issues into and out of DSA/GSA stock are eliminated, as shipments are made directly from the vendor to NSC, transshipped through DSA/GSA.
3. In the third system. receipts at NSC are increased due to the increased range at NSC. Note that this is not true of the second system (total push) since the economic order quantities received at NSC (now directly from the vendor) are significantly greater than in the current system, resulting in less frequent receipts at NSC.

TABLE 5-1

Dollar Demand (millions of dollars per year)

	Current Pull	Total Push	Local Push/ Expanded Range	Local Push/ Current Range
Vendor to DSA/GSA	43.021	0	43.021	43.021
Vendor to NSC thru DSA/GSA	0	43.021	0	0
Vendor to NSC direct	1.116	1.330	1.330	1.116
Vendor to Major Activities	.196	0	0	.196
Vendor to Servmarts	.018	0	0	.018
DSA/GSA to NSC	36.087	0	43.021	36.087
DSA/GSA to Major Activities	6.341	0	0	6.341
DSA/GSA to Servmarts	.593	0	0	.593
NSC to Major Activities	15.437	21.974	21.974	15.437
NSC to Servmarts	7.428	8.039	8.039	7.428
NSC to direct Customers	14.338	14.338	14.338	14.338

TABLE 5-2

Line Items Transacted (thousands per year)

	Current Pull	Total Push	Local Push/ Expanded Range	Local Push/ Current Range
Vendor to NSC thru DSA/GSA	0	69.1	0	0
Vendor to NSC direct	4.3	5.4	5.4	4.3
Vendor to Major Activities	1.1	0	0	1.2
Vendor to Servmarts	0.5	0	0	.2
DSA/GSA to NSC	137.8	0	173.9	137.8
DSA/GSA to Major Activities	34.4	0	0	38.2
DSA/GSA to Servmarts	15.7	0	0	7.0
NSC to Major Activities	69.2	104.7	104.7	69.2
NSC to Servmarts	134.9	151.1	151.1	134.9
NSC to direct Customers	436.0	436.0	436.0	436.0
Major Activities to Customers	618.3	618.3	618.3	618.3
Servmarts to Customers	1363.4	1363.4	1363.4	1363.4

6.0 INVENTORY LEVELS

6.1 On-Hand Inventory Levels

When estimating inventory levels, it is convenient to distinguish between two types of inventories: on-hand and transit inventories. As soon as an order is transacted against the inventory ledger of an issuing facility, these supplies are classified as inventory which is in transit from the issuing facility to the receiving facility. Material which is actively present within the facility shall be referred to as on-hand inventory. A comparison of average on-hand inventories for the alternative systems will be made in this section, while the comparison of transit inventories will be made in Section 6.2.

Table 6-1 provides the average on-hand inventories for the Current Pull, Total Push, and Local Push systems. In this chart, it is not necessary to distinguish between Local Push/Expanded Range and Local Push/Current Range, as both of these alternatives will have the same area-wide inventory in San Diego, although the distribution of this inventory among main supply, activities, and Servmarts will be different.

Three types of inventory are listed for each system: Pro-rated DSA; Pro-rated GSA; and San Diego Area-Wide. The Pro-rated DSA inventory is an estimate of the peacetime DSA inventory that is held for resupplying San Diego. Our approach for estimating this amount is given in detail in the footnotes to Table 6-1, and is based upon determining the proportion of world-wide DSA sales that is attributed to San Diego. The Pro-rated GSA inventory is an estimate of the GSA inventory that is held for resupplying San Diego. Our approach for estimating this inventory is also given in the

TABLE 6-1

COMPARISON OF AVERAGE ON-HAND INVENTORIES

(In millions of dollars)

Type of Inventory	Current Pull System	Total Push System	Local Push System
Pro-rated DSA[1]	$29.307	$ 0.	$29.307
Pro-rated GSA[2]	2.968	0.	2.968
San Diego Area-Wide[3]	14.053	36.538	10.821
	$46.328	$36.538	$43.096

---

1 This is an estimate of the peacetime DSA inventory that is held for resupplying San Diego. The worldwide inventory (9Z, 9L, 9G, 9N, 9C) was $1441.3 million in June 1973 according to An Introduction to the Defense Supply Agency (1974). From a sample of DSA items, .858 is estimated to be the fraction of DSA inventory that is peacetime, which implies that the peacetime inventory is $1236.6 million. According to historical data supplied by the Naval Supply Systems Command, worldwide DSA sales (9Z, 9L, 9G, 9N, 9C) were $1237.6 million. The corresponding sales in San Diego were estimated to be $29.377 million, which implies that the ratio of San Diego to DSA sales is .0237. Thus, $29.307 = (1236.6)(.0237) is the appropriate estimate.

2 This is an estimate of GSA inventory (located in region 9) that is held for resupplying San Diego. According to data supplied by GSA, the FY1974 region 9 average inventory was $19.4 million and total sales were $98.041 million. The estimated San Diego 9Q sales were $14.983 million, which implies that the ratio of San Diego to GSA sales is .153. Thus, $2.968 = (19.4)(.153) is the appropriate estimate.

3 This is the estimated San Diego area-wide inventory, including assets held at main supply, Servmarts, and major activities. Refer to Appendix B.

footnotes to Table 6-1, and it is also based upon determining the proportion of GSA sales that can be attributed to San Diego.

Appendix B discusses our methods for estimating the San Diego area-wide inventories for the alternative systems. The figure listed for the Current Pull system, $14.053 million, is the actual current on-hand inventory in San Diego. However, the estimates for Total Push and Local Push are based upon theoretical models of the operations of these two systems. Appendix B provides the formulas, data, and derivations for these theoretical models. The area-wide service levels in the proposed systems were constrained to be equal to the activity service levels in the current system. Basically, our approach was the following: compute theoretical estimates of the area-wide on-hand inventory for the Current Pull, Total Push, and Local Push systems; compute the ratio of Total Push to Current Pull inventory, and apply this ratio to the actual current inventory to obtain the estimate of Total Push inventory given in Table 6-1; and compute the ratio of Local Push to Current Pull inventory, and apply this ratio to the actual current inventory to obtain the estimate of Local Push inventory given in Table 6-1. Refer to Appendix B for the details of these calculations. Note that the estimate of San Diego inventory is much larger for Total Push than for Current Pull or Local Push, because a portion of the inventory which had previously been stored at DSA/GSA has been prepositioned at San Diego in this alternative.

Of the current $14.053 million of inventory held in the San Diego area, $8.493 million is held at the major activities and $.816 million is held at the Servmarts. In the alternative push systems, the area-wide visibility of NSC minimizes the importance of specifying the exact distribution of the San Diego inventory. For the purposes of theis report we (somewhat arbitrarily)

assume that the amount held at the Servmarts and major activities is unchanged, so that changes in San Diego on-hand inventory will be reflected in changes at NSC.

6.2 In-Transit Inventory Levels

In-transit inventory is defined as that inventory which has been released for shipment from one activity to another but which has not yet arrived at the second activity. The average in-transit inventory level may be computed by multiplying the transit time by the dollar value of demand.

Table 6-2 shows in-transit inventory calculations for each of the four alternative systems. Thus, for example, the current in-transit inventory between DSA/GSA and NSC is $1.913 million. In the Total Push System, the portion of the vendor-to NSC in-transit inventory which is under DSA/GSA ownership (i.e., the portion occurring after the transshipment operation at DSA/GSA) is $1.721 million. In the Local Push/Expanded Range System, the in-transit inventory between DSA/GSA and NSC is $2.280 million. Finally, in the Local Push/Current Range system, the in-transit inventory is identical to the current system.

TABLE 6-2

IN-TRANSIT INVENTORY LEVELS

(millions of dollars)

	Current Pull	Total Push	Local Push/ Expanded Range	Local Push/ Current Range
Vendor to NSC thru DSA/GSA	0	1.721[1]	0	0
DSA/GSA to NSC	1.913	0	2.280	1.913
DSA/GSA to Major Activities	.336	0	0	.336
DSA/GSA to Servmarts	.031	0	0	.031
NSC to Major Activities	.170	.242	.242	.170
NSC to Servmarts	.082	.088	.088	.082

[1] Portion under DSA/GSA ownership

7.0 COST ESTIMATES

The purpose of this section is to attach cost estimates to the changes predicted in Sections 5 and 6. These estimates are shown in Tables 7-1 through 7-9. Tables 7-1, 7-2, and 7-3 compare costs of the current system with the Total Push system. Tables 7-4, 7-5, and 7-6 do likewise for the Local Push/Expanded Range system, and Tables 7-7, 7-8, and 7-9 deal with the Local Push/Current Range system. The first table in each group of three summarizes the cost estimates by type of cost or function (e.g. inventory holding vs. transportation, etc.). The second table in each group gives a more detailed breakdown of these costs. The third organizes the cost estimates according to the party incurring the expenses.

The inventory holding costs in Tables 7-1 through 7-9 are obtained by applying an annual holding rate of 21% to the average dollar value of inventory. The holding rate includes the cost of capital, obsolescence and a carrying cost. Thus, for example, the current DSA/GSA on-hand inventory holding cost (from Table 7-1) is $6.778 million per year, compared to $7.673 million in the total Push system. However, the holding cost in the latter case applies to inventory owned by DSA/GSA but not stocked at a DSA/GSA depot. Referring to Table 7-2, it is seen that $5.889 million is incurred by DSA/GSA for stock on-hand at NSC and the Servmarts and $1.784 is incurred for stock on hand at the 7 major activities. (The parenthetical expressions in Table 7-2 indicate the party incurring the expense.) The same information may be obtained from Table 7-3. Note from Table 7-1

that there is an overall $2.056 million reduction in inventory holding cost due to the area-wide visibility and to the reduction of lead times. There is likewise a reduction in the two Local Push systems as seen in Tables 7-4 and 7-7.

The in-transit inventory holding costs are obtained by applying the annual holding rate of 21% to the average dollar value of in-transit inventory as reported in Section 6. The in-transit inventory holding costs in each system are roughly comparable, there being a slight decrease in the Total Push system (due to shorter transit times for material arriving at NSC) and a slight increase in the Local Push/Expanded Range system (due to additional transit time incurred for items which were formerly not stocked at NSC and must now be brought into stock).

The current transportation costs for DSA/GSA are estimated to be $6.564 million per year. For each of the alternative systems, this cost is estimated to be unchanged, based on assumptions of an equivalent amount of material being shipped to the San Diego area with equivalent cost rates. It is felt that these assumptions result in an over-estimate for the alternative transportation costs for the following reasons:

1. In the Total Push system, it is likely that some material will be shipped direct from the vendor to NSC rather than transshipped through DSA/GSA, thus avoiding double transportation costs. It is not possible to estimate the fraction of material which would be shipped direct.

2. In the Total Push system, there will be an increase in shipment size for material shipped to NSC. This may result in fewer costly parcel post shipments as well as more advantageous common carrier rates.
3. In the Total Push and the Local Push/Expanded Range systems, certain items which were shipped directly to activities and Servmarts in the current system are now shipped to NSC, perhaps facilitating more economic transportation rates.

The NSC local transportation costs are $.725 million in the current system and are increased slightly in each of the alternative systems. This increase is due to transportation costs associated with the increased range at NSC (in the second and third systems) and to transportation costs associated with material redistribution which is necessary to implement the area-wide service level concept.

The receiving cost estimates include the following cost accounts: incoming storage, receipt control, receiving operations, and bin operations. The DSA/GSA receipt costs are eliminated in the Total Push system (see Table 7-1) since material is no longer received into stock at DSA/GSA depots (there is, however, a transshipment cost; see below). The NSC receiving costs are increased in the Total Push and the Local Push/Expanded Range systems (see Tables 7-1 and 7-4) since the range of stock at NSC is increased. However, in the Local Push/Current Range system (see Table 7-7), the NSC receiving costs (including Servmart

costs) are decreased slightly because of a decrease in the receipt frequency of material sent from DSA/GSA to Servmarts. See Table 7-9, Part II-4, for a more detailed cost breakdown showing this decrease.

The issuing cost estimates include the following cost accounts: requisition processing, packing, bin issue, bulk issue, and shipping (loading). The DSA/GSA costs are eliminated in the Total Push system and are reduced in the other two Push systems due to slight reductions in the frequency of shipment. The NSC issuing costs are affected by two factors: the elimination of requisition processing cost in all systems other than the current, and the increase in issues due to the increased range in the Total Push and the Local Push/Expanded Range systems. The net result is a slight increase in issuing costs in the Total Push and the Local Push/Expanded Range systems and a slight decrease in issuing costs in the Local Push/Current Range system.

The DSA/GSA transshipment handling cost is DSA/GSA's cost (excluding transportation) of transshipping material from the vendor to NSC in the Total Push system. As discussed in Appendix C, this cost is based upon current DSA/GSA costs for loading and unloading of material, packing, and receipt control.

The current overhead costs are based on the following accounts: care of material in storage, rewarehousing, preservation and packaging, inventory, training storage, storage and warehouse support, labor and equipment overhead, package and issue support, command, management engineering, comptroller,

civilian manpower, data processing, office services, miscellaneous administration, communications, security, utilities, building maintenance, real property maintenance, procurement of pallets, and general engineering support. Changes in overhead costs at a particular location are computed assuming a fixed ratio of overhead costs to operating costs in issuing, receiving, transshipment handling, and local transportation.

Current land and building costs associated with the retail supply function are estimated by considering a rental value per square foot of space. A division is made between land and building associated with retail supply operations (such as material handling, requisition processing, etc.) and land and building associated with the storage of retail inventory. Changes in operations-related land and building costs are estimated assuming a fixed ratio of these costs to operating costs in issuing receiving, transshipment handling, and local transportation. Changes in storage-related land and building costs are estimated assuming a fixed ratio of these costs to dollar value of inventory.

TABLE 7-1

SUMMARY COMPARISON OF ANNUAL RECURRING SYSTEM COSTS BY FUNCTION FOR CURRENT PULL VS. TOTAL PUSH SYSTEM[1]

(*in support of San Diego's area-wide demand for currently retail managed inventory; millions of dollars per year*)

Financial Account	Current System	Proposed System	Savings
1. Inventory Holding Costs (not including land & building; @21% of inventory value)			
a. DSA/GSA	6.778	7.673	(.895)
b. NSC (including Servmarts)	1.167	0	1.167
c. Major activities[2]	1.784	0	1.784
Total Inventory Holding Costs	9.729	7.673	2.056
2. In-transit Inventory Holding Costs (@21% of inventory value)			
a) DSA/GSA	0	.431	(.431)
b) NSC (including Servmarts)	.426	0	.426
c) Major activities	.107	0	.107
Total In-transit Inventory Holding Costs	.533	.431	.102
3. Transportation Costs			
a) DSA/GSA	6.564	6.564	0
b) NSC (including Servmarts)	.725	.886	(.161)
Total Transportation Costs	7.289	7.450	(.161)
4. Receipt Costs (includes incoming storage, receipt control, receiving operations & bin operations)			
a) DSA/GSA	.295	0	.295
b) NSC (including Servmarts)	.762	.812	(.050)
c) Major activities	.346	.346	0
Total Receipt Costs	1.403	1.158	.245
5. Issue Costs (includes requisition processing, packing, bin and bulk issues and loading)			
a) DSA/GSA	.593	0	.593
b) NSC (including Servmarts)	1.155	1.245	(.090)
Total Issue Costs	1.748	1.245	.503
6. Transshipment Handling			
a) DSA/GSA (includes receiving operations, receipt control, packing and loading)	0	.499	(.499)
7. Overhead			
a) DSA/GSA (applied to receipt, issue and transshipment handling handling costs)	1.166	.655	.511
b) NSC (including Servmarts; applied to issue, receipt and transportation costs)	3.469	3.864	(.395)
c) Major activities (applied to receipt costs)	.454	.454	0
Total Overhead Costs	5.089	4.973	.116
8. Land and Building			
a) DSA/GSA	1.089	.040	1.049
b) NSC (including Servmarts)	.389	1.121	(.732)
c) Major activities	.296	.296	0
Total Land and Building Costs	1.774	1.457	.317
GRAND TOTAL	27.565	24.886	2.679

[1] The proposed wholesale system is one in which DSA/GSA prepositions stock at an Area Naval Support Center (perhaps Main Supply) and at the Major Activities. The Area Naval Support Center maintains detailed area asset visibility and provides uniform service to activities; the system consists of full vertical management support where inventory is pushed both from DSA/GSA to NSC and in turn from NSC to the Major Activities. The range of items carried at the Naval Support Center is increased from the current NSC range to include all items carried at the Servmarts and major activities.

[2] The following activities are included: DATC, NSLB, NARF, NAS-NI, NAS-MIR, PWC, NHOSP-SD.

TABLE 7-2

DETAIL OF ANNUAL RECURRING SYSTEM COSTS BY FUNCTION FOR CURRENT PULL VS. TOTAL PUSH SYSTEM

(millions of dollars per year)

Financial Account	Current System	Proposed System	Savings
1. Inventory Holding Costs (not including land & buildings @21% of inventory value)			
a. Related to peacetime assets held at DSA/GSA	6.778 (D/G)[1]	0	6.778
b. Related to peacetime assets at NSC and 11 Servmarts	1.167 (NSC)	5.889 (D/G)	(4.722)
c. Related to peacetime assets at 7 major activities	1.784 (ACT)	1.784 (D/G)	0
Total Inventory Holding Costs	9.729	7.673	2.056
(Alternatively this translates to a one-time reduction in inventory of $9.79M.)			
2. In-transit Inventory Holding Costs (@21% of inventory value)			
a) In-transit from DSA/GSA to NSC (excluding Servmarts)	.402 (NSC)	.361 (D/G)	.041
b) In-transit from DSA/GSA to Servmarts	.007 (NSC)	0	.007
c) In-transit from DSA/GSA to major activities	.071 (ACT)	0	.071
d) In-transit from NSC to Servmarts	.017 (NSC)	.019 (D/G)	(.002)
e) In-transit from NSC to major activities	.036 (ACT)	.051 (D/G)	(.015)
Total In-transit Inventory Holding Costs	.533	.431	.102
(This translates to a one-time reduction in inventory of $.49M.)			
3. Transportation Costs			
a) DSA/GSA to NSC (excluding Servmarts)	5.507 (D/G)	6.564 (D/G)	(1.057)
b) DSA/GSA to Servmarts	.088 (D/G)	0	.088
c) DSA/GSA to major activities	.969 (D/G)	0	.969
d) NSC to Servmarts	.145 (NSC)	.161 (NSC)	(.016)
e) NSC to major activities	.301 (NSC)	.439 (NSC)	(.138)
f) NSC to other customers	.279 (NSC)	.286 (NSC)	(.007)
Total Transportation Costs	7.289	7.450	(.161)
4. Receipt Costs (includes incoming storage, receipt control, receiving operations, bin operations)			
a) From DSA/GSA to NSC (excluding Servmarts)	.548 (NSC)	.595 (NSC)	(.047)
b) From DSA/GSA to Servmarts	.017 (NSC)	0	.017
c) From DSA/GSA to major activities	.102 (ACT)	0	.102
d) From NSC to Servmarts	.179 (NSC)	.197 (NSC)	(.018)
e) From NSC to major activities	.241 (ACT)	.346 (ACT)	(.105)
f) From vendors to DSA/GSA	.295 (D/G)	0	.295
g) From vendors to NSC (excluding Servmarts)	.017 (NSC)	.020 (NSC)	(.003)
h) From vendors to Servmarts	.001 (NSC)	0	.001
f) From vendors to major activities	.003 (ACT)	0	.003
Total Receipt Costs	1.403	1.158	.245
5. Issue Costs (includes requisition processing, packing, bin and bulk issues and loading)			
a) From DSA/GSA to NSC (excluding Servmarts)	.500 (D/G)	0	.500
b) From DSA/GSA to Servmarts	.017 (D/G)	0	.017
c) From DSA/GSA to major activities	.076 (D/G)	0	.076
d) From NSC to Servmarts	.236 (NSC)	.213 (NSC)	.023
e) From NSC to major activities	.331 (NSC)	.444 (NSC)	(.113)
f) From NSC to all other customers	.588 (NSC)	.588 (NSC)	0
Total Issue Costs	1.748	1.245	.503

TABLE 7-2 (continued)

Financial Account	Current System	Proposed System	Savings
6. Transshipment Handling (includes receiving operations, receipt control, packing and loading)	0	.499(D/G)	(.499)
7. Overhead Costs			
a) DSA/GSA (applied to receipt, issue, & transshipment handling costs)	1.166(D/G)	.655(D/G)	.511
b) NSC (including Servmarts and applied to issue receipt and transportation costs)	3.469(NSC)	3.864(NSC)	(.395)
c) Major activities (applied to receipt costs)	.454(ACT)	.454(ACT)	0
Total Overhead Costs	5.089	4.973	.116
8. Land & Building			
a) Storage-related at DSA/GSA (applied to on-hand inventory)	1.017(D/G)	0(D/G)	1.017
b) Operations-related DSA/GSA (applied to appropriate handling costs)	.072(D/G)	.040(D/G)	.032
c) Storage-related at NSC (including Servmarts)	.175(NSC)	.883(NSC)	(.708)
d) Operations-related at NSC	.214(NSC)	.238(NSC)	(.024)
e) Storage-related at major activities	.268(ACT)	.268(ACT)	0
f) Operations-related at major activities	.028(ACT)	.028(ACT)	0
Total Land and Building Costs	1.774	1.457	.317
GRAND TOTAL of Annual Costs	$27.565M	$24.886M	$2.679M

(Grand Total of one-time Reduction in Inventory of $10.28M)

---

[1] Parenthetical expression indicates party charged with expense.

TABLE 7-3

SUMMARY OF ANNUAL RECURRING COSTS

CURRENT PULL VS. TOTAL PUSH

(millions of dollars per year)

Financial Account	Current System	Proposed System	Savings (current less proposed)
1. DSA/GSA Costs			
1. Inventory Holding Costs (not including land and building)			
a) Related to peacetime assets held at DSA/GSA depots (@21% of inventory value)	6.778	0	6.778
b) Related to peacetime assets at NSC (including 11 Servmarts)	0	5.889	(5.889)
c) Related to peacetime assets at 7 Major Activities	0	1.784	(1.784)
Total Inventory Holding Costs	6.778	7.673	(.895)
2. In-transit Inventory Holding Costs (@21% of inventory value)			
a) In transit from DSA/GSA to NSC (excluding Servmarts)	0	.361	(.361)
b) In transit from DSA/GSA to Servmarts	0	0	0
c) In transit from DSA/GSA to Major Activities	0	0	0
d) In transit from NSC to Servmarts	0	.019	(.019)
e) In transit from NSC to Major Activities	0	.051	(.051)
Total In Transit Inventory Holding Costs	0	.431	(.431)
3. Transportation Costs			
a) DSA/GSA to NSC (excluding Servmarts)	5.507	6.564	(1.057)
b) DSA/GSA to Servmarts	.088	0	.088
c) DSA/GSA to Major Activities	.969	0	.969
Total Transportation Costs	6.564	6.564	0
4. Receipt Costs (includes incoming storage, receipt control, receiving operations and bin operations; represents receipts from vendors into DSA/GSA stocks)	.295	-	.295
5. Issue Costs (includes requisition processing, packing, bin and bulk issues and loading)			
a) DSA/GSA to NSC (excluding Servmarts)	.500	-	.500
b) DSA/GSA to Servmarts	.017	-	.017
c) DSA/GSA to Major Activities	.076	-	.076
Total Issue Costs	.593	-	.593
6. Transshipment Handling (includes receiving operations, receipt control, packing and loading)	0	.499	(.499)
7. Overhead (applied to receipt, issue and transshipment handling costs)	1.166	.655	.511

TABLE 7-3 (continued)

Financial Account	Current System	Proposed System	Savings (current less proposed)
8. Land and Building			
a) Storage-related (applied to on-hand inventory at DSA/GSA)	1.017	0	1.017
b) Operations-related (applied to receipt, issue and transshipment handling)	.072	.040	.032
Total Land and Building	1.089	.040	1.049
TOTAL OF FINANCIAL ACCOUNTS 1 - 8	16.485	15.862	.623
II. NSC Costs (including 11 Servmarts)			
1. Inventory Holding Costs (not including land & building)			
a) Related to peacetime assets held at NSC and Servmarts (@21% of inventory value)	1.167	0	1.167
2. In-transit Inventory Holding Costs (@21% of inventory value)			
a) In transit from DSA/GSA to NSC	.402	0	.402
b) In transit from DSA/GSA to Servmarts	.007	0	.007
c) In transit from NSC to Servmarts	.017	0	.017
Total In-transit Inventory Holding Costs	.426	0	.426
3. Transportation Costs			
a) NSC to Servmarts	.145	.161	(.016)
b) NSC to Major Activities	.301	.439	(.138)
c) NSC to other customers	.279	.286	(.007)
Total Transportation Costs	.725	.886	(.161)
4. Receipt Costs (includes incoming storage, receipt control, receiving operations, and bin operations; represents receipts from vendors and DSA/GSA depots into stock at NSC and Servmarts)			
a) From DSA/GSA to NSC	.548	.595	(.047)
b) From DSA/GSA to Servmarts	.017	0	.017
c) From vendors to NSC	.017	.020	(.003)
d) From vendors to Servmarts	.001	0	.001
e) From NSC to Servmarts	.179	.197	(.018)
Total Receipt Costs	.761	.812	(.050)
5. Issue Costs (includes requisition processing, packing, bin and bulk issue and loading)			
a) From NSC to Servmarts	.236	.213	.023
b) From NSC to Major Activities	.331	.444	(.113)
c) From NSC to all other customers	.588	.588	0
Total Issue Costs	1.155	1.245	(.090)

TABLE 7-3 (continued)

Financial Account	Current System	Proposed System	Savings (current less proposed)
6. Overhead Costs (applied to issue, receipt and transportation costs)	3.469	3.864	(.395)
7. Land and Building Costs			
a) Storage-related (applied to on-hand inventory at NSC and Servmarts)	.175	.883	(.708)
b) Operations-related (applied to receipt, issue and transportation)	.214	.238	(.024)
Total Land and Building Costs	.389	1.121	(.732)
TOTAL OF ACCOUNTS 1 - 7	8.093	7.928	.165
III. Major Activity Costs			
1. Inventory Holding Costs (not including land and building)			
a) Related to peacetime assets at 7 Major Activities	1.784	0	1.784
2. In-transit Inventory Holding Costs (@21% of inventory value)			
a) In transit from DSA/GSA to Major Activities	.071	0	.071
b) In transit from NSC to Major Activities	.036	0	.036
Total In-transit Inventory Holding Costs	.107	0	.107
3. Receipt Costs (including storage, receipt control, receiving operations and bin operations; represents receipts from vendor, DSA/GSA depots, and NSC units stocked at the Major Activities			
a) From vendors	.003	0	.003
b) From DSA/GSA	.102	0	.102
c) From NSC	.241	.346	(.105)
Total Receipt Costs	.346	.346	0
4. Overhead Costs (applied to Receipt Costs)	.454	.454	0
5. Land and Building			
a) Storage-related (applied to on-hand inventory at activities)	.268	.268	0
b) Operations-related (applied to receipt)	.028	.028	0
Total Land and Building	.296	.296	0
TOTAL OF ACCOUNTS 1 - 5	2.987	1.096	1.891
GRAND TOTAL	$27.565	$24.886	$2.679

TABLE 7-4

SUMMARY COMPARISON OF ANNUAL RECURRING SYSTEM COSTS BY FUNCTION FOR CURRENT PULL VS. LOCAL PUSH/EXPANDED RANGE SYSTEM[1]

(in support of San Diego's area-wide demand for currently-retail-managed inventory; millions of dollars per year)

Financial Account	Current System	Proposed System	Savings
1. Inventory Holding Costs (not including land and building; @21% of inventory value)			
a) DSA/GSA	6.778	6.778	0
b) NSC (including Servmarts)	1.167	2.273	(1.106)
c) Major activities	1.784	0	1.784
Total Inventory Holding Costs	9.729	9.051	.678
(Alternatively this translates to a one-time reduction in inventory of $3.23M)			
2. In-transit Inventory Holding Costs (@21% of inventory values)			
a) DSA/GSA	0	0	0
b) NSC (including Servmarts)	.426	.549	(.123)
c) Major activities	.107	0	.107
Total In-transit Inventory Holding Costs	.533	.549	(.016)
3. Transportation Costs			
a) DSA/GSA	6.564	6.564	0
b) NSC (including Servmarts)	.725	.886	(.161)
Total Transportation Costs	7.289	7.450	(.161)
4. Receipt Costs (includes incoming storage, receipt control, receiving operations and bin operations)			
a) DSA/GSA	.295	.295	0
b) NSC (including Servmarts)	.762	.877	(.115)
c) Major Activities	.346	.346	0
Total Receipt Costs	1.403	1.518	(.115)
5. Issue Costs (includes requisition processing, packing, bin and bulk issues and loading)			
a) DSA/GSA	.593	.575	.018
b) NSC (including Servmarts)	1.155	1.245	(.090)
Total Issue Costs	1.748	1.820	(.072)

[1] In contrast to the Total Push system, the proposed system is one in which DSA/GSA depot stock is not eliminated. The area Naval Support CEnter requisitions material from DSA/GSA. Local management of inventory, however, is identical to that in the Total Push system. Likewise, the range of items carried at the Naval Support Center includes all items carried at the Servmarts and Major Activities.

TABLE 7-4 (continued)

Financial Account	Current System	Proposed System	Savings
6. Overhead			
a) DSA/GSA (applied to receipt and issue costs)	1.166	1.142	.024
b) NSC (including Servmarts; applied to issue, receipt and transportation costs)	3.469	3.950	(.481)
c) Major Activities	.454	.454	0
Total Overhead Costs	5.089	5.546	(.457)
7. Land and Building			
a) DSA/GSA	1.089	1.087	.002
b) NSC (including Servmarts)	.389	.317	.072
c) Major Activities	.296	.296	0
Total Land and Building Costs	1.774	1.700	.074
GRAND TOTAL	$27.565	$27.634	(.069)

TABLE 7-5

DETAIL OF ANNUAL RECURRING SYSTEM COSTS BY FUNCTION FOR CURRENT PULL VS. LOCAL PUSH/EXPANDED RANGE SYSTEM[1]

(millions of dollars per year)

Financial Account	Current System	Proposed System	Savings
1. Inventory Holding Costs (not including land and building; @21% of inventory value)			
a) Related to peacetime assets held at DSA/GSA	6.778 (D/G)	6.778 (D/G)	0
b) Related to peacetime assets at NSC and 11 Servmarts	1.167 (NSC)	.489 (NSC)	.678
c) Related to peacetime assets at 7 Major Activities	1.784 (ACT)	1.784 (NSC)	0
Total Inventory Holding Costs	9.729	9.051	.678
(Alternatively this translates to a one-time reduction in inventory of $3.23M)			
2. In-transit Inventory Holding Costs (@21% of inventory value)			
a) In-transit from DSA/GSA to NSC (excluding Servmarts)	.402 (NSC)	.479 (NSC)	(.077)
b) In-transit from DSA/GSA to Servmarts	.007 (NSC)	0	.007
c) In-transit from DSA/GSA to Major Activities	.071 (ACT)	0	.071
d) In-transit from NSC to Servmarts	.017 (NSC)	.019 (NSC)	(.002)
e) In-transit from NSC to Major Activities	.036 (ACT)	.051 (NSC)	(.015)
Total In-transit Inventory Holding Costs	.533	.549	(.016)
(This translates to a one-time increase in inventory of $.078M)			
3. Transportation Costs			
a) DSA/GSA to NSC (excluding Servmarts)	5.507 (D/G)	6.564 (D/G)	(1.057)
b) DSA/GSA to Servmarts	.088 (D/G)	0	.088
c) DSA/GSA to Major Activities	.969 (D/G)	0	.969
d) NSC to Servmarts	.145 (NSC)	.161 (NSC)	(.016)
e) NSC to Major Activities	.301 (NSC)	.439 (NSC)	(.138)
f) NSC to other customers	.279 (NSC)	.286 (NSC)	(.007)
Total Transportation Costs	7.289	7.450	(.161)

[1] Parenthetical expression indicates party charged with expense.

TABLE 7-5 (continued)

Financial Account	Current System	Proposed System	Savings
4. Receipt Costs (includes incoming storage, receipt control, receiving operations, bin operations)			
a) From DSA/GSA to NSC (excluding Servmarts)	.548 (NSC)	.660 (NSC)	(.112)
b) From DSA/GSA to Servmarts	.017 (NSC)	0	.017
c) From DSA/GSA to Major Activities	.102 (ACT)	0	.102
d) From NSC to Servmarts	.179 (NSC)	.197 (NSC)	(.018)
e) From NSC to Major Activities	.241 (ACT)	.346 (ACT)	(.105)
f) From vendors to DSA/GSA	.295 (D/G)	.295 (D/G)	0
g) From vendors to NSC (excluding Servmarts)	.017 (NSC)	.020 (NSC)	(.003)
h) From vendors to Servmarts	.001 (NSC)	0	.001
i) From vendors to Major Activities	.003 (ACT)	0	.003
Total Receipt Costs	1.403	1.518	(.115)
5. Issue Costs (includes requisition processing, packing, bin and bulk issues and loading)			
a) From DSA/GSA to NSC (excluding Servmarts)	.500 (D/G)	.575 (D/G)	(.075)
b) From DSA/GSA to Servmarts	.017 (D/G)	0	.017
c) From DSA/GSA to Major Activities	.076 (D/G)	0	.076
d) From NSC to Servmarts	.236 (NSC)	.213 (NSC)	.023
e) From NSC to Major Activities	.331 (NSC)	.444 (NSC)	(.113)
f) From NSC to all other customers	.588 (NSC)	.588 (NSC)	0
Total Issue Costs	1.748	1.820	(.072)
6. Overhead Costs			
a) DSA/GSA (applied to receipt and issue costs)	1.166 (D/G)	1.142 (D/G)	.024
b) NSC (including Servmarts and applied to issue receipt and transportation costs)	3.469 (NSC)	3.950 (NSC)	(.481)
c) Major Activities (applied to receipt costs)	.454 (ACT)	.454 (ACT)	0
Total Overhead Costs	5.089	5.546	(.457)
7. Land and Building			
a) Storage-related at DSA/GSA (applied to on-hand inventory)	1.017 (D/G)	1.017 (D/G)	0
b) Operations-related DSA/GSA (applied to appropriate handling costs)	.072 (D/G)	.070 (D/G)	.002
c) Storage-related at NSC (including Servmarts)	.175 (NSC)	.073 (NSC)	.102
d) Operations-related at NSC	.214 (NSC)	.244 (NSC)	(.030)
e) Storage-related at Major Activities	.268 (ACT)	.268 (ACT)	0
f) Operations-related at Major Activities	.028 (ACT)	.028 (ACT)	0
Total Land and Building Costs	1.774	1.700	.074
GRAND TOTAL OF ANNUAL COSTS	$27.565M	$27.634	(.069)

Net Annual Reduction in

TABLE 7-6

SUMMARY OF ANNUAL RECURRING COSTS

CURRENT PULL VS. LOCAL PUSH/EXPANDED RANGE SYSTEM

(millions of dollars per year)

Financial Account	Current System	Proposed System	Savings (current less proposed)
I. DSA/GSA Costs			
1. Inventory Holding Costs (not including land and building)			
a) Related to peacetime assets held at DSA/GSA depots (@21 of inventory value)	6.778	6.778	0
Total Inventory Holding Costs			
2. In-transit Inventory Holding Costs (@21% of inventory value)	0	0	0
3. Transportation			
a) DSA/GSA to NSC (excluding Servmarts)	5.507	6.564	(1.057)
b) DSA/GSA to Servmarts	.088	0	.088
c) DSA/GSA to Major Activities	.969	0	.969
Total Transportation	6.564	6.564	0
4. Receipt Costs (includes incoming storage, receipt control, receiving operations and bin operations; represents receipts from vendors into DSA/GSA stocks)	295	295	0
5. Issue Costs (includes requisition processing, packing, bin and bulk issues and loading)			
a) DSA/GSA to NSC (excluding Servmarts)	.500	.575	(.075)
b) DSA/GSA to Servmarts	.017	0	.017
c) DSA/GSA to Major Activities	.076	0	.076
Total Issue Costs	.593	.575	.018
6. Overhead (applied to receipt and issue costs)	1.166	1.142	.024
7. Land and Building			
a) Storage-related (applied to on-hand inventory at DSA/GSA)	1.017	1.017	0
b) Operations-related (applied to receipt, issue and transshipment handling)	.072	.070	.002
Total Land and Building	1.089	1.087	.002
TOTAL OF FINANCIAL ACCOUNTS 1 - 7	16.485	16.441	.044
II. NSC Costs (including 11 Servmarts)			
1. Inventory Holding Costs (not including land and building)			
a) Related to peacetime assets held at NSC and Servmart (@21% of inventory value)	1.167	.489	.678
b) Related to peacetime assets held at 7 Major Activities	0	1.784	(1.784)
Total of Inventory Costs	1.167	2.273	(1.106)

TABLE 7-6 (continued)

Financial Accounts	Current System	Proposed System	Savings (current less proposed)
2. In-transit Inventory Holding Costs (@21% of inventory value)			
a) In transit from DSA/GSA to NSC	.402	.479	(.077)
b) In transit from DSA/GSA to Servmarts	.007	0	.007
c) In transit from NSC to Servmarts	.017	.019	(.002)
d) In transit from NSC to Major Activities	0	.051	(.051)
Total In-transit Inventory Holding Costs	.426	.549	(.123)
3. Transportation Costs			
a) NSC to Servmarts	.145	.161	(.016)
b) NSC to Major Activities	.301	.439	(.138)
c) NSC to other customers	.279	.286	(.007)
Total Transportation Costs	.725	.886	(.161)
4. Receipt Costs (includes incoming storage, receipt control, receiving operations, and bin operations; represents receipts from vendors and DSA/GSA depots into stock at NSC and Servmarts)			
a) From DSA/GSA to NSC	.548	.660	(.112)
b) From DSA/GSA to Servmarts	.017	0	.017
c) From vendors to NSC	.017	.020	(.003)
d) From vendors to Servmarts	.001	0	.001
e) From NSC to Servmarts	.179	.197	(.018)
Total Receipt Costs	.762	.877	(.115)
5. Issue Costs (includes requisition processing, packing, bin and bulk issue and loading)			
a) From NSC to Servmarts	.236	.213	.023
b) From NSC to Major Activities	.331	.444	(.113)
c) From NSC to all other customers	.588	.588	0
Total Issue Costs	1.155	1.245	(.090)
6. Overhead Costs (applied to issue, receipt and transportation costs)	3.469	3.950	(.481)
7. Land and Building Costs			
a) Storage-related (applied to on-hand inventory)	.175	.073	.102
b) Operations-related (applied to receipt, issue and transportation)	.214	.244	(.030)
Total Land and Building	.389	.317	.072
TOTAL OF ACCOUNTS 1 - 7	8.093	10.097	(2.004)

TABLE 7-6 (continued)

Financial Accounts	Current System	Proposed System	Savings (current less proposed)
III. Major Activity Costs			
1. Inventory Holding Costs (not including land and building)			
a) Related to peacetime assets at 7 Major Activities	1.784	0	1.784
2. In-transit Inventory Holding Costs (@21% of inventory value)			
a) In transit from DSA/GSA to Major Activities	.071	0	.071
b) In transit from NSC to Major Activities	.036	0	.036
Total In-transit Inventory Holding Costs	.107	0	.107
3. Receipt Costs (includes incoming storage, receipt control, receiving operations and bin operations; represents receipts from vendor, DSA/GSA depots, and NSC)			
a) From vendors	.003	0	.003
b) From DSA/GSA	.102	0	.102
c) From NSC	.241	.346	(.105)
Total Receipt Costs	.346	.346	0
4. Overhead Costs (applied to Receipt Costs)	.454	.454	0
5. Land and Building			
a) Storage-related (applied to on-hand inventory at Activities	.268	.268	0
b) Operations-related (applied to receipt)	.028	.028	0
Total Land and Building	.296	.296	0
TOTAL OF ACCOUNTS 1 - 5	2.987	1.096	1.891
GRAND TOTAL	$27.565M	$27.634M	($.069)

TABLE 7 - 7

SUMMARY COMPARISON OF ANNUAL RECURRING SYSTEM COSTS

BY FUNCTION FOR CURRENT PULL VS. LOCAL PUSH/CURRENT RANGE SYSTEM[1]

(in support of San Diego's area-wide demand for currently retail-managed inventory; *millions of dollars per year*)

Financial Account	Current System	Proposed System	Savings
1. Inventory Holding Costs (not including land and building; @21% of inventory value)			
a) DSA/GSA	6.778	6.778	0
b) NSC (including Servmarts)	1.167	2.273	(1.106)
c) Major Activities	1.784	0	1.784
Total Inventory Holding Costs	9.729	9.051	.678
2. In-transit Inventory Holding Costs (@21% of inventory value)			
a) DSA/GSA	0	0	0
b) NSC (including Servmarts)	.426	.533	(.107)
c) Major Activities	.107	0	.107
Total In-transit Inventory Holding Costs	.533	.533	0
3. Transportation Costs			
a) DSA/GSA	6.564	6.564	0
b) DSC (including SErvmarts)	.725	.747	(.022)
Total Transportation Costs	7.289	7.311	(.022)
4. Receipt Costs (includes incoming storage, receipt control, receiving operations, and bin operations)			
a) DSA/GSA	.295	.295	0
b) NSC (including Servmarts)	.762	.756	.006
c) Major Activities	.346	.350	(.004)
Total Receipt Costs	1.403	1.401	.002
5. Issue Costs (includes requisition processing, packing, bin and bulk issues and loading)			
a) DSA/GSA	.593	.589	.004
b) NSC (including Servmarts)	1.155	1.094	.061
Total Issue Costs	1.748	1.683	.065

[1] The proposed system is identical to the Local Push/Expanded Range system except that the range of items stocked at the Area Naval Support Center is the same as the range-currently at NSC. This system is motivated by the fact that an overwhelming majority of the times not stocked at NSC are demanded only at one activity or Servmart.

TABLE 7-7 (continued)

Financial Account	Current System	Proposed System	Savings
6. Overhead			
a) DSA/GSA (applied to receipt and issue costs)	1.166	1.161	.005
b) NSC (including Servmarts; applied to issue, receipt and transportation costs)	3.469	3.410	.059
c) Major Activities (applied to receipt costs)	.454	.460	(.006)
Total Overhead Costs	5.089	5.031	.058
7. Land and Building			
a) DSA/GSA	1.089	1.089	0
b) NSC (including Servmarts)	.389	.283	.106
c) Major Activities	.296	.296	0
Total Land and Building Costs	1.774	1.668	.106
GRAND TOTAL	$27.565M	$26.678M	$.887M

TABLE 7-8

DETAIL OF ANNUAL RECURRING SYSTEM COSTS BY FUNCTION FOR CURRENT PULL VS. LOCAL PUSH/CURRENT RANGE SYSTEM

(millions of dollars per year)

Financial Account	Current System	Proposed System	Savings
1. Inventory Holding Costs (not including land and building; @21% of inventory value)			
a) Related to peacetime assets held at DSA/GSA	6.778(D/G)	6.778(D/G)	0
b) Related to peacetime assets at NSC and 11 Servmarts	1.167(NSC)	.489(NSC)	.678
c) Related to peacetime assets at 7 Major Activities	1.784(ACT)	1.784(NSC)	0
Total Inventory Holding Costs	9.729	9.051	.678
(Alternatively this translates to a one-time reduction in inventory of $3.23M)			
2. In-transit Inventory Holding Costs (@21% of inventory value)			
a) In-transit from DSA/GSA to NSC (excluding Servmarts)	.402(NSC)	.402(NSC)	0
b) In-transit from DSA/GSA to Servmarts	.007(NSC)	.007(NSC)	0
c) In-transit from DSA/GSA to Major Activities	.071(ACT)	.071(NSC)	0
d) In-transit from NSC to Servmarts	.017(NSC)	.017(NSC)	0
e) In-transit from NSC to Major Activities	.036(ACT)	.036(NSC)	0
Total In-transit Inventory Holding Costs	.533	.533	0
3. Transportation Costs			
a) DSA/GSA to NSC (excluding Servmarts)	5.507(D/G)	5.507(D/G)	0
b) DSA/GSA to Servmarts	.088(D/G)	.088(D/G)	0
c) DSA/GSA to Major Activities	.969(D/G)	.969(D/G)	0
d) NSC to Servmarts	.145(NSC)	.149(NSC)	(.004)
e) NSC to Major Activities	.301(NSC)	.312(NSC)	(.011)
f) NSC to other customers	.279(NSC)	.286(NSC)	(.007)
Total Transportation Costs	7.489	7.311	(.022)
4. Receipt Costs (includes incoming storage, receipt control, receiving operations, bin operations)			
a) From DSA/GSA to NSC (excluding Servmarts)	.548(NSC)	.548(NSC)	0
b) From DSA/GSA to Servmarts	.017(NSC)	.012(NSC)	.005
c) From DSA/GSA to Major Activities	.102(ACT)	.105(ACT)	(.003)
d) From NSC to Servmarts	.179(NSC)	.179(NSC)	0
e) From NSC to Major Activities	.241(ACT)	.241(ACT)	0
f) From vendors to DSA/GSA	.295(D/G)	.295(D/G)	0

TABLE 7-8 (continued)

Financial Account	Current System	Proposed System	Savings
4. (continued)			
g) From vendors to NSC (excluding Servmarts)	.017(NSC)	.017(NSC)	0
h) From vendors to Servmarts	.001(NSC)	.000(NSC)	.001
i) From vendors to Major Activities	.003(ACT)	.004(ACT)	(.001)
Total Receipt Costs	1.403	1.401	.002
5. Issue Costs (includes requisition processing, packing, bin and bulk issues and loading)			
a) From DSA/GSA to NSC (excluding Servmarts)	.500(D/G)	.500(D/G)	0
b) From DSA/GSA to Servmarts	.017(D/G)	.010(D/G)	.007
c) From DSA/GSA to Major Activities	.076(D/G)	.079(D/G)	(.003)
d) From NSC to Servmarts	.236(NSC)	.196(NSC)	.040
e) From NSC to Major Activities	.331(NSC)	.310(NSC)	.021
f) From NSC to all other customers	.588(NSC)	.588(NSC)	0
Total Issue Costs	1.748	1.683	.065
6. Overhead Costs			
a) DSA/GSA (applied to receipt and issue costs)	1.166(D/G)	1.161(D/G)	.005
b) NSC (including Servmarts and applied to issue receipt and transportation costs)	3.469(NSC)	3.410(NSC)	.059
c) Major Activities (applied to receipt costs)	.454(ACT)	.460(ACT)	(.006)
Total Overhead Costs	5.089	5.031	.058
7. Land and Building			
a) Storage-related at DSA/GSA (applied to on-hand inventory)	1.017(D/G)	1.017(D/G)	0
b) Operations-related DSA/GSA (applied to appropriate handling costs)	.072(D/G)	.072(D/G)	0
c) Storage-related at NSC (including Servmarts)	.175(NSC)	.073(NSC)	.102
d) Operations-related at NSC	.214(NSC)	.210(NSC)	.004
e) Storage-related at Major Activities	.269(ACT)	.268(ACT)	0
f) Operations-related at Major Activities	.028(ACT)	.028(ACT)	0
Total Land and Building Costs	1.774	1.668	.106
GRAND TOTAL OF ANNUAL COSTS (Grand Total of one-time Reduction in Inventory of $3.23M)	$27.565M	$26.678M	$.887M

TABLE 7-9

SUMMARY OF ANNUAL RECURRING COSTS FOR CURRENT PULL VS. LOCAL PUSH/CURRENT RANGE SYSTEM

(millions of dollars per year)

Financial Account	Current System	Proposed System	Savings (current less proposed)
I. DSA/GSA Costs			
1. Inventory Holding Costs (not including land and building)			
a) Related to peacetime assets held at DSA/GSA depots (@21% of inventory value)	6.778	6.778	0
Total Inventory Holding Costs			
2. In-transit Inventory Holding Costs (@21% of inventory value)	0	0	0
3. Transportation Costs			
a) DSA/GSA to NSC (excluding Servmarts)	5.507	5.507	0
b) DSA/GSA to Servmarts	.088	.088	0
c) DSA/GSA to Major Activities	.969	.969	0
Total Transportation Costs	6.564	6.564	0
4. Receipt Costs (included incoming storage, receipt control, receiving operations and bin operations; represents receipts from vendors into DSA/GSA stocks)	.295	.295	0
5. Issue Costs (includes requisition processing, packing, bin and bulk issues and loading)			
a) DSA/GSA to NSC (excluding Servmarts)	.500	.500	0
b) DSA/GSA to Servmarts	.017	.010	.007
c) DSA/GSA to Major Activities	.076	.079	(.003)
Total Issue Costs	.593	.589	.004
6. Overhead (applied to receipt and issue costs)	1.166	1.161	.005
7. Land and Building			
a) Storage-related (applied to on-hand inventory at DSA/GSA)	1.017	1.017	0
b) Operations-related (applied to receipt, issue and transshipment handling)	.072	.072	0
Total Land and Building	1.089	1.089	0
TOTAL OF FINANCIAL ACCOUNTS 1 - 7	16.485	16.476	.009
II. NSC Costs (including 11 Servmarts)			
1. Inventory Holding Costs (not including land and building)			
a) Related to peacetime assets held at NSC and Servmarts (@21% of inventory value)	1.167	.489	.678
b) Related to peacetime assets held at 7 Major Activities	0	1.784	(1.784)
			(1.106)

TABLE 7-9 (continued)

Financial Account	Current System	Proposed System	Savings (current less proposed)
2. In-transit Inventory Holding Costs (@21% of inventory value)			
a) In transit from DSA/GSA to NSC	.402	.402	0
b) In transit from DSA/GSA to Servmarts	.007	.007	0
c) In transit from NSC to Servmarts	.017	.017	0
d) In transit from NSC to Major Activities	0	.036	(.036)
e) In transit from DSA/GSA to Major Activities	0	.071	(.071)
Total In-transit Inventory Holding Costs	.426	.533	(.107)
3. Transportation Costs			
a) NSC to Servmarts	.145	.149	(.004)
b) NSC to Major Activities	.301	.312	(.011)
c) NSC to other customers	.279	.286	(.007)
Total Transportation Costs	.725	.747	(.022)
4. Receipt Costs (includes incoming storage, receipt control, receiving operations, and bin operations; represents receipts from vendors and DSA/GSA depots into stock at NSC and Servmarts)			
a) From DSA/GSA to NSC	.548	.548	0
b) From DSA/GSA to Servmarts	.017	.012	.005
c) From vendors to NSC	.017	.017	0
d) From vendors to Servmarts	.001	.000	.001
e) From NSC to Servmarts	.179	.179	0
Total Receipt Costs	.762	.756	.006
5. Issue Costs (includes requisition processing, packing, bin and bulk issue and loading)			
a) From NSC to Servmarts	.236	.196	.040
b) From NSC to Major Activities	.331	.310	.021
c) From NSC to all other customers	.588	.588	0
Total Issue Costs	1.155	1.094	.061
6. Overhead Costs (applied to issue, receipt and transportation costs)	3.469	3.410	.059
7. Land and Building Costs			
a) Storage-related (applied to on-hand inventory at NSC and Servmarts)	.175	.073	.102
b) Operations-related (applied to receipt, issue and transportation)	.214	.210	.004
Total Land and Building Costs	.389	.283	.106
TOTAL OF ACCOUNTS 1 - 7	8.093	9.096	(1.003)

TABLE 7-9 (continued)

Financial Account	Current System	Proposed System	Savings (current less proposed)
III. Major Activity Costs			
1. Inventory Holding Costs (not including land and building)			
a) Related to peacetime assets at 7 Major Activities	1.784	0	1.784
2. In-transit Inventory Holding Costs (@21% of inventory value)			
a) In transit from DSA/GSA to Major Activities	.071	0	.071
b) In transit from NSC to Major Activities	.036	0	.036
Total In-transit Inventory Holding Costs	.107	0	.107
3. Receipt Costs (includes incoming storage, receipt control, receiving operations and bin operations; represents receipts from vendor, DSA/GSA depots, and NSC units stocked at the Major Activities)			
a) From vendors	.003	.004	(.001)
b) From DSA/GSA	.102	.105	(.003)
c) From NSC	.241	.241	0
Total Receipt Costs	.346	.350	(.004)
4. Overhead Costs (applied to Receipt Costs)	.454	.460	(.006)
5. Land and Building			
a) Storage-related (applied to on-hand inventory at activities)	.268	.268	0
b) Operations-related (applied to receipt)	.028	.028	0
Total	.296	.296	0
TOTAL OF ACCOUNTS 1 - 5	2.987	1.106	1.881
GRAND TOTAL	$27.565M	$26.678M	$.887M

8.0 INFORMATION TRANSMISSION AND PROCESSING COSTS

In this section, we discuss costs associated with the informational support of the inventory management systems. Such support costs include the cost of data processing associated with issuing and receiving of stock, control of document and material movement, accounting for transfer of assets, etc. As mentioned in Section 1, the scope of this study has not been such as to include detailed specifications or costing of the changes in informational support which would occur if any of the proposed systems were to be implemented. Rather, we shall be content with obtaining order-of-magnitude estimates showing the potential impact of these costs relative to the other costs given in Section 7.

We begin with a discussion of the information costs incurred in the current system. Estimates for 9 cog information costs at NSC-SD are based on five cost accounts and are as follows:

Inventory Audit/Reconciliation	$ 62,313
Location Audit	5,010
Stock Control Requirements	127,586
Supply-oriented Data Processing	609,752
Stores Accounting	37,393
TOTAL	$842,054

These costs were obtained by multiplying the appropriate F474 2168 accounting data by estimates, for each account, of

the fraction of expenses attributable to 9 cog support. These fractions were obtained as follows:

- Inventory Audit/Reconciliation: .646 based on fraction of issues which are 9 cog
- Location Audit: .472 based on fraction of line items carried which are 9 cog
- Stock Control Requirements: .625 based on fraction of personnel processing 9 cog
- Data Processing: .639 based on fraction of issues plus receipts which are 9 cog
- Stores Accounting: .22 based on fraction of personnel processing 9 cog.

Thus the total current NSC information costs are $.842 million per year, compared to $8.093 million in other costs reported in Table 7-3 earlier. Now the total current number of NSC 9 cog transactions (issues plus receipts) is 782.2 thousand per year (from Table 5-2). Hence the information cost per transaction is $1.08. The current system-wide number of transactions (excluding Servmart issues which do not currently require any information processing) is 1.8442 million per year. Hence, if one assumes the same cost per transaction system-wide as at NSC, then the current system-wide information cost would be $1.992 million, compared with other system-wide costs of $27.565 million as reported in Section 7. In other words, the information costs would represent about 7% of the total costs.

Now the information systems in the proposed Push systems must perform basically the same functions as performed in the current system, namely:

1. Maintaining and updating of asset information associated with each location where an item is stocked,
2. Processing and control of documents and material movement associated with the issuing and receiving of stock,
3. Financial accounting of issues and receipts.
4. Manual review of stock requirements,
5. Audit and reconciliation of inventory levels and location.

In spite of the above similarities of function, however, there are four specific areas in which the proposed Push systems differ from the current system. These are:

1. It is necessary to implement transaction reporting at the Servmarts, so that the Area Naval Support Center maintains current asset visibility of Servmart stocks.
2. It is necessary to establish a communication system whereby the Area Naval Support Center maintains timely asset data, controls the issuing of stock from varied locations, and provides a data bank of asset information for use at those locations. In the Total Push system, communication must also be established between NSC and DSA/GSA.

3. There is a reduction in inventory transaction accounting in the Push systems, as there are fewer changes of stock ownership.
4. There is a savings due to centralization of the information processing at the Area Naval Support Center, where in the current system it occurs at each activity. For example, in the current system, each activity maintains a separate Master Item Stock Record and must operate and maintain the computer systems necessary to keep this file current. In the Push systems, only one such file would be maintained, at the Area Naval Support Center.

In what follows. rough estimates are given for the incremental costs associated with items 1 and 2 above. This of course provides an upper bound for the increase in information processing costs. It is not possible to obtain estimates for the incremental savings associated with items 3 and 4. However, it is felt that these savings may very well be greater than the incremental costs of 1 and 2.

In obtaining estimates for costs associated with Servmart transaction reporting, the experience of NSC-Charleston (with an automatic cash register system) provides a useful benchmark. Based on the Charleston experience, the hardware requirements for San Diego are estimated as follows:

For each of 16 Servmart checkout lanes:

i) Retail Terminal (key entry/cash register), with a lease cost of $912 per year,

ii) Wand Reader (reads price and stock # data on item), with a lease cost of $216 per year,

For each of 11 Servmarts:

i) Data Collector (accumulates data on magnetic tape), with a lease cost of $3,900 per year,

ii) Tag Printer (prints price on item), with a lease cost of $3,900 per year.

Thus the total cost for implementing the automatic transaction reporting system at the Servmarts is 16($912 + 216) + 11(3900 + 3900) or $103.8 thousand per year. It is not anticipated that any additional personnel would be required.

An additional cost associated with Servmart transaction reporting is the updating of Servmart asset information on a master file at the Area Naval Support Center. A gross upper bound estimate for this cost is obtained by assuming that each Servmart issue requires a separate disk access to update the master file. (In fact, with consolidation of multiple transactions against the same stock number, the number of accesses could be considerably reduced). From Table 5-2 we know the annual number of Servmart issues to be 1.3634 million. Assuming an access time of 10^{-2} seconds and assuming a (high) cost per hour of $500, then the annual updating cost is

(1.3634 million transactions per year) x (10^{-2}sec per transaction) x (1 hour per 3600 sec) x ($500 per hr) or $1900 per year.

Hence the total annual Servmart transaction reporting and file updating cost is $103.8 thousand plus $1.9 thousand or $105.7 thousand.

In estimating costs associated with the transmission of data, it is assumed that information will be transmitted in a batch mode on a daily basis. Such information will include transaction data generated at the activities, Servmarts, and NSC, instructions by NSC directing activities to issue specific items to specific customers, and daily asset level printouts to be used in serving customers. The costs associated with this data transmission are estimated as follows (lease costs obtained from International Business Machines, Inc.):

For each of 11 Servmarts:

i) Remote Magnetic Tape Reader (3747 Data Converter), with a lease cost of $6700 per year,

ii) Remote Terminal Card Reader/Printer, with a lease cost of $5700 per year,

For each of 7 major activities:

i) Remote Terminal Card Reader/Printer, with a lease cost of $5700 per year,

For the Naval Support Center:

i) 3747 Data Converter, with a lease cost of $6700 per year.

From NSA to DSA/GSA headquarters, it is envisioned that Autodin could be used to transmit data, at least to some nearby Navy installation; and then transmission lines used to reach each of the SA item managers at a cost of $.50 per mile per month. In addition, transmission lines might be needed from each of the activities to NSC. Hence, assuming a total mileage of, say, 1000 miles, a total transmission line cost of $6000 per year might be appropriate. Thus the total transmission cost, including remote reader/printers and transmission lines, is 11($6700 + 5700) + 7(5700) + 6700 + 6000 = $189.0 thousand per year.

Combining the Servmart transaction reporting costs with the data transmission costs, we obtain an upper bound of $105.7 thousand plus $189.0 thousand, or $294.7 thousand for the annual increase in information processing costs associated with implementing a Push system. (Recall, however, that no estimates have been made for one-time implementation costs.)

As mentioned earlier, it has not been possible to estimate savings in information processing costs associated with centralization and with reduced inventory accounting. However, it is interesting to examine these savings parametrically as a percentage of current informational costs. As discussed above, if one assumes a current system-wide information cost per transaction equal to NSC's cost, then an estimate for the total current system-wide information cost is $1.992 million per year. Thus a 10% savings due to centralization and simplified accounting would translate to an annual savings of $199.2 thousand, compared

to the increased Servmart transaction reporting and data transmission costs of $294.7 thousand. A 15% savings would compensate fully for the $294.7 thousand increased costs. Thus, it is seen that only slight savings due to centralization and simplified accounting would be required to insure that the net information cost would be lower in the Push system than in the current Pull system.

APPENDIX A: CALCULATION OF DOLLAR DEMAND AND LINE ITEMS TRANSACTED

A.1 DOLLAR DEMAND

A.1.1 Current Pull System

From the FMSO Report (1), the total value of annual demand for 9 cog material at NSC is $37,203,116. From the MISR tapes, the total value of annual demand among the 7 major activities for NSC-carried 9 cog material is $15,437,234, and for non-NSC 9 cog material, $6,536,709. Similarly, the total value of annual demand among the 11 servmarts for NSC-carried 9 cog material is $7,428,312, and for non-NSC 9 cog material, $611,609. The value of annual demand among direct customers for NSC-carried 9 cog material is calculated as the total NSC dollar demand less the sum of the carried demand from activities and servmarts, $37,203,116 - ($15,437,234 + $7,428,312) = $14,337,570.

From sampling (3), 3% of NSC receipts of 9 cog material come directly from vendors rather than from DSA depots or GSA warehouses. Applying this percentage to total NSC dollar demand, the portion satisfied by vendors directly is $37,203,116 x .03 = $1,116,093. The remainder, from DSA/GSA, is $37,203,116 - $1,116,093 = $36,087,023. Applying this same 3% to the value of non-NSC demand at the activities and servmarts, the activities receive $6,536,709 x .03 = $196,101 directly from vendors and $6,536,709 - $196,101 = $6,340,608 from DSA/GSA, while the servmarts receive $611,609 x .03 = $18,349 directly from vendors and $611,609 - $18,349 = $593,260 from DSA/GSA. The total dollar demand placed directly

on DSA/GSA by NSC, the activities, and the servmarts is then, $36,087,023 + $6,340,608 + $593,260 = $43,020,891.

A.1.2 Total Push System

Under this alternative, NSC stocks all area 9 cog items which were not carried under the Current Pull System. Therefore, the total value of demand for both NSC-carried and formerly non-NSC 9 cog material at the activities, $15,437,234 + $6,536,709 = $21,973,943, and the servmarts, $7,428,312 + $611,609 = $8,039,921, must now be filled entirely by NSC. The NSC demand from other customers, $14,337,570, remains unchanged.

DSA/GSA no longer stocks material, but rather transships from vendors to NSC all 9 cog material which was formerly shipped from DSA/GSA stocks to NSC, activities, and servmarts under the Current Pull System. Therefore, the total dollar demand transshipped by DSA/GSA is $43,020,891, exactly the same amount shipped under the Current Pull System. The amount of non-NSC 9 cog material formerly obtained by the activities and servmarts directly from vendors, $196,101 + $18,349 = $214,450, is now supplied through NSC and thus increases the amount NSC receives directly from vendors to $1,116,093 + $214,450 = $1,330,543.

A.1.3 Local Push/Expanded Range System

As in the Total Push System, NSC now supplies all 9 cog items which were not carried under the Current Pull System. The value of demand at NSC from major activities ($21,973,943), servmarts ($8,039,921), and direct customers ($14,337,570) is the same as that under the Total

Push System in Section A.1.2. That portion of the dollar demand at NSC which is supplied directly from vendors is also the same as in Section A.1.2. ($1,330,543).

Under this system, there is no transshipment operation, and DSA/GSA continue to stock material. The total value of demand placed upon DSA/GSA, $43,020,891, now comes entirely from NSC.

A.1.4 Local Push/Current Range System

All dollar demand values for this alternative are exactly the same as those developed for the current Pull System in Section A.1.1.

A.2 LINE ITEMS TRANSACTED

A.2.1 Current Pull System

From Table A.2-1, the total number of 9 cog issues at NSC during FY74 was 640,184. From the MISR tapes, the frequency of ordering 9 cog NSC-carried material by the major activities was 69,240 per year. From discussions with NSC personnel, the frequency of NSC issues of 9 cog material to servmarts is 11,244 per month, or 134,928 per year. The total number of NSC issues of 9 cog material to direct customers is then computed as 640,184 - (69,240 + 134,928) = 436,016.

From Table A.2-1, the total number of 9 cog receipts at NSC during FY 74 was 142,056. From sampling (3), 3% of NSC 9 cog receipts come directly from vendors rather than from DSA depots or GSA warehouses. The number of NSC 9 cog receipts arriving directly from vendors is 142,056 x .03 = 4262, and from DSA/GSA, 142,056 - 4262 = 137,794.

From the MISR tapes, the frequency of ordering 9 cog non-NSC material by the major activities is 35,438 per year, while for servmarts the frequency is 16,146. Assuming again that 3% of these orders are filled

TABLE A.2-1

FY 74 ISSUES AND RECEIPTS AT NSC BY COG

COG	ISSUES	RECEIPTS
9C	71,330	26,969
9G	86,992	19,886
9N	114,515	31,763
9Q	183,111	22,107
9Z	134,545	33,096
9L	49,691	8,235
TOTAL	640,184	142,056

Source: From NSC San Diego Stock Control Statistics

by vendors directly, the number of 9 cog receipts at the major activities arriving directly from vendors is 35,438 x .03 = 1063, leaving 35,438 - 1063 = 34,375 receipts from DSA/GSA. Similarly for servmarts, the number of 9 cog receipts arriving directly from vendors is 16,146 x .03 = 484, leaving 16,146 - 484 = 15,662 from DSA/GSA.

From the MISR tapes, the total number of 9 cog issues by the major activities to all customers is 618,277 per year. From discussions with NSC personnel, the total number of 9 cog issues by servmarts to all customers is 1,363,400 per year.

A.2.2 Total Push System

The major activities and servmarts now obtain all 9 cog items from NSC. The total number of 9 cog receipts at the activities and at the servmarts does not change from that experienced under the Current Pull System; only the source changes. The total number of 9 cog receipts at the major activities is the sum of receipts formerly from NSC, DSA/GSA and direct from vendors under the Current Pull System, 64240 + 34,375 + 1063 = 104,678. Similarly, the total number of 9 cog receipts at the servmarts is 134,928 + 15,662 + 484 = 151,074. The number of NSC issues of 9 cog material to direct customers remains the same as current NSC issues to direct customers, 436,016.

The new number of 9 cog receipts at NSC arriving directly from vendors and from transshipment through DSA/GSA will be calculated in two stages. The first stage will deal with formerly NSC-carried items; the second stage will deal with formerly non-NSC items. Table A.2-2 exhibits, by NSC VAD category, the current NSC order quantities in months of supply (Column (2)) as prescribed in Table 2.1, and the corresponding DSA/GSA order quantities (column (3)), as computed by sampling (4). The order

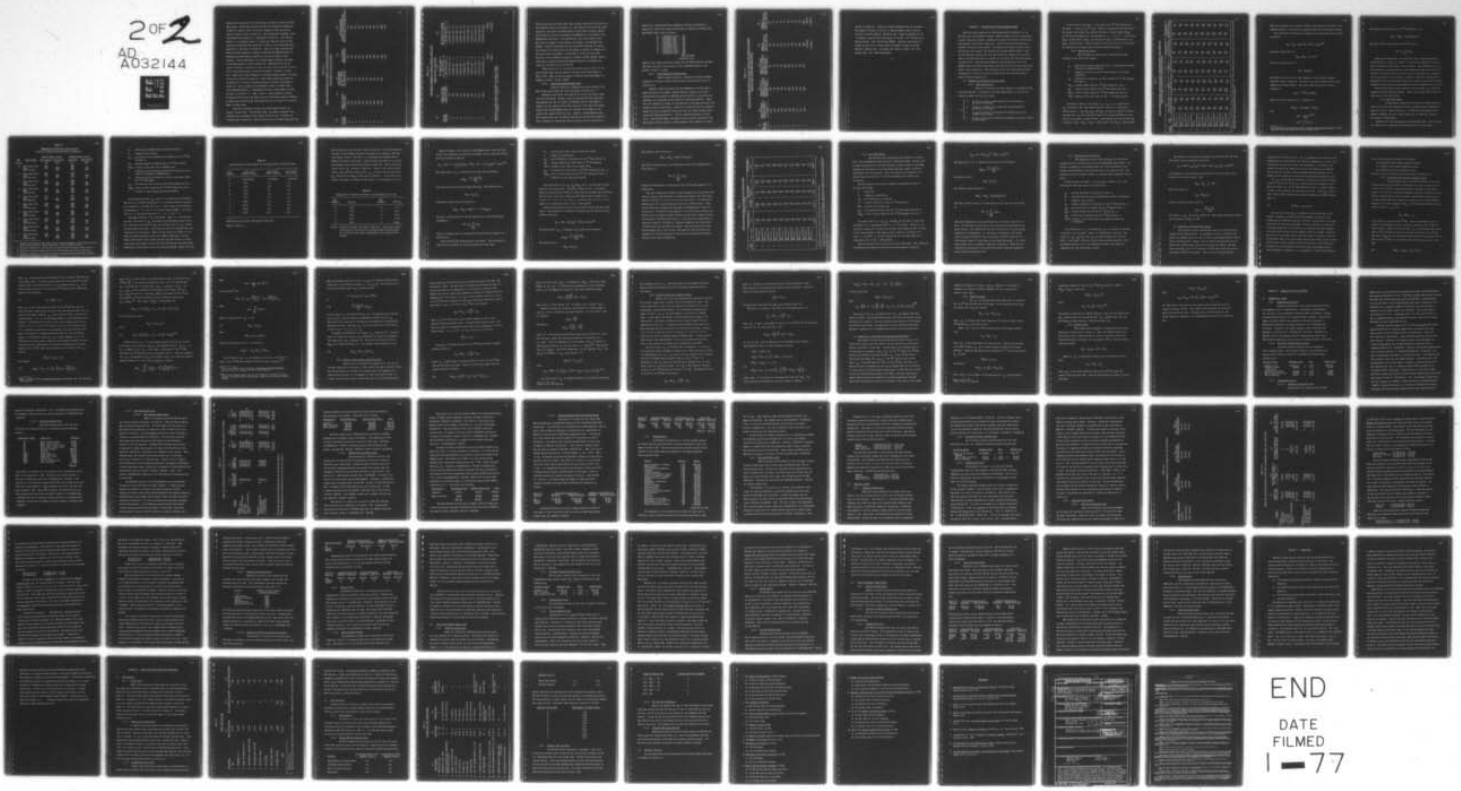
TABLE A.2-2

FRACTION DECREASE, BY VAD, IN NUMBER OF RECEIPTS OF NSC-CARRIED DSA/GSA MATERIAL AT NSC UNDER THE TOTAL PUSH SYSTEM

(1) NSC VAD CATEGORY	(2) NSC ORDER QTY (MONTHS OF SUPPLY)	(3) CORRESPONDING DSA/GSA ORDER QTY (FROM REFERENCE (4))	(4) NSC FREQ OF RECEIPTS/ITEM/MO (1 ÷ COL (2))	(5) DSA/GSA FREQ OF RECEIPTS/ITEM/MO (1 ÷ COL (3))	(6) FRACTION DECREASE COLUMN (4) to (5)
A	1.00	10.35	1.000	.097	.903
B	1.50	9.42	.667	.106	.841
C	2.00	9.30	.500	.108	.784
D	2.50	9.51	.400	.105	.738
E	3.00	9.69	.333	.103	.691
F	4.00	11.67	.250	.086	.656
G	5.00	13.80	.200	.072	.640
H	6.00	12.36	.167	.081	.515
I	8.00	14.82	.125	.067	.464
J	12.00	13.08	.083	.076	.084

AD-A032 144 CONTROL ANALYSIS CORP PALO ALTO CALIF F/G 15/5
AN EVALUATION OF THE AREA SUPPORT/WHOLESALE MANAGEMENT CONCEPT --ETC(U)
DEC 74 M A CRANE, Z F LANSDOWNE, R C MOREY N00014-72-C-0266
UNCLASSIFIED 266-13 NL

2 OF 2
AD A032144



END
DATE FILMED
1-77

quantities in column (3) will replace those in column (2) under the Total Push System. Dividing one month by the NSC order quantities (expressed in months of supply) yields the current frequency of NSC receipts per item, per month, by VAD in column (4). The corresponding frequency, using the DSA/GSA order quantities, is presented in column (5). The fraction decrease in the expected number of receipts per item, per month, by VAD from using the DSA/GSA order quantities in place of the current NSC order quantities is then given in column (6). Table A.2-3 then calculates the overall fraction decrease in receipts of NSC-carried DSA/GSA material by weighting each VAD category according to its current share of total receipts. From the MISR tapes, the current number of NSC-carried items in each VAD category is shown in column (2). Multiplying this by the current frequency of receipts per item, per month, from column (4) of Table A.2-2, the expected number of receipts per month is obtained in column (3). Column (4) is then a weighting of each VAD category based on its share of the total receipts in column (3). Using these weights and column (6) of Table A.2-2, an overall percentage decrease of 60.6% is calculated in column (5). The new number of transshipment receipts of formerly NSC-carried DSA/GSA material is then computed from the current number (137,794 per year) as 137,794 x (1 - .606) = 54,291. The new number of receipts of formerly NSC-carried 9 cog material direct from vendors remains unchanged at 4262 since the current NSC order quantities will be used to fill requirements for these items.

Table A.2-4 displays a similar (the second stage) analysis for formerly non-NSC items. From the MISR tapes, the number of non-NSC items carried by any combination of the 7 major activities and 11 servmarts is listed by VAD in column (2). NSC will now stock all of these items under the

TABLE A.2-3

OVERALL FRACTION DECREASE IN NUMBER OF RECEIPTS OF CARRIED DSA/GSA MATERIAL

AT NSC UNDER THE TOTAL PUSH SYSTEM

(1) NSC VAD CATEGORY	(2) NUMBER OF CARRIED ITEMS AT NSC	(3) EXPECTED NUMBER OF RECEIPTS/MO (COL (2) x COL (4) OF TABLE A.2-2)	(4) VAD CATEGORIES WEIGHTED PER (3)	(5) WEIGHTED FRACTION DECREASE IN FREQ RECEIPTS/MO (COL (4) x COL (6) OF TABLE A.2-2)
A	1188	1188	.155	.140
B	1243	829	.108	.091
C	1474	737	.096	.075
D	1485	594	.078	.058
E	2112	703	.092	.064
F	2706	677	.089	.058
G	2310	462	.060	.038
H	2772	463	.060	.031
I	4576	572	.075	.035
J	17270	1433	.187	.016
			1.000	.606

TABLE A.2-4

NEW RECEIPT FREQUENCY OF FORMERLY NON-NSC ITEMS AT NSC

UNDER THE TOTAL PUSH SYSTEM

(1) NSC VAD CATEGORY	(2) NUMBER OF NON-NSC ITEMS IN SD AREA (FROM MISR TAPES)	(3) NEW RECEIPTS DIRECTLY FROM VENDOR (3% of COL (2) x COL (4) OF TABLE A.2-2)	(4) NEW RECEIPTS OF DSA/GSA (97% OF COL (2) x COL (5) OF TABLE A.2-2)
A	539	(.03)539(1.000) = 16	(.97)539(.097) = 51
B	429	(.03)429(.667) = 9	(.97)429(.106) = 44
C	583	(.03)583(.500) = 9	(.97)583(.108) = 61
D	561	(.03)561(.400) = 7	(.97)561(.105) = 57
E	682	(.03)682(.333) = 7	(.97)682(.103) = 68
F	1045	(.03)1045(.250) = 8	(.97)1045(.086)= 87
G	891	(.03)891(.200) = 5	(.97)891(.072) = 62
H	1111	(.03)1111(.167) = 6	(.97)1111(.081)= 87
I	2112	(.03)2112(.125) = 8	(.97)2112(.067)=137
J	7810*	(.03)7810(.083) = 19	(.97)7810(.076)=576
		94/mo.	1230/mo.
		1128/yr.	14,760/yr.

*Represents an upper bound on the number of non-zero demand FSN's in category J in all locations. Lower bound is 6402.

Total Push System, receiving those items currently supplied to the activities and servmarts directly from vendors at a rate based on the current NSC order quantities, and receiving transshipments of those items currently supplied to the major activities and servmarts from DSA/GSA, at a rate based on the DSA/GSA order quantities. From sampling (3), 3% of these formerly non-NSC items are assumed to come directly from vendors, the remainder from DSA/GSA. Using this percentage and the current NSC frequency of receipts from column (4) of Table A.2-2, the new number of receipts of formerly non-NSC items direct from vendors is calculated in column (3) to be 1128. Similarly, the new number of receipts of formerly non-NSC, DSA/GSA items is calculated in column (4) (using the DSA/GSA frequency of receipts from column (5) of Table A.2-2) to be 14,760.

Adding the results for formerly NSC-carried items to those for formerly non-NSC items, the new number of receipts direct from vendors is 4262 + 1128 = 5390, and the new number of receipts from transshipment via DSA/GSA is 54,291 + 14,760 = 69,051.

A.2.3 Local Push/Expanded Range System

Issues to activities, servmarts and direct customers from NSC are the same as under the Total Push System in Section A.2.2.

Receipts at NSC direct from vendors will also be the same as under the Total Push System. However, since the original NSC order quantities now determine the rate of receipts for DSA/GSA material, the number of receipts for this material will differ from that in the Total Push System. Formerly NSC-carried DSA/GSA items will continue to be ordered at the current rate, namely 137,794 per year. Formerly non-NSC DSA/GSA items, now stocked by NSC, will be ordered using the current NSC order quantities, with a frequency of receipts per item, per month, given by column (4) of

Table A.2-2. Substituting these frequencies into the calculations of Table A.2-4, column (4), yields the new number of receipts of formerly non-NSC DSA/GSA items at NSC as follows:

A	(.97)(539)(1.000) =	523
B	(.97)(429)(.667) =	277
C	(.97)(583)(.500) =	283
D	(.97)(561)(.400) =	218
E	(.97)(682)(.333) =	220
F	(.97)(1045)(.250) =	253
G	(.97)(891)(.200) =	173
H	(.97)(1111)(.167) =	180
I	(.97)(2112)(.125) =	256
J	(.97)(7810)(.083) =	629
		3012 per month
	≈	36,146 per year

Adding to this figure the annual receipt rate for formerly NSC-carried DSA/GSA items, the total 9 cog receipts at NSC of DSA/GSA material is now 36,146 + 137,794 = 173,940.

A.2.4 Local Push/Current Range System

Issues to major activities, servmarts and direct customers from NSC are the same as those from NSC under the Current Pull System in Section A.2.1.

Receipts at NSC from vendors and from DSA/GSA are also the same as under the Current Pull System. Non-NSC material, however, will now be pulled by NSC from vendors and DSA/GSA and sent directly to activities and servmarts, at a rate based on the current NSC ordering quantities. Therefore, the frequency of receipts of this material at the major activities and servmarts must be recalculated. Table A.2-5 is the basis for this analysis. Column (2) lists the expected receipts per item, per month, by VAD, using current NSC ordering quantities. This was computed previously in Table A.2-2. From the MISR tapes, the number of major activity locations of non-NSC material having a positive recorded demand at that location is listed,

TABLE A.2-5

ACTIVITY AND SERVMART RECEIPTS OF NON-NSC MATERIAL FROM VENDORS AND DSA/GSA UNDER THE LOCAL PUSH/CURRENT RANGE SYSTEM

(1) NSC VAD CATEGORY	(2) RECEIPTS/ITEM/MO UNDER NSC ORDER QTY (COLUMN (4) TABLE A.2-2)	(3) NUMBER OF ACTIVITY LOCATIONS OF POSITIVE DEMAND NON-NSC MATL (FROM MISR TAPES)	(4) NUMBER OF SERVMART LOCATIONS OF POSITIVE DEMAND NON-NSC MATL (FROM MISR TAPES)	(5) NUMBER OF ACTIVITY RECEIPTS (COL (2) x Col (3))	(6) NUMBER OF SERVMART RECEIPTS (COL (2) x Col (4))
A	1.000	660	110	660	110
B	.667	495	88	330	59
C	.500	682	88	341	44
D	.400	638	110	255	44
E	.333	671	209	223	70
F	.250	1045	264	261	66
G	.200	902	165	180	33
H	.167	1144	176	191	29
I	.125	2145	363	268	45
J	.083	6853	1199	569	100
				3,278/mo	600/mo
				39,336/yr	7,200/yr

by VAD, in column (3). Column (4) contains analogous data for servmarts. The product of columns (2) and (3) is the new number of major activity receipts of non-NSC material, 39,336 per year. Based on sampling (3), 3% is assumed to come directly from vendors, or 39,336 x .03 = 1180 per year, leaving 39,336 - 1180 = 38,156 from DSA/GSA. Similarly, the product of columns (2) and (4) is the new number of servmart receipts of non-NSC material, 7200 per year. The number from vendors is 7200 x .03 = 216, leaving 7200 - 216 = 6984 from DSA/GSA.

APPENDIX B: CALCULATION OF ON-HAND INVENTORY LEVELS

Section 6.1 gave comparisons of the average on-hand inventories in the San Diego area for alternative systems. Refer to Section 2.8 for a description of these alternative systems. Appendix B.1 provides the formulas and data that were employed to make these comparisons. These formulas are based upon two different inventory control models: the reorder point-reorder quantity model; and the base stock system. The reorder point-reorder quantity model is used for the formulas in Section B.1.2 for the Current Pull system, for the vendor items in the Total Push system in Section B.1.3, and for the Local Push system in Section B.1.4. The base stock system is used in Section B.1.3 for the DSA/GSA items in the Total Push system, and in Section B.1.5 for the conditional service level calculations. The derivation for the base stock system is given in Appendix B.2; and the derivation for the reorder point-reorder quantity model is given in Appendix B.3.

B.1 Formulas for Computing Inventory Levels

B.1.1 Item Classification

Section 2.7 described our basic approach of classifying items into VAD categories. In addition to the VAD classification, it is also convenient to group items into four types:

$$k = \begin{cases} 1 & \text{if item is located at main supply and is not carried at activities or Servmarts} \\ 2 & \text{if item is located at main supply and is also carried at activities or Servmarts} \\ 3 & \text{if item is located at activities and Servmarts and is also carried at main supply} \\ 4 & \text{if item is located at activities and Servmarts and is not carried at main supply.} \end{cases}$$

In what follows, the index i will refer to the i^{th} VAD category, and the index k refers to the k^{th} type. Table B-1 illustrates these definitions. For example, four numbers are given for the Value of Annual Demand (VAD_{ik}) in the first VAD category (A), corresponding to $k = 1, 2, 3, 4$. In this case, VAD_{11} = \$1.967 million, VAD_{12} = \$1.716 million, VAD_{13} = \$11.889 million, and VAD_{14} = \$4.131 million. Refer to Section 2.7 for an over-view of our approach for computing the average on-hand inventory using VAD categories.

B.1.2 Current Pull System

The following are input data for computing the on-hand inventory in the Current Pull system:

L_k = lead time in current system for type k (time between ordering decision and shipment arrival),

W = length of review period (time between reviews of inventory positions),

π_{ik} = coefficient of variation in current system for i^{th} VAD category and type k,

RP_{ik} = current reorder point for i^{th} VAD category and type k,

Q_{ik} = current reorder quantity for i^{th} VAD category and type k,

VAD_{ik} = value of annual demand for i^{th} VAD category and type k,

$V(L_k)$ = variance of the lead time for type k in current system.

According to Table 3-1 in Section 3, $L_1 = L_2 = L_4 = 1.13$ months and $L_3 = .33$ months. The review period used was 1 day or $W = .045$ months. Current values of π_{ik}, RP_{ik}, Q_{ik}, and VAD_{ik} are given in Table B-1; however, the values for π_{ik} are listed with respect to a quarter inverval and must first be converted to a month interval. The following were used as lead time variances: $V(L_1) = V(L_2) = V(L_4) = .2081$ months^2 and $V(L_3) = .0217$ months^2.

TABLE B-1

DATA FOR INVENTORY CALCULATIONS: VALUE OF ANNUAL DEMAND, CURRENT REORDER QUANTITY, CURRENT REORDER POINT, CURRENT COEFFICIENT OF VARIATIONS AND NEW COEFFICIENT OF VARIATIONS

VAD Category	Type of Item *	VAD_{ik} Value of Annual Demand (millions of dollars)		Q_{ik} Current Reorder Quantity (months)		RP_{ik} Current Reorder Point (months)		Current Coefficient of Variations π_{ik} (quarter time interval)		New Coefficient of Variations π'_{ik} (quarter time interval)	
		Main Supply	Activities	Main Supply	Activities	Main Supply	Activities	Main Supply	Activities	Main Supply	Activities
A	Main Supply Only	$1.967	-	1.00	-	1.80	-	.412	-	.412	-
	Both	1.716	$11.889	1.00	1.21	2.12	1.24	.313	.423	.251	.251
	Activity Only	-	4.131	-	1.40	-	1.95	-	.518	-	.477
B	Main Supply Only	.600	-	1.50	-	2.17	-	.537	-	.537	-
	Both	5.119	3.474	1.50	1.57	2.33	1.51	.336	.426	.258	.258
	Activity Only	-	.860	-	1.83	-	2.11	-	.633	-	.594
C	Main Supply Only	.473	-	2.00	-	3.68	-	.540	-	.540	-
	Both	3.336	2.347	2.00	1.71	2.31	1.19	.345	.445	.263	.263
	Activity Only	-	.582	-	2.20	-	1.98	-	.728	-	.676
D	Main Supply Only	.424	-	2.50	-	3.11	1.49	.574	-	.574	-
	Both	1.797	1.088	2.50	2.35	2.69	1.98	.416	.471	.372	.372
	Activity	-	.442	-	2.68	-		-	.729	-	.686
E	Main Supply Only	.459	-	3.00	-	3.04	-	.587	-	.587	-
	Both	1.746	1.259	3.00	2.23	2.51	1.37	.373	.509	.310	.310
	Activity Only	-	.272	-	2.68	-	1.98	-	.750	-	.706
F	Main Supply Only	.328	-	4.00	-	3.02	-	.664	-	.664	-
	Both	1.330	.906	4.00	2.56	2.49	1.23	.417	.563	.345	.345
	Activity Only	-	.282	-	3.87	-	2.04	-	.839	-	.794
G	Main Supply Only	.230	-	5.00	-	3.68	-	.675	-	.675	-
	Both	.694	.417	5.00	3.03	2.96	1.12	.449	.606	.396	.396
	Activity Only	-	.156	-	4.61	-	2.00	-	.953	-	.920
H	Main Supply Only	.164	-	6.00	-	3.29	-	.799	-	.799	-
	Both	.566	.367	6.00	3.82	2.98	1.12	.504	.618	.444	.444
	Activity Only	-	.127	-	6.63	-	2.03	-	.852	-	.821
I	Main Supply Only	.181	-	8.00	-	3.66	-	.793	-	.793	-
	Both	.509	.333	8.00	4.79	3.15	1.25	.498	.716	.448	.448
	Activity Only	-	.148	-	7.47	-	1.99	-	.983	-	.946
J	Main Supply Only	.177	-	12.00	-	3.64	-	.849	-	.849	-
	Both	.836	.786	12.00	6.49	3.19	1.39	.523	.707	.472	.472
	Activity Only	-	.148	-	8.78	-	1.86	-	1.043	-	1.031

* "Main Supply Only" refers to items carried only at Main Supply; "Both" refers to items carried at Main Supply and at least one Activity and/or Servmart; "Active Only" refers to items not carried at Main Supply.

These were estimated from a previous study* by assuming that the ratios of the standard deviation to the mean for comparable lead times would remain constant.

The coefficient of variations for demand over the lead plus review periods is given by

$$\Pi_{ik} = \{(L_k + W/2)\ \pi_{ik}^2 + W^2/12 + V(L_k)\}^{1/2} .$$

The current safety stock is

$$SS_{ik} = RP_{ik} - L_k - W/2 .$$

The current safety factor is

$$K_{ik} = SS_{ik}/\Pi_{ik} .$$

The measure of service used in this Appendix is the fraction of demand satisfied without a backorder, and this is the service measure used in most commercial inventory systems. The current theoretical service level is computed as

$$\rho_{ik} = 1 - g(K_{ik})\ \Pi_{ik}/Q_{ik} ,$$

where the service function $g(\cdot)$ is defined as

$$g(K_{ik}) = -K_{ik}\ \Phi(K_{ik}) + \varphi(K_{ik}) ,$$

and

$$\varphi(r) = \frac{1}{\sqrt{2\pi}}\ e^{-r^2/2} ,$$

$$\Phi(r) = \int_r^\infty \varphi(x)\ dx .$$

*The Evaluation of Alternative Retail Inventory Distribution Concepts, Control Analysis Corporation Report No. 86-13, October 1973.

The average on-hand inventory for i^{th} VAD and type k is

$$AOI_{ik} = (SS_{ik} + Q_{ik}/2)\ VAD_{ik}/12 \ .$$

The total on-hand inventory in the San Diego area is

$$AOI = \sum_{i} \sum_{k=1}^{4} AOI_{ik} \ .$$

Using the foregoing data, the theoretical value of AOI was computed to be \$12.23 million. However, as Table 6-1 in Section 6 indicates, the actual value of inventory in San Diego is \$14.05 million. This difference is due to the following: an average analysis by VAD category was used (see Section 2.7), instead of a detailed analysis for each item; our data tapes were incomplete, and it was necessary to use certain "enrichment" procedures (see Section 2.9 and Appendix E); and the foregoing theoretical formulas are based upon certain assumptions which may only be approximately valid (see Appendices B.2 and B.3).

Table B-2 gives the current theoretical service levels ρ_{ik} which were computed using the foregoing formulas. These service levels will be used as input data for the other systems.

B.1.3 Total Push System

As discussed in Section 2.8, there are two broad classes of items in the Total Push system, and different ordering rules are employed for these two classes. These classes are: 1) items sent from vendors, transshipped at DSA/GSA, and sent to main supply; and 2) items sent directly from vendors to main supply.

Consider first items transshipped through DSA/GSA depots. The following are input data for computing the on-hand inventory for these items:

TABLE B-2

COMPARISON OF THEORETICAL SERVICE LEVELS[1]

(Fraction of Demand Satisfied Without a Backorder)

VAD	Type of Item	CURRENT SERVICE LEVELS		PROPOSED SERVICE LEVELS	
		Main Supply[2]	Activities[2]	Area-wide[3]	Conditional[4]
Average		.973	.974	.977	.874
A	Main Supply Only	.878	-	.878	-
	Both	.967	.996	.996	.919
	Activity Only	-	.900	.900	.802
B	Main Supply Only	.930	-	.930	-
	Both	.986	.999	.999	.944
	Activity Only	-	.911	.911	.761
C	Main Supply Only	.998	-	.998	-
	Both	.988	.995	.995	.897
	Activity Only	-	.887	.887	.693
D	Main Supply Only	.991	-	.991	-
	Both	.994	.999	.999	.901
	Activity Only	-	.907	.907	.708
E	Main Supply Only	.991	-	.991	-
	Both	.994	.997	.997	.889
	Activity Only	-	.902	.902	.696
F	Main Supply Only	.988	-	.988	-
	Both	.993	.993	.993	.848
	Activity Only	-	.923	.923	.695
G	Main Supply Only	.997	-	.997	-
	Both	.998	.988	.988	.817
	Activity Only	-	.917	.917	.656
H	Main Supply Only	.990	-	.990	-
	Both	.997	.990	.990	.816
	Activity Only	-	.953	.953	.742
I	Main Supply Only	.996	-	.996	-
	Both	.999	.991	.991	.814
	Activity Only	-	.946	.946	.706
J	Main Supply Only	.996	-	.996	-
	Both	.999	.996	.996	.839
	Activity Only	-	.944	.944	.695

1 Theoretical function of mean lead times, lead time variences, coefficients of variations, reorder points, reorder quantities, length of review periods.

2 Fraction of demand at a facility that can be satisfied by stock at that facility.

3 Fraction of area-wide demand that can be satisfied by stock in San Diego area.

4 Fraction of demand at an activity that can be satisfied by stock at that activity, given that main supply is always in stock.

DL = lead time for DSA/GSA items in Total Push system,

W = length of review period,

π'_{ik} = new (or area-wide) coefficient of variation for the i^{th} VAD and type k,

DQ_i = reorder quantity for DSA/GSA items in i^{th} VAD category,

$V(DL)$ = variance of the lead time for DSA/GSA items,

P = composition delay (interval between reordering decision and arrival of shipment at DSA/GSA depot),

R_i = ratio of nation-wide demand for an item to San Diego demand, for i^{th} VAD category,

ρ'_{ik} = new area-wide service levels for i^{th} VAD category and type k,

VAD_{ik} = value of annual demand for the i^{th} VAD category and type k,

γ = fraction of items coming directly from vendors.

In the proposed systems, ρ'_{ik} refers to an area-wide service measure: the fraction of area-wide demand that can be satisfied without a backorder. As a consequence, only three values of k will be used, as the inventory corresponding to $k = 2$ and $k = 3$ will be treated together. The three values of k that will be used are: $k = 1$, $k = 2$, and $k = 4$.

According to Table 3-1, $DL = 8.59$ months. Again $W = .045$ months (or one day). The values of π'_{ik} are given in the right-hand column in Table B-1. Note that the values for π'_{ik} are less than those for π_{ik} (except for main supply only items). The reason for this is the detailed area-wide visibility in the new system. Values for DQ_i are given in Table B-3, and these were obtained from an October 1974 sample of DSA items. We used $V(DL) = .0646$ months^2, which assumes that the lead time variance is mainly attributed to the transit portion between the DSA/GSA depot and main supply, rather than to the portion between the vendor and DSA/GSA. Again, this lead

TABLE B-3

Order Quantities By VAD Category for Resupplying NSC in Proposed Systems

VAD Category	Total Push[1] DSA/GSA Items-DQ_i	Total Push[2] Vendor Items-VQ_i	Local Push[2] All Items-Q_i
A	10.35 months	1.0 months	1.0 months
B	9.42	1.5	1.5
C	9.30	2.0	2.0
D	9.51	2.5	2.5
E	9.69	3.0	3.0
F	11.67	4.0	4.0
G	13.80	5.0	5.0
H	12.36	6.0	6.0
I	14.82	8.0	8.0
J	13.08	12.0	12.0

[1]Estimated from an October 1974 sample of DSA items.

[2]Based on Table 2-1.

time variance was obtained from a previous study (Ref. [2]) by assuming that the ratio of the standard deviation to the mean for a comparable lead time would remain constant. The delay $P = 7.96$ months was estimated from an October 1974 sample of DSA items. Table B-4 gives the values of R_i, which were estimated from an October 1974 sample of DSA items. The new area-wide service levels ρ'_{ik} are given in Table B-2. These are the current service levels, except that the activity level ρ_{i3} is used as the area-wide level ρ'_{i2}. The values for VAD_{ik} are again given in Table B-1. On the basis of an October 1974 sample of receipts at main supply, γ was estimated to be .03.

TABLE B-4

Median Ratio of National DSA Demand to NSC-SD Demand for an Item

VAD Category	Ratio-R_i	VAD Category	Ratio-R_i
A	5.76	F	7.61
B	8.46	G	11.15
C	6.27	H	14.93
D	6.78	I	9.43
E	6.03	J	40.00

Source: Based on an October 1974 sample of DSA items. Each figure listed is the median of the ratios of the national DSA to NSC-SD demand for the items in the sample corresponding to the particular VAD category.

Next the formulas will be given for the DSA/GSA items in the Total Push system. The coefficient of variations for demand over the lead, plus review, plus cycle periods is given by

$$\Pi_{ik} = \{(W/2 + P + DQ_i)(\pi'_{ik})^2/R_i + W^2/12 + (DL - P + DQ_i)(\pi'_{ik})^2 + V(DL)\}^{1/2} .$$

The safety factor K_{ik} is computed as the unique value satisfying

$$g(K_{ik}) = \frac{(1 - \rho'_{ik})\, DQ_i}{\Pi_{ik}} ,$$

where the service function was defined previously. The safety stock is

$$SS_{ik} = K_{ik}\, \Pi_{ik} .$$

The average on-hand inventory is given by

$$AOI_{ik} = (SS_{ik} + DQ_i/2)\,(1 - \gamma)\,(VAD_{ik})/12 .$$

The total on-hand inventory in the San Diego area for items transshipped at DSA/GSA is

$$AOI = \sum_i \sum_{\substack{k=1 \\ k\neq 3}}^{4} AOI_{ik} .$$

Using the foregoing data, the theoretical value for AOI was computed to be $31.50 million.

Next consider items coming directly from vendors. The following are input data for computing the on-hand inventory for these items:

VL = lead time for vendor items in Total Push system,

W = length of review period,

π'_{ik} = new coefficient of variations for the i^{th} VAD and type k,

VQ_i = reorder quantity for vendor items in i^{th} VAD category,

$V(VL)$ = variance of the lead time for vendor items,

ρ'_{ik} = new area-wide service level for i^{th} VAD category and type k,

VAD_{ik} = value of annual demand for the i^{th} VAD category and type k,

γ = fraction of items coming from vendors.

The values used for W, π'_{ik}, ρ'_{ik}, VAD_{ik}, and γ are the same as those given for the previous case. According to Table 3-1, $VL = 1.13$ months. Values for VQ_i are given in Table B-3, and these are the same order quantities that are used in the current system by main supply (refer to Table 2-1 in Section 2.7). Since $VL = L_1$, where L_1 was the current lead time for main supply to be replenished, $V(VL) = V(L_1) = .2081$ months^2.

Next the formulas will be given for the vendor items in the Total Push system. The coefficient of variations for demand over the lead plus review periods is given by

$$\Pi_{ik} = \{(VL + W/2)(\pi'_{ik})^2 + W^2/12 + V(VL)\}^{1/2} .$$

The safety factor K_{ik} is computed as the unique value satisfying

$$g(K_{ik}) = \frac{(1 - \rho'_{ik})\, VQ_{ik}}{\Pi_{ik}} .$$

The safety stock is

$$SS_{ik} = K_{ik}\, \Pi_{ik} .$$

The average on-hand inventory is

$$AOI_{ik} = (SS_{ik} + VQ_i/2)\cdot\gamma(VAD_{ik})/12 \ .$$

The total on-hand inventory in the San Diego area for items coming directly from vendors is

$$AOI = \sum_i \sum_{\substack{k=1 \\ k\neq 3}}^{4} AOI_{ik} \ .$$

Using the foregoing data, the theoretical value for AOI was computed to be $.28 million.

The total theoretical inventory in the San Diego area for the Total Push system is equal to $31.78 millions, including the inventory for items transshipped at DSA/GSA and items coming directly from vendors. As indicated in Section B.1.2, the current theoretical inventory is $12.23 million. Thus the new theoretical inventory for San Diego is approximately 2.6 times the previous one. The factor 2.6 was applied to the actual current inventory of $14.05 to give an estimate of $36.54 million for the total on-hand inventory in San Diego for the Total Push system. It is this latter figure which is reported in Table 6-1 of Section 6. Table B-5 summarizes the calculations for the Current Pull and Total Push systems. These calculations are given by VAD category and by type of item. The figures in this table have been normalized to give $14.05 million as the value for Current Pull and $36.54 million as the value for Total Push.

TABLE B-5

AVERAGE ON-HAND INVENTORIES IN THE SAN DIEGO AREA FOR ALTERNATIVE SYSTEMS[1]
(in Millions of Dollars)

VAD Category	Type of Item[2]	Current Pull System	Total Push System			Local Push System
		Total	Transshipped at DSA/GSA	Direct from Vendors	Total	Total
A	Main Supply Only	$ .22	$ .88	$ .01	$ .88	$ .21
	Both	4.59	14.84	.11	14.95	3.69
	Activity Only	.59	2.14	.02	2.16	.55
B	Main Supply Only	.10	.35	.00	.35	.10
	Both	1.60	3.96	.04	3.99	1.21
	Activity Only	.15	.49	.00	.49	.14
C	Main Supply Only	.16	.52	.01	.52	.16
	Both	1.07	2.22	.02	2.24	.70
	Activity Only	.11	.33	.00	.33	.10
D	Main Supply Only	.13	.41	.00	.41	.13
	Both	.72	1.67	.02	1.69	.55
	Activity Only	.09	.28	.00	.28	.09
E	Main Supply Only	.15	.45	.00	.46	.15
	Both	.74	1.35	.01	1.37	.48
	Activity Only	.06	.17	.00	.17	.06
F	Main Supply Only	.12	.38	.00	.38	.12
	Both	.62	1.12	.01	1.13	.39
	Activity Only	.08	.23	.00	.24	.07
G	Main Supply Only	.11	.35	.00	.35	.11
	Both	.38	.65	.01	.66	.23
	Activity Only	.05	.15	.00	.15	.05
H	Main Supply Only	.08	.22	.00	.22	.08
	Both	.35	.53	.01	.53	.22
	Activity Only	.05	.13	.00	.13	.05
I	Main Supply Only	.11	.31	.00	.31	.11
	Both	.40	.56	.01	.57	.24
	Activity Only	.07	.18	.00	.18	.07
J	Main Supply Only	.14	.29	.00	.29	.14
	Both	.96	.92	.02	.93	.57
	Activity Only	.07	.17	.00	.17	.09
		$14.05	$36.21	$ .33	$36.54	$10.82

1 Because of roundoff error, the sum of a column may not be equal to the total indicated.

2 This classification is defined in terms of the Current System. Items which are "Activity Only" in the Current System will be carried at main supply in either Total Push or Local Push/Expanded Range System. Servmarts are considered to be activities.

B.1.4 Local Push System

Two different Local Push systems were described in Section 2.8: Local Push/Expanded Range; and Local Push/Current Range. However, both of these systems will have the same area-wide on-hand inventory in San Diego, although the distribution of this inventory among main supply, activities, and Servments will be different. Since the purpose of this Appendix is to compute area-wide inventory, we will not distinguish here between these two systems.

The following are input data for computing the on-hand inventory for the Local Push system:

L = lead time,

W = length of review period,

π'_{ik} = new coefficient of variation,

Q_i = reorder quantity for items in i^{th} VAD category,

$V(L)$ = variance of the lead time,

ρ'_{ik} = new area-wide service level for i^{th} VAD category and type k,

VAD_{ik} = value of annual demand for the i^{th} VAD category and type k.

The values used for W, π'_{ik}, ρ'_{ik}, and VAD_{ik} are the same as those used in Section B.1.3. According to Table 3-1, $L = 1.13$ months. Values for Q_i are given in Table B-3, and these are the same order quantities that are used in the current system by main supply (refer to Table 2-1 in Section 2.7). Since $L = L_1$, where L_1 was the current lead time for main supply to be replenished, $V(L) = V(L_1) = .2081$ months^2.

Next the formulas will be given for the Local Push system. The coefficient of variations for demand over the lead plus review periods is given by

$$\Pi_{ik} = \{(L + W/2)(\pi'_{ik})^2 + W^2/12 + V(L)\}^{1/2} .$$

The safety factor K_i is computed as the unique value satisfying

$$g(K_{ik}) = \frac{(1 - \rho'_{ik})\, Q_i}{\Pi_{ik}} .$$

The safety stock is

$$SS_{ik} = K_{ik}\, \Pi_{ik} .$$

The average on-hand inventory is

$$AOI_{ik} = (SS_{ik} + Q_i/2)(VAD_{ik})/12 .$$

The total on-hand inventory in the San Diego area for the Local Push system is

$$AOI = \sum_i \sum_{\substack{k=1 \\ k \neq 3}}^{4} AOI_{ik} .$$

Using the foregoing data, the theoretical value for AOI was computed to be \$9.47. As indicated in Section B.1.2, the current theoretical inventory is \$12.23 million. This implies that the ratio between the new and the current inventories is approximately .77. This factor was applied to the actual current inventory of \$14.05 to give an estimate of \$10.82 million for the total on-hand inventory in San Diego for the Local Push system. It is this latter figure which is reported in Table 6-1 of Section 6. Table B-5 also includes the calculations for the Local Push system, which are normalized to give \$10.82 as the final total.

B.1.5 Conditional Service Levels

The right-hand column of Table B-2 gives the conditional services levels in the Total Push and Local Push/Expanded Range system: the fraction of demand at an activity/Servmart that can be satisfied by stock at that activity/Servmart, given that main supply is always in stock. This subsection gives the formulas employed in computing these conditional service levels.

In what follows, the index k will be equal to either 3 or 4. The following are input data used in the calculations:

L_k = current lead time to activities for type k,

TR = new lead time between main supply and activities or Servmarts,

W = length of review period,

π_{ik} = current coefficient of variation for the i^{th} VAD and type k,

π'_{ik} = new coefficient of variation for the i^{th} VAD and type k,

RP_{ik} = current reorder point for the i^{th} VAD and type k,

Q_{ik} = current reorder quantity for the i^{th} VAD and type k,

V(TR) = variance of lead time between main supply and activities or Servmarts.

As in Section B.1.2, L_3 = .33 months and L_4 = 1.13 months. According to Table 3-1, TR = .13 months. Again W = .045 months (or one day). The values for π_{ik}, π'_{ik}, RP_{ik}, and Q_{ik} are given in Table B-1. We used $V(TR) = .0033 \text{ months}^2$, which was derived from a previous study (Ref. [2]) by assuming that the ratio of the standard deviation to the mean for a comparable lead time would remain constant.

The coefficient of variations for demand at an activity over the lead, plus review, plus cycle periods is given by

$$\Pi_{ik} = \{(W/2 + Q_{ik})(\pi'_{ik})^2 + W^2/12 + (TR + Q_{ik})\,\pi^2_{ik} + V(TR)\}^{1/2} .$$

Our assumption is that activities and Servmarts will have the same safety stock as in the current system. Thus

$$SS_{ik} = RP_{ik} - L_k - W/2 .$$

The safety factor is

$$K_{ik} = SS_{ik}/\Pi_{ik} .$$

Thus the conditional service level is

$$c\rho_{ik} = 1 - \frac{g(k_{ik})\,\Pi_{ik}}{Q_{ik}} .$$

The values of $c\rho_{ik}$ are listed in Table B-2. The average conditional service level (weighted by VAD_{ik}) is .874.

B.2 Derivation of the Base Stock System

First consider items at NSC-San Diego which are currently being resupplied from DSA/GSA depots. Our assumption is that in the Total Push system, the DSA/GSA depots will only be used as transshipment points, rather than as stocking points. Supplies will be ordered simultaneously for all NSC's using a group reorder rule called the base stock system. The base stock level BSL_{ij} for the i^{th} item at the j^{th} NSC govern both the ordering and shipment allocation decisions. This level is a desirable maximum

inventory for the particular item. At the beginning of each day (or at the beginning of any review period), the available inventory of an item is subtracted from its base stock level. The difference is "the amount to be ordered" for that item. Whenever the sum of "the amounts to be ordered" for an item over all NSC's equals a prespecified order quantity, then a shipment in that quantity is ordered from an appropriate commerical vendor.

Let a_{ij} be the area-wide available (on-hand plus on-order) inventory of the i^{th} item at the j^{th} NSC, μ_i be the mean national demand (over all NSC's) for item i, Q_i be the order quantity for item i in months' supply. In terms of this notation, the ordering rule is this: order $Q_i \mu_i$ units of item i from a vendor whenever the accumulated demand over all NSC's reaches $Q_i \mu_i$, or

$$(1) \qquad \sum_j (BSL_{ij} - a_{ij}) \geq Q_i \mu_i \ .$$

The base stock level BSL_{ij} is determined from the fact that at the instant a shipment is ordered for NSC replenishment, the amount to be ordered plus the available inventory at an NSC is exactly equal to the base stock level for the item at that NSC. To avoid a stockout, the base stock level must satisfy all of the demand for an item from the time a shipment is ordered until the time the next shipment arrives at the NSC. Therefore, the base stock level must contain sufficient weeks of inventory to last for a time period equal to the time between orders (cycle time), plus the transit time (between a vendor and NSC), plus the safety stock. The safety stock is defined to be the expected net inventory when a procurement arrives. For the purposes of exposition, it is convenient to examine the following

cases when deriving the formulas for this model:

a) Continuous review without composition delay;

b) Periodic review without composition delay;

c) Periodic review with composition delay.

However, it is only the third case that is used in Section B.1.2.

B.2.1 Continuous Review Without Composition Delay

In the simplest case, the inventory manager (IM) monitors the asset positions of all NSC's continuously over time, and the amount to be sent to the j^{th} NSC is determined whenever a purchase is made from a vendor. For this case, we make the assumption that Eqn. (1) would hold with a strict equality when an order is placed. This assumption would be valid if items were purchased by customers in single units or if their purchase quantities were small compared to BSL_{ij}. The total amount ordered from the vendor is equal to $Q_i \mu_i$. and

$$A_{ij} = BSL_{ij} - a_{ij}$$

is the amount to be sent to the j^{th} NSC. Thus, at the moment an order is placed, the total amount of item i on-hand or on-order at the j^{th} NSC is equal to BSL_{ij}. Define the mean lead time L_{ij} to be the mean time between when stock is ordered from the vendor and when it arrives at the j^{th} NSC. The value of BSL_{ij} must be sufficiently large to meet all the demands for the item i at the j^{th} NSC over an interval equal to the lead plus cycle time. Thus

$$BSL_{ij} = \mu_{ij}[L_{ij} + Q_{ij} + SS_{ij}] \quad , \tag{2}$$

where μ_{ij} is the mean (area-wide) demand for item i at the j^{th} NSC and SS_{ij} is the safety stock. The safety stock is defined to be the expected on-hand inventory when a procurement arrives. Let the random variable Z_{ij} be the actual on-hand inventory of item i at the j^{th} NSC when the next procurement arrives, and it satisfies

$$Z_{ij} = BSL_{ij} - D_{ij} , \tag{3}$$

where D_{ij} is the total demand for item i at the j^{th} NSC over the lead plus cycle times. Because both the cycle time (time between orders) and the lead time are random variables, D_{ij} can be viewed as being a random sum of random variables. Let α_i be the average number of units purchased by each customer. Our assumption in Section 2.9 was that customers arrive at the various activities of the different NSC's according to the Poisson process (i.e., customers are assumed to arrive randomly over time); thus the cycle time will correspond to a gamma distribution with mean Q_i and variance $Q_i\alpha_i/\mu_i$. If we further assume that μ_{ij} is small compared to μ_i (i.e. the demand at one NSC is small compared to the nationwide demand), then the cycle time will be (approximately) statistically independent of the daily demands at the j^{th} NSC. Under these conditions it can be shown* that D_{ij} has mean

$$E(D_{ij}) = \mu_{ij}(L_{ij} + Q_i)$$

and variance

$$V(D_{ij}) = (L_{ij} + Q_i)\,\sigma_{ij}^2 + \left[V(L_{ij}) + \frac{Q_i\alpha_i}{\mu_i}\right]\mu_{ij}^2 , \tag{4}$$

*Refer to Emanuel Parzen, Stochastic Processes, Holden-Day, Inc., San Francisco, 1962, page 56.

where $V(L_{ij})$ is the variance of the lead time for item i to be sent to the j^{th} NSC, σ_{ij}^2 is the variance of demand for item i at the j^{th} NSC per unit time. Note that Eqn. (3) implies that $V(Z_{ij})$ is equal to $V(D_{ij})$. Let $\pi_{ij} = \sigma_{ij}/\mu_{ij}$ be the coefficient of variation at the j^{th} NSC. Also let $R_{ij} = \mu_i/\mu_{ij}$ be the ratio of national demand to the demand at the j^{th} NSC. Our assumption of Poisson customer arrivals at activities implies that $\pi_{ij} = (\alpha_i/\mu_{ij})^{1/2}$. Thus $\alpha_i/\mu_i = \pi_{ij}^2/R_{ij}$. This implies that

$$V(Z_{ij}) = \{Q_i\, \pi_{ij}^2/R_{ij} + (L_{ij} + Q_i)\, \pi_{ij}^2 + V(L_{ij})\}\, \mu_{ij}^2 .$$

It is convenient to write

$$V(Z_{ij}) = (\Pi_{ij}\, \mu_{ij})^2 ,$$

where

$$\Pi_{ij} = \{Q_i\, \pi_{ij}^2/R_{ij} + (L_{ij} + Q_i)\, \pi_{ij}^2 + V(L_{ij})\}^{1/2} \tag{5}$$

We have defined Z_{ij} to be the on-hand inventory when the next procurement arrives, and it has mean $SS_{ij}\, \mu_{ij}$ and standard deviation $\Pi_{ij}\, \mu_{ij}$. If Z_{ij} is negative, then $-Z_{ij}$ is the number of backorders of the i^{th} item existing at the j^{th} NSC when the next procurement arrives. Under the assumption that Z_{ij} (or equvialently D_{ij}) has a Normal distribution, then the expected number of backorders of item i can be computed as follows:

$$BO_{ij} = \int_{z=-\infty}^{z=0} \frac{(-z)}{\Pi_{ij}\, \mu_{ij}}\, \varphi\left(\frac{z - SS_{ij}\, \mu_{ij}}{\Pi_{ij}\, \mu_{ij}}\right) dz ,$$

where

$$\varphi(r) = \frac{1}{\sqrt{2\pi}} \exp(-\frac{1}{2} r^2) .$$

It can be shown* that

$$BO_{ij} = \Pi_{ij} \mu_{ij} \varphi\left(\frac{SS_{ij}}{\Pi_{ij}}\right) - SS_{ij} \Phi\left(\frac{SS_{ij}}{\Pi_{ij}}\right) \mu_{ij} ,$$

where

$$\Phi(r) = \int_{x=r}^{\infty} \varphi(x)\, dx .$$

Define the safety factor K_{ij} so that

(6) $$SS_{ij} = K_{ij} \Pi_{ij} .$$

Thus

$$BO_{ij} = \Pi_{ij} \mu_{ij} g(K_{ij}) ,$$

where the service function $g(\cdot)$ is defined as

$$g(K_{ij}) = - K_{ij} \Phi(K_{ij}) + \varphi(K_{ij}) .$$

Let the service level ρ_{ij} be defined as the fraction of demand for item i at the j^{th} NSC that should be satisfied without a backorder.**

---

*Refer to G. Hadley and T. M. Whitin, Analysis of Inventory Systems, Prentice-Hall, Inc., Englewood Cliffs, 1963, page 446.

**This is the service measure used in such commercial inventory control systems as the IBM Consumer Goods System (COGS) and the Honeywell PROFIT system.

Since the average demand over a cycle is $\mu_{ij} Q_i$, the expected number of back-orders over a cycle should not exceed $(1 - \rho_{ij}) \mu_{ij} Q_i$. This condition will be met if the safety factor K_{ij} is chosen so that

$$(1 - \rho_{ij}) \mu_{ij} Q_i = \Pi_{ij} \mu_{ij} g(K_{ij}) ,$$

or

$$\frac{(1 - \rho_{ij}) Q_i}{\Pi_{ij}} = g(K_{ij}) . \tag{7}$$

It can be shown that the service function $g(\cdot)$ is monotonically decreasing and is convex. Thus the problem of computing the unique value of K_{ij} satisfying (7) is equivalent to finding the zero-crossing of a monotonically decreasing function. Note that K_{ij} will be the same for all items having the same values of Π_{ij}, Q_i, and ρ_{ij}.

In summary, the first step is to compute Π_{ij} using Eqn. (5). The next step is to compute the value of K_{ij} satisfying (7), which then determines the safety stock SS_{ij} using Eqn. (6). This allows the base stock level BSL_{ij} to be computed with Eqn. (2). The average on-hand inventory is then

$$AOI_{ij} = [SS_{ij} + Q_i/2] \mu_{ij} . \tag{8}$$

B.2.2 Periodic Review Without Composition Delay

Section B.2.1 only examined the simplest case. We will now add some complexities to the model. First consider the case of periodic review: The inventory assets of the NSC's are reviewed only at the beginning of a review period of length W. For example, W could be one day, two days, or a week. Hence the time interval between when Eqn. (1) is first satisfied and

when an order can be placed follows the uniform distribution with mean $W/2$ and variance $W^2/12$. In other words, the average time between when Eqn. (1) is first satisfied and the beginning of a review period is equal to $W/2$. Notice that both the ordering and composition decisions are delayed until the beginning of a review period. Let a'_{ij} be the available inventory of item i at the j^{th} NSC at the beginning of the review period when the order is placed. The amount of item i to be sent to the j^{th} NSC is now equal to

$$A'_{ij} = BSL_{ij} - D_i \frac{\mu_{ij}}{\mu_i} - a'_{ij} ,$$

when D_i is the nation-wide (over all NSC's) demand for item i that occurred during the periodic delay: the delay between when an order would have been placed in a continuous review system and the beginning of the next review period. It can be shown that this allocation rule satisfies

$$\sum_j A'_{ij} = Q_i \mu_i .$$

The amount of inventory on-hand at the j^{th} NSC when the next shipment arrives is given by

$$Z_{ij} = BSL_{ij} - D_i \frac{\mu_{ij}}{\mu_i} - D_{ij} ,$$

where D_{ij} is again equal to the total demand for item i at the j^{th} NSC over the lead plus cycle times. Because of the periodic delay, the base stock level must now satisfy

$$BSL_{ij} = \mu_{ij}[W/2 + L_{ij} + Q_{ij}] + SS_{ij} \mu_{ij} . \tag{9}$$

Again, the safety stock SS_{ij} is a function of $V(Z_{ij})$. Note that we may assume D_i and D_{ij} to be statistically independent, as these variables refer to non-overlapping time intervals. Thus these variances satisfy

$$V(Z_{ij}) = \left(\frac{\mu_{ij}}{\mu_i}\right)^2 V(D_i) + V(D_{ij}) ,$$

where $V(D_{ij})$ is given by Eqn. (4). It remains only to compute $V(D_i)$.

Because the delay due to having a review period is a random length of time, D_i will be a random sum of random variables. It can be shown* that D_i has mean

$$E(D_i) = \frac{\mu_i W}{2}$$

and variance

$$V(D_i) = \frac{W^2 \mu_i^2}{12} + \frac{W \sigma_i^2}{2} ,$$

where σ_i^2 is the variance of nation-wide demand (over all NSC's) for item i per unit time. Define the nation-wide coefficient of variation to be $\pi_i = \sigma_i/\mu_i$. Since our assumption was that customers arrive according to a Poisson process and buy α_i units of item i, $\pi_i = (\alpha_i/\mu_i)^{1/2}$. This implies that $\pi_i^2 = \pi_{ij}^2/R_{ij}$. Thus after substituting π_i and combining $V(D_i)$ with $V(D_{ij})$, the variance of Z_{ij} can be shown to be

$$V(Z_{ij}) = (\Pi_{ij}\, \mu_{ij})^2 ,$$

where

$$\Pi_{ij} = [(W/2 + Q_i)\, \pi_{ij}^2/R_{ij} + W^2/12 + V(L_{ij}) + (L_{ij} + Q_i)\, \pi_{ij}^2]^{1/2} .$$

The safety factor K_{ij} is computed from Eqn. (7) as before, except with

*Refer to Ref. [6], page 56.

the foregoing value of Π_{ij}. The safety stock is then computed with (6), which allows both the base stock level and average on-hand inventory to be obtained.

B.2.3 Periodic Review with Composition Delay

Next we will derive the reordering and composition formulas for the most complex case: periodic review with composition delay. This is the model which is used in the calculations in Section B.1.3 for items transshipped through DSA/GSA depots. The total amount purchased from a vendor is equal to $Q_i \mu_i$, and this quantity is then sent to a DSA/GSA depot. At this depot, the shipment is then allocated and shipped to the various NSC's. The models of Sections B.2.1 and B.2.2 assumed that the composition decision (i.e. the quantity which each NSC would receive) was made simultaneously with the decision to reorder from the vendor. However, a more efficient approach would be to postpone the composition decision until the time that the shipment reaches a DSA/GSA depot. In this way, the latest demand data from the NSC's could be used to make the allocation, which in turn should reduce safety stock requirements at the NSC's.

Let the lead time L_{ij} be divided into two components: P_i, which is the time between when a shipment is ordered from a vendor and when it arrives at a DSA/GSA depot; and $L_{ij} - P_i$, which is the time between when a shipment arrives at a DSA/GSA depot and when it arrives at the j^{th} NSC. Our assumption is that the composition decision can be postponed for P_i days after a decision to reorder is made. Let a''_{ij} be the available inventory of item i at the j^{th} NSC after this delay of P_i days. The amount of item i to be sent to the j^{th} NSC is now equal to

$$A''_{ij} = BSL_{ij} - D'_i \frac{\mu_{ij}}{\mu_i} - a''_{ij} ,$$

where D_i' is equal to the nation-wide (over all NSC's) demand for item i that occurred over the periodic and composition delay intervals. This allocation rule can be shown to satisfy

$$\sum_j A''_{ij} = Q_i \mu_i .$$

The appropriate base stock level BSL_{ij} still satisfies Eqn. (9).

The amount of inventory on-hand when the next shipment arrives is

$$Z_{ij} = BSL_{ij} - D_i' \frac{\mu_{ij}}{\mu_i} - D''_{ij} ,$$

where D''_{ij} is equal to the demand for item i at the j^{th} NSC over the remaining lead time $(L - P)$ plus cycle time. Thus

$$V(Z_{ij}) = \left(\frac{\mu_{ij}}{\mu_i} \right)^2 V(D_i') + V(D''_{ij}) ,$$

as D_i' and D''_{ij} refer to demands over non-overlapping time intervals. Using arguments similar to those employed previously,

$$E(D_i') = \mu_i (W/2 + P_i) ,$$

$$V(D_i') = (W/2 + P_i) \sigma_i^2 + [W^2/12 + V(P_i)] \mu_i^2 ,$$

$$E(D''_{ij}) = \mu_{ij} (L_{ij} - P_i + Q_i) ,$$

and

$$V(D''_{ij}) = (L_{ij} - P_i + Q_i) \sigma_{ij}^2 + \left[\frac{Q_i \alpha_i}{\mu_i} + V(L_{ij} - P_i) \right] \mu_{ij}^2 ,$$

where $V(P_i)$ is the variance of the composition delay and $V(L_{ij} - P_i)$ is the variance of the remaining lead time component. Because

$$V(L_{ij}) = V(P_i) + V(L_{ij} - P_i) \quad \text{and} \quad \pi_i^2 = \pi_{ij}^2 / R_{ij} ,$$

it can be shown that

$$V(Z_{ij}) = (\Pi_{ij}\, \mu_{ij})^2 ,$$

where

$$\Pi_{ik} = \left\{ (\frac{W}{2} + P_i + Q_i) \frac{\pi_{ij}^2}{R_{ij}} + \frac{W^2}{12} + (L_{ij} - P_i + Q_i)\, \pi_{ij}^2 + V(L_{ij}) \right\}^{1/2} .$$

The safety factor K_{ij} and safety stock SS_{ij} are computed from Eqns. (6)-(7) as before. This allows both the base stock level and average on-hand inventory to be computed. This also completes the derivation of the formulas for the base stock system. The application of these formulas to the models employed in Appendix B.1 is straightforward and will not be discussed here.

B.3 Derivation of the Reorder Point-Reorder Quantity Model

The standard reorder point-reorder quantity model is used in the Current Pull system, Local Push systems, and for items sent directly from a vendor to San Diego in Total Push. In these models, the ordering decision is based upon the parameters (RP_{ij}, Q_{ij}) for the i^{th} item at the j^{th} NSC: whenever the available area-wide inventory a_{ij} at the j^{th} NSC falls to the reorder point RP_{ij}, then $Q_{ij}\, \mu_{ij}$ items are ordered from a vendor, where μ_{ij} is the mean demand for item i at the j^{th} NSC. Note that the base stock system of Appendix B.2 was a group trigger model, while the model in this section is the usual single trigger model: in the base stock system an item was ordered simultaneously for all NSC's, while the reorder point-reorder quantity model only considers the inventory position at one NSC. The concept of composition delay is not relevant in this case, as the reorder

quantity will always be the same: $Q_{ij}\,\mu_{ij}$. However, it will again be convenient to develop the formulas separately for the continuous and periodic review cases.

B.3.1 Continuous Review

Let L_{ij} be the mean time between when item i is reordered for the j^{th} NSC and when stock is delivered. In the continuous review case, the reorder point RP_{ij} must satisfy

$$RP_{ij} = (L_{ij} + SS_{ij})\,\mu_{ij}\,,$$

where μ_{ij} is the mean (area-wide) demand per unit time for item i at the j^{th} NSC and SS_{ij} is the safety stock.

Define Z_{ij} to be the on-hand inventory when a procurement arrives; thus

$$Z_{ij} = RP_{ij} - D_{ij}\,,$$

where D_{ij} is the random demand over the lead time. Because the lead time is a random variable, D_{ij} can be viewed as being a random sum of random variables. Using the same approach as in Section B.2.1,* it can be shown that D_{ij} has mean

$$E(D_{ij}) = L_{ij}\,\mu_{ij}$$

and variance

$$V(D_{ij}) = L_{ij}\,\sigma_{ij}^2 + V(L_{ij})\,\mu_{ij}^2\,,$$

where $V(L_{ij})$ is the variance of the lead time and σ_{ij} is the standard

*Refer to Ref. [6], page 56.

deviation of demand for item i at the j^{th} NSC per unit time. Because $V(Z_{ij}) = V(D_{ij})$, we can write

$$V(Z_{ij}) = (\Pi_{ij}\ \mu_{ij})^2 ,$$

where

$$\Pi_{ij} = \{L_{ij}\ \pi_{ij}^2 + V(L_{ij})\}^{1/2} .$$

The analysis of Section B.2.1 applies directly to show that the safety stock SS_{ij} satisfies Eqn. (6), the safety factor K_{ij} satisfies Eqn. (7), and the average on-hand inventory is computed with Eqn. (8).

B.3.2 Periodic Review

The formulas used in Appendix B.1 assumed that the control system had a review period of length W. Hence the interval between when the reorder point is reached and when an order can be placed follows the uniform distribution with mean $W/2$ and variance $W^2/12$. Thus the reorder point must satisfy

$$RP_{ij} = \mu_{ij}[L_{ij} + W/2 + SS_{ij}] .$$

Again let Z_{ij} be the on-hand inventory when a procurement arrives. Thus

$$Z_{ij} = RP_{ij} - D'_{ij} ,$$

where D'_{ij} is the random demand for item i at the j^{th} NSC during the periodic delay plus lead time. Using the same approach as before, it can be shown that

$$V(Z_{ij}) = (\Pi_{ij}\ \mu_{ij})^2 \ ,$$

where

$$\Pi_{ij} = \{(L_{ij} + W/2)\ \pi_{ij}^2 + W^2/12 + V(L_{ij})\}^{1/2} \ .$$

The safety stock, safety factor, and average on-hand inventory can now be computed with Eqns. (6)-(8). This completes the derivation of the reorder point-reorder quantity model. The application of these formulas to the models employed in Appendix B.1 is straightforward and will not be discussed here.

APPENDIX C: CALCULATION OF COST ESTIMATES

C.1 CURRENT PULL SYSTEM

C.1.1 Inventory Holding Costs

Inventory holding costs, not including land and building, are computed as 21% of inventory value. According to the FMSO Report (1), the level of 9 cog peacetime inventory at NSC is $4,744,003, implying an annual NSC holding cost of (.21)($4,744,003) = $996,241. From the MISR tapes, the total on hand 9 cog inventory at the major activities is $8,493,196 and generates an annual holding cost of (.21)($8,493,196) = $1,783,571. Similarly, the servmart inventory level is $815,734 and generates a holding cost of (.21)($815,734) =$171,304. From Table 6.1, DSA/GSA current 9 cog inventory held for resupplying San Diego totals $32,275,000 and generates holding costs of (.21)($32,275,000) = $6,777,750.

C.1.2 In-Transit Inventory Holding Costs

In-transit inventory holding costs are computed as 21% of inventory value. The in-transit inventory levels presented for the Current Pull System in Table 6-2 generate the following annual holding costs:

In-Transit Route	Inventory Level		Rate		Holding Cost
DSA/GSA to NSC	$1,912,612	x	(.21)	=	$401,649
DSA/GSA to Major Activities	336,052	x	(.21)	=	70,571
DSA/GSA to Servmarts	31,443	x	(.21)		6,603
NSC to Major Activities	169,810	x	(.21)	=	35,660
NSC to Servmarts	81,711	x	(.21)	=	17,159

C.1.3 Transportation Costs

C.1.3.1 DSA/GSA Transportation Costs

From reference (2), Section D.2.2, the DSA

common carrier rate was $18.13 per measurement ton (MT), and the DSA parcel post rate was $163.30/MT in FY 72. Similarly, the GSA common carrier rate was $14.18/MT, and the GSA parcel post rate was $125.37/MT. Weighting these rates by the number of MT's shipped to NSC (also given in Section D.2.2 of reference (2)), a composite common carrier/parcel post rate for DSA is computed to be $19.14/MT, and for GSA, $14.23/MT. These rates and MT's were effective in FY 72. Assuming an annual inflation rate of 7% for 2 years, compounded annually, new composite shipping rates for FY 74 become $21.91/MT for DSA and $16.29/MT for GSA.

From NSC accounting reports (5), FY 74 Receiving Operations at NSC handled 406,349 MT's of incoming common carrier and parcel post cargo. From a sample of bills of lading at NSC in reference (2), .344 of all MT's received was DSA material, .395 was GSA (9Q) material, and .261 was other material. Using the FY 74 composite rates calculated above, the current transportation cost for DSA cog material received at NSC is (.344)(406,349)($21.91) = $3,062,669. Similarly, the current transportation cost for GSA cog material is (.395)(406,349)($16.29) = $2,614,673. The total is $3,062,669 + $2,614,673 = $5,677,342 per year. From sampling (3), 3% of receipts at NSC are from vendors directly. Attributing 3% of this transportation cost to these types of shipments, the total current DSA/GSA transportation cost for shipments to NSC (excluding servmarts) is (.97)($5,677,349) = $5,507,029. From Section A.1.1, the ratio of DSA/GSA dollar demand from servmarts to dollar demand from NSC under the Current Pull System is $593,260 ÷ $36,087,023 = .016. The DSA/GSA transportation cost for shipments to servmarts is then calculated as (.016)($5,507,029) = $88,112. Again from Secion A.1.1, the ratio of DSA/GSA dollar demand from major activities to dollar demand from NSC under the Current Pull

System is \$6,340,608 ÷ \$36,087,023 = .176. The DSA/GSA transportation cost for shipments to major activities is then calculated as (.176)(\$5,507,029) = \$969,237.

C.1.3.2 NSC Transportation Costs

From NSC accounting reports (5), the total FY 74 NSC truck transportation cost is determined from the following accounts:

2168 Account Number	Description	FY74 Cost
62	Maint. Vehicle Transp.	\$4,883
63	Oper. Vehicle Transp.	9,165
64	Maint. other Transp. Equip.	26,967
65	Oper. other Transp. Equip.	125
66	Equipment Rentals	503,482
67	Drivers	346,319
6810	Dispatchers	38,663
6830	Other Supervision	22,615
6840	Operations, other	14,960
6850	Allowed time	6,580
6860	Misc. Operating Costs	8,884
6870	Gas tax refunds	(1,696)
		\$980,947

From a sample in reference (2), the fraction of MT's transported by truck which is 9 cog material is .739. Therefore, the current total NSC 9 cog truck transportation costs are (.739)(\$980,947) = \$724,920. From Section A.1.1. the fraction of demand at NSC under the Current Pull System which comes from servmarts is .200, from major activities .415, and from other customers, .385. Using these fractions, the portion of NSC 9 cog truck transportation costs due to servmart shipments is (.200)(\$724,920) = \$144,984; that due to shipments to major activities is (.415)(\$724,920) = \$300,842; and that due to shipments to other customers (.385)(\$724,920) = \$279,094.

C.1.4 Issue and Receipt Costs

C.1.4.1 NSC Issue and Receipt Costs

Table C.1.4 presents the current NSC cost per 9 cog issue and receipt by account, in column (1). These are based primarily upon FY74 NSC accounting data (5). The total number of 9 cog issues at NSC during FY74 was 640,184, per Table A.2-1, and is listed in the issue portion of column (2). The corresponding 9 cog receipt total, 142,056, is listed in the receipt portion of column (2). The total NSC 9 cog issue and receipt costs under the Current Pull System are then computed in column (3), with one exception. The Requisition Processing account must be adjusted to include those requests for items which NSC does not carry, but which, nevertheless, contribute to the workload in this account. From the MISR tapes, the frequency of ordering non-NSC items by the major activities and servmarts is 51,584 per year. Assuming that all requests for non-NSC material pass through NSC (and that no subsequent transshipment of those items takes place), column (3) is corrected by inflating Requisition Processing by the ratio (51,584 + 640,184) ÷ 640,184 = 1.081. This yields (1.081)($192,055) = $207,611 as the total Requisition Processing cost in column (5).

The total NSC issuing costs of $1,155,084 must now be attributed to servmarts, major activities, and other customers. In Bulk Issue and Loading, the workload is related to the volume of material issued. Assuming that dollar value varies proportionately with the volume of material, the NSC value of annual demand from servmarts, major activities, and other customers in Section A.1.1 is used to prorate the issuing costs generated by these two accounts. In the remaining issuing accounts the workload is more closely associated with the number of issues made. Therefore, the fractions of issues from NSC to servmarts, to major activities, and

TABLE C.1.4

ANNUAL NSC ISSUING AND RECEIVING COSTS FOR 9 COG MATERIAL UNDER CURRENT PULL SYSTEM

ACCOUNT	(1) COST PER 9 COG TRANSACTION	(2) NUMBER OF TRANSACTIONS	(3) TOTAL COSTS [1]	(4) COLUMN (3) FRACTION OF TOTAL COSTS		(5) TOTAL COSTS [2]
Issuing						
Light Packing	$ .25	640,184	$ 160,046	.140	.0939	$ 160,046
Parcel Post Packing	.04	640,184	25,607	.022	.0150	25,607
Bulk Issue	.53	640,184	339,298	.298	.1990	339,298
Bin Issue	.14	640,184	89,626	.079	.0526	89,626
Requisition Processing	.30	640,184	192,055[1]	.169	.1126	207,611[2]
Loading	.52	640,184	332,896	.292	.1953	332,896
			$1,139,528	1.000	.6684	$1,155,084
Receiving						
Receiving Operations	$2.64	142,056	$ 375,028	.663	.2200	375,028
Receipt Control	.46	142,056	65,346	.116	.0383	65,346
Bin Operations	.16	142,056	22,729	.040	.0133	22,729
Incoming Storage	.72	142,056	102,280	.181	.0600	102,280
			$ 565,383	1.000	.3316	$565,383
			$1,704,911		1.0000	$1,720,467

[1] Excludes Requisition Processing Costs for not-carried requests

[2] Includes Requisition Processing Costs for not-carried requests

to other customers are used to prorate the issuing costs generated by these remaining four accounts. The results are as follows:

Attributed To	Item Related Costs	Volume-Related Costs	Total
Servmarts	$101,890	$134,439	$236,329
Major Activities	52,152	278,960	331,112
Other Customers	328,848	258,795	587,643
	$482,890	$672,194	$1,155,084

The total receipt costs of $565,383 must be attribued to DSA/GSA shipments and to shipments direct from vendors. From sampling (3), 3% of all NSC 9 cog receipts are known to be of this latter type. Therefore, (.03)($565,383) = $16,961 in receiving costs is due to receipts from vendors, and $565,383 - $16,961 = $548,422 is due to receipts from DSA/GSA.

C.1.4.2 DSA/GSA Issue and Receipt Costs

From reference (2), Tables D.5 and D.6, FY72 issuing costs for DSA and GSA were estimated to be $3.01 per issue and $4.02 per issue, respectively. Assuming an annual inflation rate of 7% for two years, compounded annually, the current FY74 issuing rates are estimated at $3.45 per issue for DSA and $4.60 per issue for GSA. From Section A.2.1, NSC received 137,794 issues from DSA/GSA. From Table A.2-1, .156 of all 9 cog receipts were 9Q (GSA managed). Therefore, (.156)137,794 = 21,496 issues were made by GSA, and 137,794 - 21,496 = 116,298 were made by DSA. In support of NSC (Main Supply) only, FY74 issuing cost for DSA is then calculated as ($3.45)(116,298) = $401,228, and for GSA, ($4.60)(21,496) = $98,882. Total DSA/GSA issuing cost in support of NSC is the sum, $401,228 + $98,882 = $500,110.

From Table C.1.4, column (3), the ratio of total NSC receiving cost to issuing cost is $565,383 ÷ $1,139,528 = .497. Assuming that the same ratio holds true for DSA/GSA operations, the DSA/GSA receiving cost in support of NSC is (.497)($500,110) = $248,555.

From Section A.1.1, the total dollar demand for 9 cog non-NSC material placed on DSA/GSA stocks directly by servmarts and major activities is $6,340,608 + $593,260 = $6,933,868. Also from A.1.1, the total 9 cog demand at NSC by all customers is $37,203,116. The ratio, $6,933,868 ÷ $37,203,116 = .186, when applied to the current DSA/GSA issuing and receiving cost in support of NSC only, yields the DSA/GSA issuing cost in support of servmarts and major activities, (.186)($500,110) = $93,020, and the DSA/GSA receiving cost in support of the servmarts and major activities, (.186)($248,555) = $46,231.

In order to prorate the $93,020 issuing cost between servmarts and major activities, it is again assumed (as in Section C.1.4.1) that the NSC issuing and receiving operation can be used as a small scale model of the DSA/GSA system. From Column (4) of Table C.1.4, the volume-related accounts (Bulk Income and Loading) make up .292 + .298 = .590 of the total NSC issue cost. Therefore, (.590)($93,020) = $54,882 in DSA/GSA costs will be prorated between the servmarts and major activities according to the relative dollar value requirements placed against DSA/GSA from Section A.1.1, and the remaining $93,020 - $54,882 = $38,138 will be distributed according to the relative numbers of requirements placed against DSA/GSA from Section A.2.1. The results are as follows:

Attributed To	Item-Related Costs	Volume-Related Costs	Total
Servmarts	$11,937	$4,720	$16,657
Major Activities	26,201	50,162	76,363
	$38,138	$54,882	$93,020

The total DSA/GSA receiving cost in support of the San Diego area is the sum of those costs due to NSC material plus those due to servmarts and major activities, $248,555 + $46,231 = $294,786.

C.1.4.3 Servmart and Major Activity Receiving Costs

From Table C.1.4 column (3), the current NSC Receiving Operations and Incoming Storage costs are $375,028 and $102,280, respectively. These functions are considered to be volume-dependent, and the dollar value of material processed is considered to be a good measure of workload in the absence of measurement tonnage statistics. From Section A.1.1, the current total value of demand for 9 cog material at NSC is $37,203,116. This implies that the Receiving Operations cost per dollar of demand is $375,028 ÷ $37,203,116 = .0101, and the Incoming Storage cost per dollar of demand is $102,280 ÷ $37,203,116 = .0027. The ratio of volume-related receiving cost to dollar demand is then .0101 + .0027 = .0128. The Receipt Control and Bin Operations accounts are item-related and their costs per receipt, from Table C.1.4, Column (1), are $.46 and $.16, for a total item-related receipt cost per receipt of $.46 + $.16 = $.62. It is assumed that the cost of the receiving function per dollar of demand and per receipt as developed here for NSC apply as well to receiving functions at servmarts and major activiaties. From Sections A.1.1 and A.2.1, the dollar demand and number of items received at servmarts and major activities under the Current Pull System are as follows:

Source of Receipts	Dollar Value Received at		Number of Items Recd. At	
	Servmarts	Major Activities	Servmarts	Major Activities
NSC	$7,428,312	$15,437,234	134,928	69,240
DSA/GSA	593,260	6,340,608	15,662	34,375
Vendors	18,349	196,101	484	1,063

By multiplying the dollar value of demand received by .0128 and the number of items received by $.62, the current servmart and activity receipt costs are computed as follows:

Source of Receipts	Volume-Related Costs		Item-Related Costs		Total Costs	
	Servmarts	Major Act	Servmarts	Major Act	Servmarts	Major Act
NSC	$95,082	$197,596	$83,655	$42,929	$178,737	$240,525
DSA/GSA	7,594	81,160	9,710	21,312	17,304	102,472
Vendors	235	2,510	300	659	535	3,169
					$196,576	$346,166

C.1.5 Overhead Costs

To estimate an overhead rate, a list of overhead accounts was formed from NSC accounting reports (5) which contribute to the 9 cog supply function at NSC. For each such account an estimate was made of the fraction of the account expense attributable to the supply operation. These estimates follow:

Account	Fraction	Amount
Care of material in storage	1.00	$446,368
Rewarehousing	1.00	68,750
Preservation and packaging	1.00	62,296
Inventory	1.00	57,197
Training storage	1.00	5,915
Storage and warehouse support	1.00	433,677
Labor and equipment overhead	1.00	292,033
Package and issue support	1.00	116,265
Command	.50	106,262
Management engineering	1.00	216,598
Comptroller	.75	910,577
Civilian manpower	.75	322,806
Data Processing	.75	577,208
Office services	.50	128,793
Miscellaneous administration	.75	356,263
Communications	.50	83,908
Security	.40	93,567
Utilities	.50	161,121
Maintenance of buildings	.90	176,111
Maintenance of real property	.90	225,103
Procurement of pallets	1.00	56,727
General engineering support	.80	332,902
		$5,230,447 per year

The denominator of the overhead ratio includes the total costs of receiving, issuing, requistion processing and truck transportation at NSC

for all cogs. These accounts, taken from NSC accounting reports (5), amount to $3,982,263. The overhead rate is then $5,230,447 ÷ $3,982,263 = 1.313, i.e., for each direct operational cost of $1.00, we allocate $1.313 in overhead cost. This rate is applied to the 9 cog costs at all levels in the current and alternative systems.

In the Current Pull System, overhead costs of $1,165,834 are computed for DSA/GSA by applying the overhead rate of 1.313 to total DSA/GSA receiving and issuing costs of $887,916. Similarly, $3,468,897 in overhead expense is charged to NSC and the servmarts on total issuing, receiving and transportation costs of $2,641,963. Major activity overhead costs of $454,516 are computed on the basis of total receiving costs of $346,166.

C.1.6 Land and Building Costs

From an estimate by NSC personnel, the 9 cog supply function involves 53,000 square feet of office space and 289,000 square feet of covered storage space. Assuming this space were rented commercially at a rate of 30.9¢ per foot, per month, for office space and 5.7¢ per foot, per month, for covered storage space, annual costs to NSC would be (53,000)(30.9¢)(12) = $196,524 for office space and (289,000)(5.7¢)(12) = $197,676 for covered storage space.

From Sections C.1.3.2 and C.1.4.1, current 9 cog operations costs at NSC for receiving ($565,383), issuing ($1,139,528), and truck transportation ($724,920) total $2,429,831. Dividing the annual cost for office space by this total yields an operations-related land and building rate of $196,524 ÷ $2,429,831 = .081. The total current 9 cog (peacetime plus reserve) inventory level at NSC from the FMSO Report (1) is $6,278,664. Dividing the annual cost for covered storage space by this amount yields a storage-related land and building rate of $197,676 ÷ $6,278,664 = .0315.

From Section C.1.1, the value of peacetime inventory levels for 9 cog material under the Current Pull System at NSC plus servmarts and at the major activities are $4,744,003 + $815,734 = $5,559,737 and $8,493,196, respectively. From Table 6.1, the value of peacetime DSA/GSA inventory held for resupplying the San Diego area is $32.275 million. Applying the storage-related rate to these inventory levels yields the following annual storage-related land and building costs:

DSA/GSA	(.0315)($32,275,000) = $1,017,000
NSC/Servmarts	(.0315)($5,559,737) = $175,132
Major Activities	(.0315)($8,493,196) = $267,536

From previous calculations in this section, the total NSC plus servmart 9 cog receiving, issuing, and truck transportation costs amount to $2,641,963. Total DSA/GSA 9 cog receiving and issuing costs are $887,916, and total major activity 9 cog receiving costs are $346,166. Applying the operations-related rate to these costs yields the following annual operations - related land and building costs:

DSA/GSA	(.081)($887,916) = $71,921
NSC/Servmarts	(.081)($2,641,963)= $213,999
Major Activities	(.081)($346,166) = $28,039

C.2 TOTAL PUSH SYSTEM

C.2.1 Inventory Holding Costs

Under this system DSA/GSA will no longer stock 9 cog material for the San Diego area and so will incur no inventory holding costs for this material. From Section C.1.1, the total San Diego 9 cog inventory value under the Current Pull System at NSC, servmarts, and major activities is $4,744,003 + $815,734 + $8,493,196 = $14,052,933. From Appendix B, the area inventory change factor for the Total Push System is 2.60. This yields a new areawide 9 cog inventory of (2.60) ($14,052,933) = $36,537,625 under this alternative, with an associated

holding cost of (.21)($36,537,625) = $7,672,901. Since the inventory levels at the major activities do not change from under the Current Pull System, the holding cost charged to NSC and the servmarts under this alternative is just the difference between the new total holding cost and the current activity holding cost from Section C.1.1, $7,672,901 - $1,783,571 = $5,889,330.

C.2.2 In-transit Inventory Holding Costs

The in-transit inventory levels presented for the Total Push System in Table 6-2 generate the following annual holding costs:

In-Transit Route	Inventory Level		Rate		Holding Cost
Vendor to NSC through DSA/GSA	$1,720,836	x	(.21)	=	$361,376
NSC to major activities	241,713	x	(.21)	=	50,760
NSC to servmarts	88,439	x	(.21)	=	18,572

C.2.3 Transportation Costs

As described in Section C.1.3.1, the total DSA/GSA transportation costs for 9 cog shipments to NSC ($5,507,029), servmarts ($88,112), and major activities ($969,237) is $6,564,378. This will be the new transportation cost borne by DSA/GSA for transshipments to NSC under the Total Push System.

The amount of material shipped by NSC will increase in proportion to the increase in demand. From Section A.1.1, the total 9 cog demand at NSC under the Current Pull System is $37,203,116. From Section A.1.2, the 9 cog demand at NSC under the Total Push System from activities ($21,973,943), servmarts ($8,039,921) and other customers ($14,337,570) totals $44,351,434. The ratio of new demand to old demand, $44,351,434 ÷ $37,203,116 = 1.192, is an appropriate factor with which to estimate the new NSC transportation cost from the old. This is computed to be (1.192)($724,920) = $864,105. Since the demand from other customers does not change, the current NSC transportation

cost due to shipments to other customers ($279,094, from Section C.1.3.2) should not change due to demand. Therefore, the new NSC transportation cost due to increased shipments to servmarts and to major activities is $864,105 - $279,094 = $585,011. Prorating this amount on the basis of the relative value of demand coming from servmarts (.268) and major activities (.732) under the Total Push System in Section A.1.2, we attribute $156,783 of the new NSC transportation cost to servmart shipments and $428,228 to major activity shipments. A second inflation of these costs is now necessary to account for expected redistribution of material within the San Diego area due to the area-wide asset visibility under this alternative. From a computation based on the inventory model, the probability that an item is not at the activity (or servmart) where requested, given that it is in the area, is .126. Also, the probability that an item is not at NSC, given that it is not at the activity (or servmart) where requested and is in the area, is .200. The product of these probabilities, (.126)(.200) = .0252, is the probability that the item is not at NSC and is in the area, i.e., it is available for redistribution to the activity (or servmart) where requested from another activity (or servmart) in the area. The NSC transportation costs computed thus far must be inflated by a factor of 1.0252 to yield an estimate which accounts for this anticipated redistribution of material. The above calculations are summarized in columns (2) through (4) of Table C.2.3.

C.2.4 Issue and Receipt Costs

C.2.4.1 NSC Issue and Receipt Costs

Table C.2.4 displays a two-stage development of the annual NSC issuing and receiving costs for 9 cog material under the Total Push System. Column (1) lists, by account, the issuing and receiving costs under the Current Pull System as developed in Table C.1.4.

TABLE C.2.3

CALCULATION OF NSC TRANSPORTATION COSTS UNDER THE TOTAL PUSH SYSTEM

(1) SHIPMENT DESTINATION	(2) COST UNDER CURRENT PULL SYSTEM	(3) INITIAL INFLATION FOR INCREASED DEMAND	(4) FINAL INFLATION FOR REDISTRIBUTION
Servmarts	$144,984	$156,783	$160,734
Major Activities	300,842	428,228	439,019
Other Customers	279,094	279,094	286,127

TABLE C.2.4

ANNUAL NSC ISSUING AND RECEIVING COSTS FOR 9 COG MATERIAL UNDER TOTAL PUSH SYSTEM

ACCOUNT	(1) CURRENT PULL SYSTEM COSTS	(2) NET CHANGE IN COLUMN (1) FROM FORMERLY NON-NSC ITEMS	(3) NET CHANGE IN COLUMN (1) FROM FORMERLY NSC ITEMS	(4) TOTAL NEW COSTS (COLUMNS (1)+(2)+(3))
Issuing				
Light Packing	$160,046	$12,896	0	$172,942
Parcel Post Packing	25,607	2,063	0	27,670
Bulk Issue	339,298	65,145	0	404,443
Bin Issue	89,626	7,222	0	96,848
Requisition Processing	207,611	0	($61,250)	146,361
Loading	332,896	63,916	0	396,812
	$1,155,084	$151,242	($61,250)	$1,245,076
Receiving				
Receiving Operations	$ 102,280	$ 19,638	0	$ 121,918
Receipt Control	65,346	7,308	($38,423)	34,231
Bin Operations	375,028	72,005	0	447,033
Incoming Storage	22,729	2,542	(13,365)	11,906
	$ 565,383	$101,493	($51,788)	$ 615,088

In column (2), the net dollar changes, by account, due to items which were formerly not carried by NSC under the Current Pull System are presented. Of the six issuing accounts, Light Packing, Parcel Post Packing, and Bin Issue are considered to be item-dependent. From the MISR tapes (2), the frequency of ordering formerly non-NSC items by the servmarts and major activities is 51,584 per year. This represents the new number of requirements to be filled from NSC stocks under the Total Push System. Using the per issue rates in Table C.1.4 corresponding to these three accounts, the entries in column (2) are calculated as follows:

Light Packing	(51,584)($.25)	= $12,896
Parcel Post Packing	(51,584)($.04)	= $2,063
Bin Issue	(51,584)($.14)	= $7,222

Since all servmart and major activity requirements filled by NSC under this alternative will be pushed rather than requisitioned, there will be no increase in requisition processing costs due to these items. The Bulk Issue and Loading accounts are considered to be volume-dependent and proportional to the dollar value of material processed. From section A.1.1, the dollar demand currently among major activities and servmarts for non-NSC 9 cog material is $6,536,709 + $611,609 = $7,148,318. The total value of annual demand for 9 cog material at NSC currently is $37,203,116. This ratio, $7,148,318 ÷ $37,203,116 = .192, when applied to the current Bulk Issue and Loading costs, yields an estimate of the increase in these accounts due to the issuing of formerly non-NSC items now carried in NSC Stocks. These calculations follow:

Bulk Issue	(.192)($339,298)	= $65,145
Loading	(.192)($332,896)	= $63,916

Among the receiving accounts, Incoming Storage and Receiving Operations are considered volume-related and can be handled in the same manner as above:

Incoming Storage	(.192)($102,280)	= $19,638
Receiving Operations	(.192)($375,028)	= $72,005

The remaining receiving accounts, Receipt Control and Bin Operations, are considered item-dependent. From Table A.2-4, the total new receipts of formerly non-NSC items at NSC under the Total Push System is the sum of those coming directly from vendors, 1128 per year, plus those coming via DSA/GSA transshipments, 14,760 per year, for a total of 15,888. Using this figure and the current per receipt rates for Receipt Control and Bin Operations from Table C.1.4, the final entries of column (2) are calculated as follows:

Receipt Control	(15,888)($.46) =	$7,308
Bin Operations	(15,888)($.16) =	$2,542

In column (3) net dollar changes due to items which were formerly carried by NSC under the current system are presented. Only one issue account, Requisition Processing, is non-zero. From Section A.2.1, the current number of issues to servmarts (134,928) and to major activities (69,240) total 204,168. Since under the Total Push System these requisitions to NSC will be eliminated, this figure, together with the Requisition Processing rate per requisition from Table C.1.4, allow the following computation of the reduction in Requisition Processing costs due to the elimination of these requisitions:

Requisition Processing (204,168)(.30) = $61,250 reduction

Since the same volume of formerly NSC-carried items will be received at NSC under the Total Push System as is received currently, the volume-related receipt accounts for this type of material will not change. However, due to different ordering quantities, there will be a change in the total number of receipts of this material, thus affecting the item-related Receipt Control and Bin Operations accounts. Column (5) of Table A.2-3 gives the weighted fraction decrease (.606) in the number of receipts of carried DSA/GSA material at NSC under the new DSA/GSA ordering

quantities of the Total Push System. Since .97 of all 9 cog receipts at NSC arrive from DSA/GSA according to a sample (3), (.97)(.606) = .588 represents the fraction decrease in receipts of formerly NSC-carried items under the Total Push System. The change in Receipt Control and Bin Operations costs due to this reduction are then calculated as follows:

Receipt Control	(.588)($65,346) = $38,423
Bin Operations	(.588)($22,729) = $13,365

Column (4) of Table C.2.4 presents the new NSC issue and receipt costs under the Total Push System (the net effect of columns (2) and (3) on the current issuing and receiving costs in column (1)).

NSC receiving costs will now be prorated, by account, between shipments from DSA/GSA and shipments direct from vendors. From Section A.2.2, 5390 NSC receipts are from vendors and 69,051 from DSA/GSA under this alternative, and from Section A.1.2, $1,330,543 of NSC demand is met by vendors and $43,020,891 by DSA/GSA. Based on this data, the volume-related accounts (Incoming Storage, Receiving Operations) are prorated at a rate of .03 to vendors and .97 to DSA/GSA, and the item related accounts (Receipt Control, Bin Operations) are distributed .072 to vendors and .928 to DSA/GSA. These calculations result in attributing $20,391 in NSC receiving costs to shipments from vendors and $594,697 to shipments from DSA/GSA.

In a similar fashion, NSC issuing costs will now be attributed to the various customers supported by NSC. Issues to other customers will remain unchanged from the Current Pull System in both number and dollar value. Therefore, the current other customer share of volume-related issuing accounts ($258,795) and item-related issuing accounts ($328,848) from Section C.1.4.1 must be subtracted before prorating the remainder of the new NSC issuing costs between servmarts and major activities. From Section A.1.2, $8,039,921 in NSC demand comes from servmarts and $21,973,943

from major activities. From Section A.2.2, 151,074 issues are made to Servmarts and 104,678 to major activities. Based on this data, the volume-related accounts (Bulk Issue, Loading) less $258,795 in other customer costs, are divided at a rate of .268 to servmarts and .732 to major activities, and the item-related accounts (Light Packing, Parcel Post Packing, Bin Issue, Requisition Processing) less $328,848 in other customer costs, are divided .591 to servmarts and .409 to major activities. These calculations result in attributing $213,328 in NSC issuing costs to servmart issues and $444,105 to major activity issues.

C.2.4.2 DSA/GSA Transshipment Costs

DSA/GSA do not carry 9 cog inventory for the San Diego area under the Total Push System; however, they do order and transship material to NSC. This transshipment operation includes the functions described by the following accounts from Table C.1.4:

Account	Fraction of Total Issuing and Receiving Costs
Light Packing	.0939
Parcel Post Packing	.0150
Loading	.1953
Receipt Control	.0383
Receiving Operations	.2200
	.5625

The fraction which each account contributes to the total current NSC issuing and receiving costs is from column (4) of that same table. Assuming these fractions hold true for the DSA/GSA operation as well, the cost of the transshipment operation is estimated to be .5625 of the total current DSA/GSA issuing and receiving costs from Section C.1.4.2, i.e., (.5625)($887,916) = $499,453.

C.2.4.3 Servmart and Major Activity Receiving Costs

From Sections A.1.2 and A.2.2, the dollar value and number of receipts arriving at servmarts and major activities under the Total Push System are:

Source of Receipts	Dollar Value Received At Servmarts	Dollar Value Received At Major Activities	Number of Receipts At Servmarts	Number of Receipts At Major Activities
NSC	$8,039,921	$21,973,943	151,074	104,678
DSA/GSA	0	0	0	0
Vendors	0	0	0	0

Multiplying the dollar value received by the volume-related receiving rate (.0128) and the number of receipts by the item-related receipt cost ($.62), both from Section C.1.4.3, the new servmart and major activity receiving costs are computed as follows:

Source of Receipts	Volume-Related Costs Servmarts	Volume-Related Costs Major Act	Item-Related Costs Servmarts	Item-Related Costs Major Act	Total Costs Servmarts	Total Costs Major Act
NSC	$102,911	$281,266	$93,665	$64,900	$196,576	$346,166
DSA/GSA	0	0	0	0	0	0
Vendors	0	0	0	0	0	0

C.2.5 Overhead Costs

The DSA/GSA overhead cost is now based entirely on the transshipment functions described in the previous section. Applying the overhead rate of Section C.1.5 to the cost of transshipment yields a new DSA/GSA overhead cost of (1.313)($499,453) = $655,782. From Sections C.2.3 and C.2.4.1, the new NSC issuing ($1,245,076), receiving ($615,088) and transportation costs ($885,880) under the Total Push System total $2,746,044. Adding the total receiving cost at servmarts ($196,576), the total operational costs subject to the overhead rate is $2,746,044 + $196,576 = $2,942,620. This yields an overhead cost of (1.313)($2,942,620) = $3,863,660 for NSC, including servmarts. The receipt costs at major activities have not changed, and therefore the overhead cost remains $454,516.

C.2.6 Land and Building Costs

Since DSA/GSA no longer stock 9 cog material for the San Diego area, there is no storage-related land and building cost for DSA/GSA. From Section C.1.1, the total San Diego 9 cog inventory value

under the Current Pull System at NSC, servmarts, and major activities is $4,744,003 + $815,734 + $8,493,196 = $14,052,933. From Appendix B, the area inventory change factor for the Total Push System is 2.60. This yields a new areawide 9 cog inventory of (2.60)($14,052,933) = $36,537,625. Since servmart and major activity inventory levels will remain constant, $36,537,625 - $815,734 - $8,493,196 = $27,228,695 is the new NSC (only) inventory level. Applying the storage-related land and building rate of .0315 (from Section C.1.6) to the sum of NSC and servmart inventory values yields an NSC storage-related land and building cost of (.0315)($27,228,695 + $815,734) = $883,400. Since major activity inventory levels do not change, neither will the associated storage-related land and building cost of $267,536.

DSA/GSA operational costs under the Total Push System are represented by the $499,453 in transshipment costs described in Section C.2.4.2. Applying the operations-related land and building rate of .081 (from Section C.1.6), this yields a DSA/GSA operations-related cost of (.081)($499,453) = $40,456. As computed in Section C.2.5, the total NSC plus Servmart operational costs under the Total Push System amount to $2,942,620, implying an NSC operations-related land and building cost of (.081)($2,942,620) = $238,352. Major activity operations-related costs do not change from the current $28,039.

C.3 LOCAL PUSH/EXPANDED RANGE SYSTEM

C.3.1 Inventory Holding Costs

Under this alternative, DSA/GSA maintain the same level of 9 cog inventory as is currently stocked. The holding cost incurred is therefore the same as under the current system, $6,777,750. From Appendix B, the area inventory change factor for the Local Push/Expanded Range System is .77. The current area inventory as computed in Section C.2.1

is $14,052,933, implying a new area inventory of (.77)($14,052,933) = $10,820,758 under this system. Since the current inventory at major activities, $8,493,196, and associated holding costs remain unchanged, the portion of this new area inventory which is at NSC and servmarts is $10,820,758 - $8,493,196 = $2,327,562. The new holding cost charged to NSC and servmarts is the computed from this inventory level to be (.21) ($2,327,562) = $488,788.

C.3.2 In-Transit Inventory Holding Costs

The in-transit inventory levels presented for the Local Push/Expanded Range System in Table 6-2 generate the following annual holding costs:

In-Transit Route	Inventory Level		Rate		Holding Cost
DSA/GSA to NSC	$2,280,107	x	(.21)	=	$478,822
NSC to Servmarts	88,439	x	(.21)	=	18,572
NSC to Major Activities	241,713	x	(.21)	=	50,760

C.3.3 Transportation Costs

All transportation costs are the same as computed in Section C.2.3 for the Total Push System.

C.3.4 Issue and Receipt Costs

From Section C.1.4.2, current DSA/GSA issuing costs in support of NSC ($500,110), servmarts ($16,657), and major activities ($76,363) total $593,130. From Table C.1.4 Column (4), the volume-related issuing accounts (Bulk Issue and Loading) contribute .590 of the total issuing costs at NSC. Assuming that this fraction is also true of the DSA/GSA issuing operation, (.590)($593,130) = $349,947 of the current DSA/GSA issuing costs are volume dependent and $593,130 - $349,947 = $243,183 are item-dependent. Under this alternative, the same volume of material will be issued, therefore the volume-dependent costs will not change. There

is, however, a decrease in the number of issues made. From Section A.2.1, the current number of DSA/GSA issues to NSC (137,794), servmarts (15,662) and major activities (34,375) total 187,831. From Section A.2.3, the total number of DSA/GSA issues under this alternative (all to NSC) is 173,940. Applying the ratio 173,940 ÷ 187,831 = .926 to the current DSA/GSA item-dependent issuing costs yields the following estimate of the new DSA/GSA item-dependent issuing costs: (.926)($243,183) = $225,187. Total DSA/GSA issuing costs are then $ 225,187 + $349,947 = $575,133. All NSC issuing costs are the same as those calculated in Section C.2.4.1 for the Total Push System.

Receipt costs at servmarts and major activities for items from NSC are also the same as those calculated in Section C.2.4.3 for the Total Push System. The receipt cost at DSA/GSA for items received from vendors will be the same as that experienced currently ($294,786) as computed in Section C.1.4.2. The receipt cost at NSC for items received directly from vendors will be the same ($20,391) as that calculated in Section C.2.4.1 for the Total Push System. However, for those <u>formerly non-NSC items</u> now received at NSC from DSA/GSA, the NSC receipt cost will differ from that calculated under the Total Push System because receipts of DSA/GSA material now arrive at a rate which is based on NSC order quantities rather than DSA/GSA order quantities. Since the volume of material received is the same as under the Total Push System, only Receipt Control and Bin Operations-- the item-related receiving accounts--will change. From Sections A.2.2 and A.2.3, there are 21,386 more receipts from DSA/GSA at NSC under the Local Push/ Expanded Range System than under the Total Push System. At the per receipt costs listed in Table C.1.4, this difference results in an increased Receipt Control cost of (.46)(21,386) = $9838 and an increased Bin Operations cost of (.16)(21,386) = $3422. At the end of Section C.2.4.1, reductions in these

two accounts were made under the Total Push System due to the adoption of DSA/GSA order quantities and the resulting reduction in receipts of formerly NSC-carried items coming from DSA/GSA under the Current Pull System. Since the Local Push/Expanded Range System maintains the current NSC order quantities, these reductions no longer apply. Therefore, $38,423 must be added back to Receipt Control and $13,365 to Bin Operations. The total of all these changes to Receipt Control and Bin Operations combined is $9,838 + $3,422 + $38,423 + $13,365 = $65,048. The new NSC receipt cost for material from DSA/GSA under the Local Push/Expanded Range System is now the cost under the Total Push System as computed in Section C.2.4.1 ($594,697) plus all changes to the item-related accounts: $594,697 + $65,048 = $659,745.

C.3.5 Overhead Costs

The DSA/GSA issuing ($575,133) and receiving costs ($294,786) under this alternative total $869,919, and generate overhead expenses of (1.313)($869,919) = $1,142,204, using the overhead rate of Section C.1.5. The NSC issuing ($1,245,076), receiving ($680,136), and transportation costs ($885,880) under this alternative total $2,811,092, and generate (1.313)($2,811,092) = $3,690,964 in overhead cost. Servmart receiving costs ($196,576) contribute an additional (1.313)($196,576) = $258,104 to the NSC overhead expenses, for a total of $3,690,964 + $258,104 = $3,949,068. Major activity overhead expenses do not change from the current $454,516.

C.3.6 Land and Building Costs

Storage-related land and building costs for DSA/GSA do not change from the Current Pull System. The total DSA/GSA operational costs under this system, as computed in the previous section, are $869,919. Applying the operations-related land and building rate from Section C.1.6, the DSA/GSA operations-related costs are computed to be (.081)($869,919) = $70,463.

From Section C.3.1, the inventory value at NSC and the servmarts under this alternative is $2,327,562. Applying the storage-related land and building rate from C.1.6, the NSC storage-related costs are (.0315)($2,327,562) = $73,318. The total NSC plus servmart operational costs as computed in the previous section are $2,811,092 + $196,576 = $3,007,668, and generate operations-related land and building costs of (.081)($3,007,668) = $243,621. Both the storage and operations-related land and building costs for major activities are exactly the same as under the Current Pull System.

C.4 LOCAL PUSH/CURRENT RANGE SYSTEM

C.4.1 Inventory Holding Costs

DSA/GSA and major activity inventory levels under this alternative are the same as under the Current Pull System, therefore holding costs are unchanged. NSC plus servmart inventories are the same as in the Local Push/Expanded Range System, and so the holding cost associated with this material is the same as computed for that alternative in Section C.3.1.

C.4.2 In-Transit Inventory Holding Costs

All in-transit inventory levels and holding costs are the same as under the Current Pull System except that NSC is now charged for all these expenses.

C.4.3 Transportation Costs

All DSA/GSA transportation costs are exactly the same as under the Current Pull System. NSC transportation costs are equal to the current costs (since demand at NSC is the same) plus an amount corresponding to the expected redistribution of material within the area (due to areawide asset visibility). This last amount is available from calculations made for the Total Push System in Table C.2.3. NSC transportation costs for the Local Push/Current Range System may be computed as column (2) of that table,

plus the difference between columns (4) and (3). The resulting costs are as follows: $148,935 due to servmart shipments, $311,633 due to major activity shipments, and $286,127 due to other customer shipments, for a total of $746,695.

C.4.4 Issue and Receipt Costs

Receiving costs at DSA/GSA and at NSC are the same as under the Current Pull System. Receiving costs at both servmarts and major activities due to material arriving from NSC are also the same as under the Current Pull System. However, costs due to receipts of material arriving from vendors and from DSA/GSA must be calculated for both servmarts and major activities using the same methodology as in Section C.2.4.3. From Sections A.1.4 and A.2.4, the dollar demand and number of receipts at servmarts and major activities under the Local Push/Current Range System are:

Source of Receipts	Dollar Value Received At		Number of Receipts At	
	Servmarts	Major Activities	Servmarts	Major Activities
DSA/GSA	$593,260	$6,340,608	6984	38,156
Vendors	18,349	196,101	216	1,180

Multiplying the dollar value of demand received by the volume-related receiving rate (.0128) and the number of receipts by the item-related receipt cost ($.62), both from Section C.1.4.3, the remaining servmart and major activity receipt costs are computed as follows:

Source of Receipts	Volume Related Costs		Item-Related Costs		Total Costs	
	Servmarts	Major Act	Servmarts	Major Act	Servmarts	Major Act.
DSA/GSA	$7594	$81,160	$4,330	$23,657	$11,924	$104,817
Vendors	235	2,510	134	732	369	3,242
NSC	95082	197,596	83,655	42,929	178,737	240,525
					$191,030	$348,584

DSA/GSA issuing costs for issues to NSC are the same as under the Current Pull System. From the end of Section C.1.4.2, the current volume-related DSA/GSA issuing cost for issues to servmarts is $4,720, and to major activities, $50,162. The current item-related DSA/GSA issuing cost for issues to servmarts is $11,937, and to major activities, $26,201. The volume-related costs will remain constant since the same volume of material will be issued under this alternative. The item-related costs, however, will change in proportion to the change in the number of issues. From Section A.2.1, the current number of issues to servmarts from DSA/GSA is 15,662, and the current number of issues to major activities is 34,375. From Section A.2.4, the new number of issues under the Local Push/Current Range System includes 6984 to servmarts and 38,156 to major activities. By multiplying the current servmart item-related cost by the ratio 6984 ÷ 15,662 = .446, we obtain a new item-related cost of (.446)($11,937) = $5,324, and a total DSA/GSA issuing cost to servmarts of $4,720 + $5,324 = $10,044. In a similar fashion, multiplying the current major activity item-related cost by the ratio 38,156 ÷ 34,375 = 1.110, we obtain a new item-related cost of (1.110)($26,201) = $29,083, and a total DSA/GSA issuing cost to major activities of $50,162 + $29,083 = $79,245.

NSC issuing costs are the same as under the Current Pull System less an amount corresponding to the current Requisition Processing costs for requisitions from servmarts and major activities. From Section A.2.1, the current number of requisitions from servmarts and major activities for NSC-carried material is 134,928 + 69,240 = 204,168. At the $.30 Requisition Processing rate quoted in Table C.1.4, this implies a reduction of ($.30)(204,168) = $61,250 in current Requisition Processing costs. Prorating this reduction between servmarts and major activities based on the new number of issues to each (134,928 to servmarts and 69,240 to major activities),

we attribute (.661)($61,250)= $40,486 of the reduction in issuing costs to servmart issues and (.339) ($61,250) = $20,764 to major activity issues. Applying these prorated reductions to the appropriate costs under the Current Pull System from Section C.1.4.1, we obtain new servmart-related NSC issuing costs of $236,329 - $40,486 = $195,843, major activity-related NSC issuing costs of $331,112 - $20,764 = $310,348, and other customer-related NSC issuing costs equal to the current $587,643.

C.4.5 Overhead Costs

Total DSA/GSA receiving ($294,786) and issuing costs ($589,399) under this alternative total $884,185. Applying the overhead rate from Section C.1.5, these operational costs generate (1.313)($884,185) = $1,160,935 in overhead expense. NSC receiving ($565,383), issuing($1,093,834), and transportation costs ($746,695), plus servmart receiving costs ($191,030) total $2,596,942, and generate (1.313)($2,596,942) = $3,409,785 in overhead costs for NSC. Major activity receiving costs of $348,584 produce (1.313) ($348,584) = $457,691 in overhead expense.

C.4.6 Land and Building Costs

Storage-related land and building costs are exactly the same as under the Local Push/Expanded Range System. Applying the operations-related land and building rate (.081) developed in Section C.1.6 to the total operations costs summarized in the previous section, operations-related land and building costs for DSA/GSA are calculated to be (.081)($884,185) = $71,619 for NSC, (.081)($2,596,942) = $210,352, and for major activities (.081)($348,584) = $28,235 .

APPENDIX D: SIMULATION

Appendix B showed how the reordering rule for resupplying NSC-SD in the proposed systems is specified by the area-wide service level. The average on-hand inventory for San Diego as a whole is also determined by this area-wide measure. However, the following statistics corresponding to a particular area-wide service level can not be computed with exact analytical expressions:

a) The frequency of shipments between main supply and the activities/ Servmarts;

b) The individual service levels at main supply and at the activities/ Servmarts;

c) The individual average on-hand inventories at main supply and at the activities/Servmarts.

One approach for obtaining these statistics is to simulate the operations of the proposed Naval Supply System. Consequently, a simulation model of the supply system was developed. However, while the simulation was useful toward gaining an understanding of system operations, it was ultimately not used directly in the analysis. Instead, the simulation provided insight which led to analytical approximations for the foregoing statistics. It was felt that these approximations would provide more accurate estimates than would be provided by the simulation model for the following reason: for some items, the DSA/GSA cycle is more than one year; i.e., shipments from DSA/GSA would come less than once a year. But some statistics, such as the service level at main supply, can only be computed when DSA/GSA shipments arrive, which implies that the simulation must include

a number of years to obtain statistically reliable estimates. On the other hand, demands must be generated for each day of each year in the simulation, in order to estimate the amount of direct customer sales, activity sales, effect of rationing, frequency of shipments to activities, service levels at activities, etc. Thus, the simulation effort would require a large amount of computer time. Furthermore, the simulation would have to be performed for several types of items (by VAD category, type of reordering rule, etc.). As a result of these considerations, it was concluded that the simulation approach would not be feasible to carry out in practice, and that the alternative approach of using approximate formulas would be more reliable.

Nevertheless, we will briefly describe how the simulation model was formulated. Two random variables are generated for each day to represent San Diego demands during that day: the direct customer sales at main supply; and the total sales at all activities and Servmarts. When the accumulated activity/Servmart sales reaches its reorder point (for the group trigger of the base stock system), then a shipment to the activities/Servmarts is sent. Note that with a group trigger rule, all activities and Servmarts are resupplied simultaneously. Thus, it is not necessary to generate the daily demand separately for each activity and Servmart: only the area-wide (excluding direct customers) demand needs to be known. This follows from the fact that the area-wide activity/Servmart demand and the demand at any activity/Servmart can be represented with a bivariate Normal distribution; thus, if the area-wide demand were known and if the correlation coefficient between the area-wide demand and demand at an individual activity/Servmart were known, then the conditional distribution of demand at that activity/Servmart (given the area-wide demand) would also be known. This would allow the individual service levels and on-hand inventories at the activities/Servmarts to be computed using only knowledge of the

generated area-wide demand over an activity/Servmart replenishment cycle. Furthermore, the area-wide demand (because of the group trigger) also specifies the frequency of shipments to the activities/Servmarts. In addition to simulating the reordering process for resupplying activities and Servmarts, it is also necessary to simulate the reordering process for resupplying main supply from vendors. In this case, two ordering rules are possible: a reorder point-reorder quantity model for direct shipments from vendors; and the base stock system for transshipments through DSA/GSA. In the case of the base stock system, it is also necessary to model the effects of composition delay and a random DSA/GSA cycle time.

APPENDIX E: MASTER ITEM STOCK RECORD TAPE PROCESSING

E.1 DATA HANDLING

E.1.1 Initial Edit

Master Item Stock Record (MISR) Tapes were available for NSC San Diego, the 11 Servmarts currently operated by NSC (one consolidated Master Servmart File), and the seven major San Diego Naval activities, listed in Table E.1. The data elements which were present on these tapes are indicated in Table E.2. Selection of 9 cog records (except in the case of Servmarts, where no cog was present) resulted in the number of records shown in column (1), Table E.1. An initial edit was then made to detect alpha characters in numeric fields excluded the number of records indicated in column (2). The Servmart figure here corresponds closely to the known number of local stock numbers currently in use.

E.1.2 Sampling and Consolidation

A sampling scheme was applied to each MISR tape to distribute records into groups based on the integer remainder obtained upon dividing their FSN's by eleven. Groups of nearly equal size resulted, representing the remainders 0 through 10. The 0-remainder group was selected from each tape. These records were then assigned location source codes, consolidated into a working tape in the format of Table E.2, column (2), and sorted by source code within FIIN. As a result, an FSN selected from one location appeared with all corresponding records from every other location carrying that same FSN. All statistics computed from the working tape which were dependent upon sample size, e.g., the value of annual demand, were scaled by a factor of 11.

E.1.3 Extended Money Value Edit

A money value extension of the OH, AQD, RP, and RO fields was made to detect erroneous data which might distort subsequent calculations made

TABLE E-1

MISR TAPE SAMPLING

Tape Source	(1) Total 9-COG Records	(2) No. of Records Excluded[2]	(3) No. of Records In Sample
1. NSC	37,324	58	3,381
2. SERVMARTS (11)	26,949[1]	1,580	2,497
3. NAVAL AIR REWORK FACILITY	9,773	337	907
4. DEVELOPMENT & TRAINING CENTER	13,072	0	1,178
5. LONG BEACH NAVAL SHIPYARD	10,123	0	912
6. NAS NORTH ISLAND	8,209	42	761
7. NAS MIRAMAR	26,611	6	2,412
8. PUBLIC WORKS CENTER	3,448	0	327
9. SD NAVAL HOSPITAL	1,404	140	141
TOTAL	136,913	1,826	12,516

1 Includes all COG's

2 Due to initial edit for alpha characters in numeric fields -- represents primarily local stock numbers

from the working tape. An extension threshold of $5000 was selected for the OH, AQD, and RP fields, and $10,000 for the RO field. Exactly 37 records were flagged for exceeding one or more of these limits and six of these were deleted after a manual determination had been made regarding the existence of an obvious error condition. At the same time, 307 Servmart non-NSC records representing ØI and lI cog material were deleted, based on the FSC portion of the FSN (no COG's were present in Servmart records.)

E.2 DATA ENRICHMENT

Columns (3) and (4) of Table E.2 indicate the original data elements present on the MISR tapes and those elements which had to be extrapolated or inferred, either from original data or from external sources.

E.2.1 VAD Categories

Assignment of an area-wide VAD category for each non-NSC item was made, based on the value of the total area-wide annual demand at all carrying activities and Servmarts, the cog symbol, and the NSC VAD parameters developed by FMSO and displayed in Table 2.1. The NSC VAD category served as the area-wide VAD category for NSC-carried items.

E.2.2 Reorder Objective/Reorder Point

RO and RP computations were necessary for all major activities except NSC, NAS North Island, and the Servmarts. Reorder points were computed according to the following rules, based on information obtained through NSC-SD:

ACTIVITY	RP FOR NSC-CARRIED ITEMS (MONTHS' SUPPLY)	RP FOR NON-NSC ITEMS (MONTHS' SUPPLY)
Development and Training Center	1.0	1.5
Long Beach Naval Shipyard	1.5	2.0
Naval Air Rework Facility	1.5	2.0
NAS Miramar	2.0	2.5

TABLE E-2

STANDARD MISR TAPE RECORD FORMAT

	(1) DATA ELEMENT	(2) DATA COLUMNS		(3) ORIGINAL DATA	(4) INFERRED DATA
1.	SOURCE CODE (SRC)	1-2	A/N	---	All Locations
2.	COGNIZANCE SYMBOL (COG)	3-4	A/N	NSC, Major Activities	Servmarts
3.	MATERIAL CONTROL CODE, ACQUISITION ADVICE CODE (MCC/ACC)	5	A	NSC, Major Activities	---
4.	FEDERAL STOCK NUMBER (FSN)	6-16	N	All Locations	---
5.	UNIT OF ISSUE (UI)	17-18	A	All Locations	---
6.	UNIT PRICE (UP)	19-28	N	All Locations	---
7.	ON HAND (OH)	29-36	N	All Locations	---
8.	ON ORDER (OO)	37-42	N	NSC, Major Activities	---
9.	BACK ORDER (BO)	43-48	N	NSC, Major Activities	---
10.	LOW LIMIT-REORDER POINT (LL or RP)	49-54	N	NSC, Servmarts	Major Activities less North Island
11.	FREQUENCY OF ANNUAL DEMAND (FAD)	55-57	N	NSC, Major Activities	Servmarts
12.	VAD CATEGORY (VAD)	58	A	NSC-Carried Items North Island	Non-NSC Items
13.	LEAD TIME (LT) in tenths of a month	59-60	N	NSC, North Island	---
14.	HIGH LIMIT-REORDER OBJECTIVE (HL or RO)	61-66	N	NSC, Servmarts	Major Activities less North Island
15.	AVERAGE QUARTERLY DEMAND (AQD) in hundredths	67-74	N	All	---
16.	MEAN ABSOLUTE DEVIATION (MAD)	75-82	N	NSC, North Island	---

ACTIVITY (cont'd)

Public Works Center	1.5	2.0
SD Naval Hospital	1.5	2.0

Reorder objectives were computed based on the average order quantity used by NAS North Island for a given area-wide VAD category, as determined by sampling. This order quantity, in months supply, was then added to the previously computed RP to obtain the RO. The average order quantities used were as follows:

AREA-WIDE VAD CATEGORY	ORDER QUANTITY (MONTHS SUPPLY)
A	1.44
B	2.09
C	2.28
D	2.90
E	2.93
F	4.17
G	5.00
H	7.17
I	8.10
J	9.20

E.2.3 Servmart COG's and FAD's

The Servmart records contained no cog symbols. Cog's were inferred from the NSC record for NSC-carried items and were assumed to be 9Q, i.e., GSA-managed material, for non-NSC items. Servmart records were also lacking FAD data. These were extrapolated based on the total area-wide AQD for the item and the area-wide FAD/AQD ratio, determined from the records of those activities carrying the same item. If no other activities carried the item, the following rules were used to assign a FAD:

Range of Servmart AQD	Corresponding FAD Assignment
$0 \leq AQD < .25$	0
$.25 \leq AQD < .50$	1
$.50 \leq AQD < .75$	2
$.75 \leq AQD < 1.00$	3
$1.00 \leq AQD$	4

E.2.4 Unit of Issue Differences

When it was apparent that unit of issue differences existed among activities carrying the same FSN, the unit of issue in use by NSC, or when not available, by the first activity record appearing, was adopted as the area standard. The OH, OO, BO, RO, RP and AQD fields of the remaining records were then scaled by the ratio of the standard unit price to the unit price of the record to be scaled. The standard unit price was then assumed by all records.

E.2.5 Area-wide AQD Exceeds NSC AQD

Whenever the total activity and Servmart AQD for an NSC-carried item exceeded the recorded AQD at NSC, e.g., due to varying demand recording and averaging procedures, the NSC AQD was increased to obtain equality. The NSC FAD was then adjusted to maintain a constant relation to the AQD.

E.3 COMPUTED STATISTICS

The following statistics were produced from the consolidated working tape as enhanced in section E.2:

1. The value of annual demand, by VAD category,
   a) at NSC for items carried elsewhere,
   b) at NSC for items not carried elsewhere,
   c) at the major activities for NSC-carried items,
   d) at the major activities for non-NSC items,
   e) at the Servmarts for NSC-carried items,
   f) at the Servmarts for non-NSC items.
2. The frequency of ordering
   a) NSC-carried items by activity/Servmart,
   b) non-NSC items by activity/Servmart.
3. The value of annual demand, by cog, among activities and Servmarts
   a) for NSC-carried items
   b) for non-NSC items.
4. The number of annual issues
   a) from NSC stocks, by VAD,
   b) from major activity stocks.
5. The number of non-NSC items carried among major activities and Servmarts, by VAD.
6. The number of NSC items carried, by VAD.
7. Coefficient of variation, by VAD,
   a) for NSC demand,
   b) for activity/Servmart demand.
8. Area-wide coefficient of variation, by VAD,
   a) for NSC demand,
   b) for activity/Servmart demand.
9. Dollar value of on-hand inventory, by VAD,
   a) of NSC-carried items at major activities,
   b) of non-NSC items at major activities,
   c) of NSC-carried items at Servmarts,
   d) of non-NSC items at Servmarts

10. Number of positive demand locations

    a) by given activity/Servmart,

    b) with non-zero on-hand balance locally by activity/Servmart,

    c) with inventory somewhere in the area by activity/Servmart.

11. Number of items having a given number of positive demand locations, by VAD,

    a) for NSC-carried items at major activities,

    b) for non-NSC items at major activities,

    c) for NSC-carried items at Servmarts,

    d) for non-NSC items at Servmarts.

12. Sum of the reorder point dollar values, by VAD,

    a) for NSC items carried elsewhere,

    b) for NSC items not carried elsewhere,

    c) for NSC-carried items of activities/Servmarts,

    d) for non-NSC items at activities/Servmarts.

13. Sum of the reorder quantity dollar values, by VAD,

    a) for NSC-carried items at activities/Servmarts,

    b) for non-NSC items at activities/Servmarts.

REFERENCES

1. FMSO Management Criteria Listing Report 4422-22 for NSC-San Diego, quarter ending 30 June 1974.

2. The Evaluation of Alternative Retail Inventory Distribution Concepts, Control Analysis Report No. 86-13 of October 1973.

3. Sample of 9-cog receipts at NSC from DSA/GSA and direct from vendors, October 1974.

4. Sample of DSA ordering quantities for NSC 9 cog items by NSC VAD category, October 1974.

5. NAVCOMPT Form 2168, Operating Budget Expense Report for NSC-San Diego, FY 74.

6. Emanuel Parzen, Stochastic Processes, Holden-Day, Inc., San Francisco, 1962.

7. G.Hadley and T.M. Whitin, Analysis of Inventory Systems, Prentice-Hall, Inc., Englewood Cliffs, 1963.

8. An Introduction to the Defense Supply Agency, Defense Supply Agency, Cameron Station, Alexandria, Virginia, 1974.

9. Variable Operating and Safety Level Requisitions Short Model, Fleet Material Support Office, July 1971.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER (9) Rept.

4. TITLE (and Subtitle) (6)
AN EVALUATION OF THE AREA SUPPORT/ WHOLESALE MANAGEMENT CONCEPT FOR RESUPPLY OF CURRENT RETAIL INVENTORY.

5. TYPE OF REPORT & PERIOD COVERED
DRAFT August-December, 74

6. PERFORMING ORG. REPORT NUMBER (14)
266-13

7. AUTHOR(s) (10)
M.A. Crane, Z.F. Lansdowne, R.C. Morey and D.P. Snyder

8. CONTRACT OR GRANT NUMBER(s) (15)
N00014-72-C-0266
(NR-347-022)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
CONTROL ANALYSIS CORPORATION
800 Welch Road, Suite 268
Palo Alto, Ca. 94304

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS (11)

12. REPORT DATE
December 1974

13. NUMBER OF PAGES
173

14. MONITORING AGENCY NAME & ADDRESS (If different from Controlling Office)
Office of Naval Research
800 N. Quincy
Arlington, VA. 22217
(12) 244 p.

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Reproduction in whole or part is permitted for any purpose of the United States Government.

DISTRIBUTION STATEMENT A
Approved for public release; Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Inventory System
Ordering Rules
Lead Times
Transit Times
Service Levels

→ This study,

20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This study, performed over five months, compares the costs and service level effectiveness associated with several alternative resupply systems. Each of these alternatives systems, characterized by more emphasis on centralization, is compared to the decentralized scheme currently in use at several Naval Supply Centers. These centralized schemes all employ the notion of an Area Naval Support Center and are motivated by the belief that replacing of the current 'pull'/ retail system by a vertically-managed 'pull'/wholesale system will offer considerable economies, both in the inventory and personnel areas.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

407383

INSTRUCTIONS FOR PREPARATION OF REPORT DOCUMENTATION PAGE

RESPONSIBILITY. The controlling DoD office will be responsible for completion of the Report Documentation Page, DD Form 1473, in all technical reports prepared by or for DoD organizations.

CLASSIFICATION. Since this Report Documentation Page, DD Form 1473, is used in preparing announcements, bibliographies, and data banks, it should be unclassified if possible. If a classification is required, identify the classified items on the page by the appropriate symbol.

COMPLETION GUIDE

General. Make Blocks 1, 4, 5, 6, 7, 11, 13, 15, and 16 agree with the corresponding information on the report cover. Leave Blocks 2 and 3 blank.

Block 1. Report Number. *Enter the unique alphanumeric report number shown on the cover.*

Block 2. Government Accession No. Leave Blank. This space is for use by the Defense Documentation Center.

Block 3. Recipient's Catalog Number. Leave blank. This space is for the use of the report recipient to assist in future retrieval of the document.

Block 4. Title and Subtitle. Enter the title in all capital letters exactly as it appears on the publication. Titles should be unclassified whenever possible. Write out the English equivalent for Greek letters and mathematical symbols in the title *(see "Abstracting Scientific and Technical Reports of Defense-sponsored RDT/E," AD-667 000)*. If the report has a subtitle, this subtitle should follow the main title, be separated by a comma or semicolon if appropriate, and be initially capitalized. If a publication has a title in a foreign language, translate the title into English and follow the English translation with the title in the original language. Make every effort to simplify the title before publication.

Block 5. Type of Report and Period Covered. Indicate here whether report is interim, final, etc., and, if applicable, inclusive dates of period covered, such as the life of a contract covered in a final contractor report.

Block 6. Performing Organization Report Number. Only numbers other than the official report number shown in Block 1, such as series numbers for in-house reports or a contractor/grantee number assigned by him, will be placed in this space. If no such numbers are used, leave this space blank.

Block 7. Author(s). Include corresponding information from the report cover. Give the name(s) of the author(s) in conventional order *(for example, John R. Doe or, if author prefers, J. Robert Doe)*. In addition, list the affiliation of an author if it differs from that of the performing organization.

Block 8. Contract or Grant Number(s). For a contractor or grantee report, enter the complete contract or grant number(s) under which the work reported was accomplished. Leave blank in in-house reports.

Block 9. Performing Organization Name and Address. For in-house reports enter the name and address, including office symbol, of the performing activity. For contractor or grantee reports enter the name and address of the contractor or grantee who prepared the report and identify the appropriate corporate division, school, laboratory, etc., of the author. List city, state, and ZIP Code.

Block 10. Program Element, Project, Task Area, and Work Unit Numbers. Enter here the number code from the applicable Department of Defense form, such as the DD Form 1498, "Research and Technology Work Unit Summary" or the DD Form 1634. "Research and Development Planning Summary," which identifies the program element, project, task area, and work unit or equivalent under which the work was authorized.

Block 11. Controlling Office Name and Address. Enter the full, official name and address, including office symbol, of the controlling office. *(Equates to funding/sponsoring agency. For definition see DoD Directive 5200.20, "Distribution Statements on Technical Documents.")*

Block 12. Report Date. Enter here the day, month, and year or month and year as shown on the cover.

Block 13. Number of Pages. Enter the total number of pages.

Block 14. Monitoring Agency Name and Address *(if different from Controlling Office)*. For use when the controlling or funding office does not directly administer a project, contract, or grant, but delegates the administrative responsibility to another organization.

Blocks 15 & 15a. Security Classification of the Report: Declassification/Downgrading Schedule of the Report. Enter in 15 the highest classification of the report. If appropriate, enter in 15a the declassification/downgrading schedule of the report, using the abbreviations for declassification/downgrading schedules listed in paragraph 4-207 of DoD 5200.1-R.

Block 16. Distribution Statement of the Report. Insert here the applicable distribution statement of the report from DoD Directive 5200.20, "Distribution Statements on Technical Documents."

Block 17. Distribution Statement *(of the abstract entered in Block 20, if different from the distribution statement of the report)*. Insert here the applicable distribution statement of the abstract from DoD Directive 5200.20, "Distribution Statements on Technical Documents."

Block 18. Supplementary Notes. Enter information not included elsewhere but useful, such as: Prepared in cooperation with . . . Translation of *(or by)* . . . Presented at conference of . . . To be published in . . .

Block 19. Key Words. Select terms or short phrases that identify the principal subjects covered in the report, and are sufficiently specific and precise to be used as index entries for cataloging, conforming to standard terminology. The DoD "Thesaurus of Engineering and Scientific Terms" *(TEST)*, AD-672 000, can be helpful.

Block 20. Abstract. The abstract should be a brief *(not to exceed 200 words)* factual summary of the most significant information contained in the report. If possible, the abstract of a classified report should be unclassified and the abstract to an unclassified report should consist of publicly- releasable information. If the report contains a significant bibliography or literature survey, mention it here. For information on preparing abstracts see "Abstracting Scientific and Technical Reports of Defense-Sponsored RDT&E," AD-667 000.