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## ON INVENTORY RECORD ACCURACY

by

David A. Schrady

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UNITED STATES NAVAL POSTGRADUATE SCHOOL
Monterey, California

Rear Admiral Robert W. McNitt, USN,
Superintendent

Dr. R. F. Rinehart,
Academic Dean

ABSTRACT:

An inventory stock record is in error when the information on the stock record is not in agreement with the actual state of affairs. We address the questions of what is meant by inventory record accuracy as reported in the literature and in official documents and what should be meant by this term, in the context of the inventory record accuracy problem defined by the Naval Supply Systems Command. The need for, and suggestions of, operational definitions of error measures are demonstrated in terms of the reporting of accuracy statistics, the formulation of inventory record accuracy goals, and the determination of corrective measures.

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Prepared by:

David A. Schrady
David A. Schrady,
Assistant Professor

Approved by:

J. R. Borsting,
Chairman, Department of
Operations Analysis

Released by:

C. E. Menneken,
Dean of
Research Administration

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# PART I - BACKGROUND

## 1. Introduction

The problem concerns errors which are generated in and exist in inventory stock records. In a broad sense, the problem embraces the subject areas of accounting and audit systems and controls, personnel, physical security, work methods and standards, management information systems, and mathematical inventory theory. The approach followed in this report is that of the operations researcher whose primary interest is in mathematical inventory theory. From the operations research point of view, there are two basic problems which inventory record errors present. The first concerns the application of optimal ordering policies to inaccurate records. If the records indicate more stock than is actually present, the system fails to order when it should with the result that greater than optimal shortages are incurred. If the records indicate less stock than is actually present, the system reorders too soon with the result that the inventory investment is too large The second problem is one of minimizing total costs. There is a cost associated with operating a system with inaccurate inventory records, and there is a cost associated with achieving and maintaining a given level of inventory record accuracy. The problem is to specify the level of record accuracy which minimizes the sum of these costs. A subproblem is to specify the procedures for obtaining a given level of record accuracy at minimum cost.

This report is limited to the discussion of what is meant by the stock record error, as a first step toward the quantitative analysis of the costs and benefits associated with record accuracy. Specifically, we address the inventory record accuracy problem as it exists in the U.S. Navy. The Auditor General of the Navy Report of April, 1965, indicated that 29 percent of the Navy and Marine Corps stock records were in error [1]. This error is a source of embarrassment to the Supply Corps, opens them to criticism from the General Accounting Office [2], compromises their budget requests, and, most significantly, reduces their ability to perform their mission of supplying the operating units of the service.

Inventory record accuracy (the lack of) is a problem confronting all of the military services, and probably industry as well. It is an old problem and one not easily remedied. It is an especially difficult problem for the military establishment due to the range of items stocked. Only the very largest of corporations have as many as 100,000 different items in inventory. General Motors carries about 120,000 items, and J. C. Penney carries about 25,000 items [3]. By contrast, the Naval Aviation Supply Office (one of three inventory managers in the Navy supply system) alone carries more than 400,000 items and a large Naval Supply Center stocks as many as 900,000 items. The sheer volume of record keeping aggravates the inventory record accuracy problem.

This volume also dictated early use of electronic data processing systems. While it is always fashionable to state that "people are no damn good" (and indeed the statement applies to certain aspects of this problem), EDP has created a physical gap between the people and the records and eroded the structure of responsibility. This increases the likelihood of error introduction and complicates the problem of error correction.

Some inventory record errors are the result of theft of material. The cost of errors generated by thefts is the cost of the material involved and the loss of service that the material could have provided. However, the majority of record errors are generated by "honest mistakes". The cost of these honest mistakes has a monitary value in terms of increased investment levels (when this results), but is best measured in terms of disservice. A recent Navy Area Audit Service report [4] went so far as to state, "...We find even less assurance that the records are sufficiently reliable to permit even adequate material support to operating forces."

Thus, the inventory record accuracy problem is real and serious, and it affects the ability of the Supply Corps to serve the operating forces. The Naval Supply Systems Command (NAVSUP) has recently responded vigorously to the problem through the establishment of the Control of Inventory Task Group, whose task it is to implement immediate and intermediate range corrective measures. Additionally,

a long-range approach to the ultimate control of this problem is currently being formulated. It is a comprehensive program aimed at three specific areas: (1) the physical inventory process, (2) the stock point supply operations and information processing, and (3) the information interfaces of the various stock points with the inventory control points (inventory managers).

The motivation behind writing this report is that, in spite of the reports and studies already conducted on inventory record accuracy, there does not appear to be a clear understanding or definition of the terms and measures of inventory record accuracy and/or error. Until we define our terms and have some common basis on which to communicate and take measurements, the study, reporting, and formulation of corrective actions for record errors will remain unnecessarily vague and imprecise. The statement that 29 percent of the Navy and Marine Corps inventory records are in error is not necessarily meaningful. One must know at the very least how the figure was arrived at, what constituted an error, and the general nature of the individual discrepancies.

By way of introduction, we note that an error is a discrepancy between what the stock record indicates as the "situation" and what is actually the "situation". Many types of discrepancies are possible. The most widely recognized error is a discrepancy in the on-hand quantity.

The mechanism by which these discrepancies are discovered and reconciled is the physical inventory. "Physical inventory" connotes a program to count the quantity of an item in storage, to compare with that

recorded on the accountable stock record and to adjust the record where discrepancies exist. Several types of physical inventories are possible. One type of inventory is the "wall-to-wall" inventory in which the on-hand quantity of every item is verified at a specified point in time. Alternatively there are "spot" inventories which are conducted on specified items at any time that the situation warrants. Commonly a spot inventory is requested for an item if the records indicate a zero balance or if there has been a warehouse refusal.

NAVSUP policy with respect to the taking of wall-to-wall inventories has changed several times during the past ten years. Declining funding dictated a move from an annual physical inventory to a tri-annual schedule. The tri-annual schedule was deemed unsatisfactory and the present plan of conducting annual inventories on "active" items only was adopted. The Fleet Material Support Office is currently developing a "trigger" scheme where the triggering of an inventory is based on item demand characteristics.

The changes have been made in an effort to be more responsive to the problem of record accuracy within a framework of limited resources. Two factors combine to reduce the perceived effectiveness of physical inventory programs. The lack of measurement of the results of expenditures on physical inventories has resulted in decreased funding. In this climate of insufficient funds and personnel, the physical inventory process has been neglected in favor of functions directly related to supply operations.

## 2. Literature

If we create a distinction between reports of measurements of inventory record accuracy and analyses of the inventory record accuracy problem, then we can state that the literature contains few reports of analyses of the problem. The General Accounting Office, Navy Auditor General, and Navy Area Audit Service reports generally only establish and document the existence of the problem. As a part of the background on inventory record accuracy we very briefly note the analyses and their conclusions.

The first study we note was conducted for the Army Office of Ordnance Research [5]. They note that, contrary to one's intuition, the paper work of issue and receipt processing contributes only about 20% of the total record error and the remaining 80% is contributed by the error correcting procedures themselves; i.e., the physical inventory process. They also define a residual error, the error remaining in the records after completion of the physical inventory, and note it to be on the order of 20% to 25%. The second study noted here was conducted by the Naval Supply Research and Development Facility at Bayonne (NAVSUPRANDFAC) [6]. They note a residual error of 7%, but there is reason to suspect that this figure is optimistic. They also note relationships between the probability of an incorrect count and the on-hand quantity, the growth of record errors as a function of the time since the last physical inventory, and the probability of a record

being in error at the end of some time interval as a function of the demand for the item during the period. Finally the recent report of the Control of Inventory Task Group [7] contains some quantitative data, among which is a study showing that 55% of the error was introduced by the physical inventory process.

The inventory record accuracy problem is about, and punctuated with, error percentages. The common term in the literature is "error rate", but it is legitimate to question the meaning of this term. For that matter, how is or should an error be defined? These are not trivial questions and will be addressed in the next section.

## PART II - THE DIMENSIONS OF STOCK RECORD ERROR

### 3. Introduction

Let us begin by indicating what was being measured in two of the analyses referenced in the previous section. In the NAVSUPRANDFAC report the only discrepancies noted as errors were discrepancies in the on-hand quantity. If the item could not be found or could not be identified, then it could not be counted. Location and identity discrepancies were considered only as they contribute to on-hand quantity discrepancies. The "error rates" cited should be interpreted in the following way: At a given point in time, in a sample of N items there were n item records in which there was discrepancy between the recorded amount on hand and the actual warehoused amount on hand, and

therefore 100(n/N)% of the records were in error. Note that all discrepancies in the on-hand quantity were counted equally as errors. This treatment ignored the absolute magnitude and sign of the discrepancies, the magnitude of the discrepancies as percentages of the actual on-hand quantities, and the dollar values of the discrepancies.

While the definition of error was never explicitly given in the NAVSUPRANDFAC report, the Army report used the following definition of error:

> "A difference between record balance and physical stock is counted as a discrepancy (error) if the difference is 1% or more of the record balance, or if the monetary value of the difference is $1 or more."

The above statement is hereafter referred to as a criterion for distinguishing between major and minor errors.

Toward developing the concept and dimensions of error, we shall question, for purposes of illustration only, the meaning of the recommended NAVSUP Specific Objective for inventory record accuracy [8]: "A program for achieving and maintaining a minimum 90% item inventory record accuracy." The 90% requirement is subject to several interpretations, even if we defer the question of what constitutes an accurate item record. It is helpful to recognize the two aspects of the statement of the Specific Objective: the performance implied in the 90% figure and the definition of record accuracy. Each of these aspects of inventory record accuracy are discussed in the sections which follow.

4. Inventory Record Accuracy Performance

Several possible interpretations of the performance measure are as follows:

I. At any arbitrarily selected time at least 90% of the records are accurate;

II. The time average of the percent of accurate records is at least 90%;

III. The time average of the accuracy of an (every) individual item record is at least 90%.

These interpretations of the 90% figure can be explained in terms of an example population of 10 item records, designated item records A, B, ..., J. Let the times at which accuracy checks are made be denoted as $t_1, t_2, \ldots$. For example, consider the time between successive checks to be a month; then 12 checks constitute a year. Given that we have some operational definition of record accuracy, at each time a check is made each item record may be classified as accurate or in error. These results will be displayed in a matrix with an accurate record indicated by a + and an inaccurate record indicated by a 0. Figure 1 (page 14) exhibits four such matrices showing the condition of each item record at the time of each of twelve accuracy checks.

Given the first interpretation of 90% record accuracy, we require that <u>in any and all monthly accuracy checks nine or ten of the ten records be accurate</u>. The matrices of Figures 1a and 1b represent acceptable performance under this interpretation of performance,

while the matrices of Figures 1c and 1d represent unacceptable performance. Implicit in the above statement is a notion of the total time period over which the performance criterion is applied. The implied time period is best taken to be infinite; i.e., over all future time. Thus Figure 1c fails because all item records are in error in the eighth test, and Figure 1d fails because two records are in error in the tenth test. While both Figures 1a and 1b represent acceptable performance, the difference, of course, is that in Figure 1a the record of item A is permanently in error.

The second interpretation of 90% record accuracy relaxes the requirement that record accuracy be 90% or greater at each check and requires only that the time average be 90% or greater. Let $n$ be the total number of records (ten in this example), $n_i$ be the number of accurate records in the $i^{th}$ check ($0 \leq n_i \leq n$), and $N$ be the number of checks over which the time average is to be computed. $N$ is equal to twelve here, and the time period over which the performance criterion is to be applied is explicit. Then the population accuracy in the $i^{th}$ check is $n_i/n$, and the time average of the population record accuracy over $N$ time periods is:

$$\text{Time Average} = \frac{1}{nN} \sum n_i \quad .$$

Thus any matrix with twelve or less zeros (records in error) is acceptable under this interpretation (12/120 = 10%). Under this less restrictive

interpretation of performance, Figures 1a, 1b, and 1c all represent acceptable performance. Only Figure 1d represents unacceptable performance.

The third interpretation of the 90% accuracy requirement specifies that the time average of the accuracy of each and every item record be 90% or greater. This interpretation prohibits any record from remaining permanently in error (as in Figure 1a). In our example interpretation III requires that any row (record accuracy history) have at most one zero. Figure 1b represents acceptable performance as the time average accuracy of all the item records is 92.5% or greater. Figure 1c represents unacceptable performance because the time average accuracy of item record "D" is only 83.3%. Similarly Figures 1a and 1d represent unacceptable performance under this interpretation.

In the table below are summarized the acceptability (A) or unacceptability (U) of each of the performance matrices with respect to each of the interpretations.

| Interpretation | Matrix 1a | 1b | 1c | 1d |
|---|---|---|---|---|
| I. | A | A | U | U |
| II. | A | A | A | U |
| III. | U | A | U | U |

Note that the performance represented in Figure 1d was not acceptable under any of the three interpretations. However, at least intuitively,

the performance in Figure 1d is preferable to the performances of Figures 1a and 1c. Figures 1a and 1c represent extreme cases and may not fairly test the adequacy of the proposed performance interpretations. However, the point raised, whether or not 1d is preferable to either or both of 1a and 1c, is indicative of pitfalls that one may encounter in designing and applying performance indices.

Finally we note the critical influence of the time parameter on the two interpretations which involve time averages. We had been thinking of the time intervals at which accuracy checks were made as months. The time averages of interpretations II and III were computed over a time period of one year. Suppose now that we are still interested in time averages computed over one year but that we now assume that the data in the four tables represents accuracy checks for three years at quarterly intervals. While the matrix of Figure 1b was acceptable under interpretation III with monthly checks, it is unacceptable under interpretation III in each of the three years now represented by the twelve quarterly checks. The following table summarizes the three years of quarterly accuracy checks represented in Figures 1a - 1d in terms of the two performance interpretations involving time averages.

| Interpretation \ Figure | 1a | | | 1b | | | 1c | | | 1d | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| II. | A | A | A | A | A | A | A | U | A | A | A | U |
| III. | U | U | U | U | U | U | U | U | A | U | U | U |

The above discussion was intended to call attention to the need to operationally define any statement or objective with respect to inventory accuracy performance. In discussing the meaning of record accuracy and/or error we have tried to separate the question of performance from the question of error. We now address the meaning of a record error.

Accuracy Check / Item

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| B | + | + | + | + | + | + | + | + | + | + | + | + |
| C | + | + | + | + | + | + | + | + | + | + | + | + |
| D | + | + | + | + | + | + | + | + | + | + | + | + |
| E | + | + | + | + | + | + | + | + | + | + | + | + |
| F | + | + | + | + | + | + | + | + | + | + | + | + |
| G | + | + | + | + | + | + | + | + | + | + | + | + |
| H | + | + | + | + | + | + | + | + | + | + | + | + |
| I | + | + | + | + | + | + | + | + | + | + | + | + |
| J | + | + | + | + | + | + | + | + | + | + | + | + |

Fig. Ia

Accuracy Check / Item

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | + | + | + | + | + | + | + | + | + | 0 | + | + |
| B | + | 0 | + | + | + | + | + | + | + | + | + | + |
| C | + | + | + | + | + | 0 | + | + | + | + | + | + |
| D | + | + | 0 | + | + | + | + | + | + | + | + | + |
| E | + | + | + | + | + | + | + | + | + | + | + | + |
| F | + | + | + | + | + | + | + | + | + | + | + | 0 |
| G | + | + | + | + | + | + | 0 | + | + | + | + | + |
| H | 0 | + | + | + | + | + | + | + | + | + | + | + |
| I | + | + | + | + | + | + | + | 0 | + | + | + | + |
| J | + | + | + | 0 | + | + | + | + | + | + | + | + |

Fig. Ib

Accuracy Check / Item

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | + | + | + | + | + | + | + | 0 | + | + | + | + |
| B | + | + | + | + | + | + | + | 0 | + | + | + | + |
| C | + | + | + | + | + | + | + | 0 | + | + | + | + |
| D | + | 0 | + | + | + | + | + | 0 | + | + | + | + |
| E | + | + | + | + | + | + | + | 0 | + | + | + | + |
| F | + | + | + | + | + | + | + | 0 | + | + | + | + |
| G | + | + | + | + | + | + | + | 0 | + | + | + | + |
| H | + | + | + | + | + | + | + | 0 | + | + | + | + |
| I | + | + | + | + | + | + | + | 0 | + | + | + | + |
| J | + | + | + | + | + | + | + | 0 | + | + | + | + |

Fig. Ic

Accuracy Check / Item

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 0 | + | + | + | + | + | + | + | + | 0 | + | + |
| B | + | 0 | + | + | + | + | + | + | + | + | 0 | + |
| C | + | + | 0 | + | + | + | + | + | + | + | + | 0 |
| D | + | + | + | 0 | + | + | + | + | + | + | + | + |
| E | + | + | + | + | 0 | + | + | + | + | + | + | + |
| F | + | + | + | + | + | 0 | + | + | + | + | + | + |
| G | + | + | + | + | + | + | 0 | + | + | + | + | + |
| H | + | + | + | + | + | + | + | 0 | + | + | + | + |
| I | + | + | + | + | + | + | + | + | 0 | + | + | + |
| J | + | + | + | + | + | + | + | + | + | 0 | + | + |

Fig. Id

## 5. The Definition of Inventory Record Error

A stock record for a given item contains a large amount of information. Any of the bits of data about the item could be discrepant. The question is one of deciding which discrepancies constitute errors and how error rates or error percentages should be defined. A record could be in error with respect to the on-hand quantity, primary storage location, identity (cog, FSC, FIIN), price, unit of issue, quantity on order, substitutes, etc. Are discrepancies in all of these bits of information equally important? Does the question of error have to be an all or nothing characteristic, i.e., any discrepancy means the record is in error and only discrepancy-free records are accurate. Is the magnitude of discrepancy important? Is a quantity error of ten units, plus or minus, as important when the actual on-hand quantity is 869 units as when the actual on-hand balance is 4 units? Regardless of the actual quantity on hand is the importance of a quantity discrepancy of ten units independent of the unit price of the item? * Should there be some concept of major and minor errors, or of the degree or seriousness of a given discrepancy?

The Army report [5] used an explicit definition of major and minor errors (see page 8, this report). Most would agree that an error representing less than one per cent of the on-hand quantity and

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* We avoid discussion of "military essentiality", because, while everyone agrees to the value of such a measure, no one can demonstrate a reasonable way to determine such utility measures.

less than one dollar in value is not worth worrying about. The question of course arises as to whether an error representing 3% of the on-hand quantity and $4.53 in value is serious. An all-encompassing answer to this type of question is not easily obtained. The problem of criteria for distinguishing between major and minor errors is illustrated in the following plot (see Fig. 2.) of error value versus error percentage. The unit square at the origin represents the Army criterion for minor errors [5]. There is some boundary (shown as a convex function) such that any error represented by a point above the boundary is almost surely a major error. This leaves a large problem area (shaded) in which it is not at all clear whether the error is a major or minor one.

Another point we wish to raise is that much of the data on an item stock record is not normally verified. While the on-hand quantity and location is verified by periodic physical inventories, there are no system-wide programs to verify such data as unit price, unit of issue, on order quantity, etc. But errors in "unit of issue" will result in on-hand quantity errors being introduced. Further, at the Inventory Control Point, procurement decisions are tied to the inventory position of the item. The inventory position is defined as the quantity on hand, plus the quantity on order, minus the quantity backordered. The on-hand quantity is but one of three pieces of information required to implement current UICP inventory policies. In today's climate of low

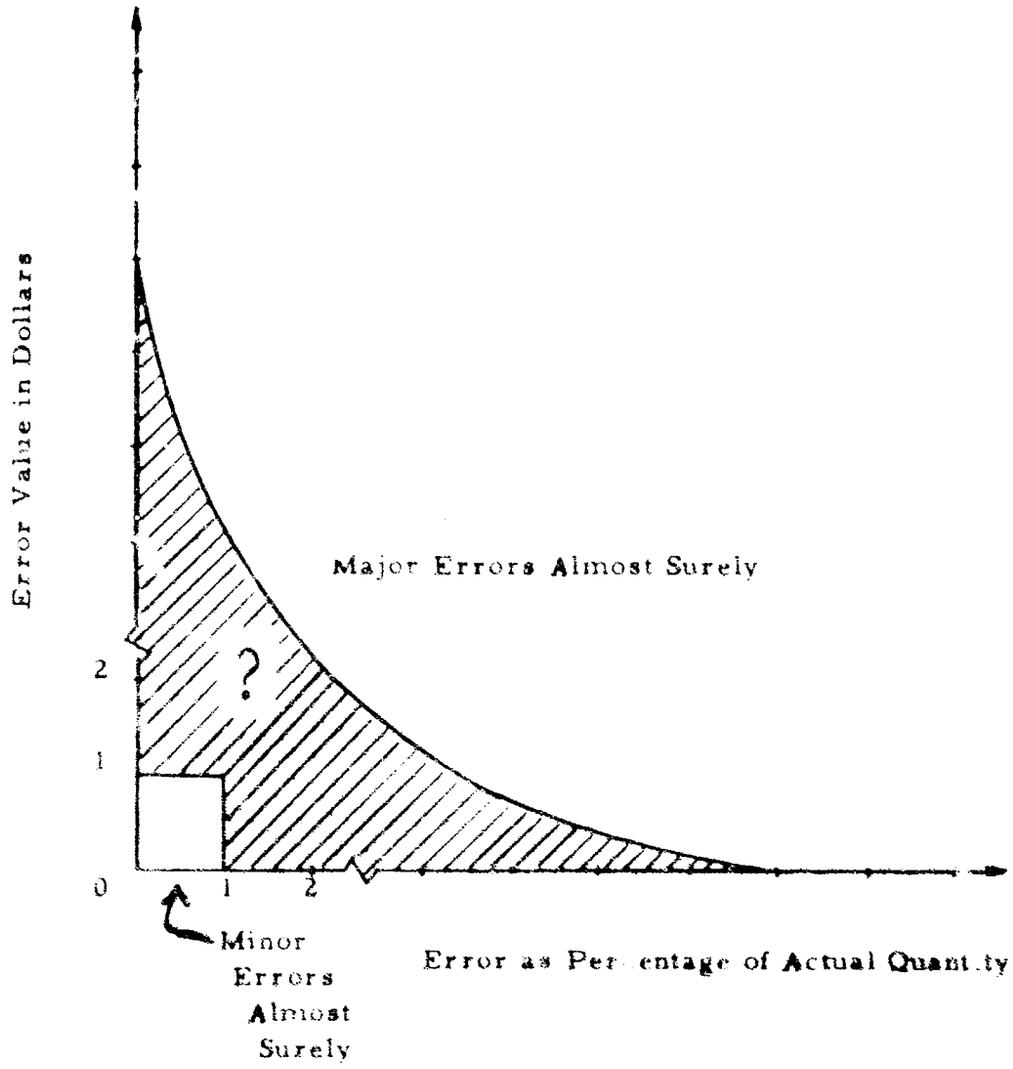


Figure 2.

Major-Minor Error Criteria

procurement budgets, the on-hand quantity may not even be the most significant of the three quantities which determine the inventory position. Thus the "buy too soon" and "buy too late" costs associated with inaccurate inventory records may be primarily dependent upon discrepancies which are not now being observed and corrected, even periodically.

We have raised a number of questions and, of course, it is easier to raise such questions than it is to answer them. However, in the next section, we propose and evaluate a number of ways of dealing with on-hand quantity discrepancies.

## 6. Possible Measures of Inventory Record Error

In this section we investigate a number of inventory record error measures, all based on discrepancies in on-hand quantities. Various measures are computed using, for purposes of exposition, a reconstruction of the data of "Sample I" of the NAVSUPRANDFAC Report [6]. This sample contains identity, recorded on-hand quantity, actual on-hand quantity, price, and demand information for 508 items. Ninety nine of these item records show on-hand quantity discrepancies.

The raw error percentage, defined here as the percent of item records with any on-hand quantity discrepancy, for this sample was 19.5%. This raw error percentage is a legitimate measure of record error, but it is by no means the only legitimate or meaningful error measure. It ignores the degree or seriousness of the individual

discrepancies, the financial gains and losses involved, and the impact of these discrepancies on supply effectiveness.

If the major error criterion of the Army report [5] was applied to the data, six errors each representing on-hand quantity discrepancies of less than 1% and less than $1 in value would be deleted (not counted as errors). The major error percentage would thus be 100(93/508) 18.3%. If major error was defined as one exceeding 5% of the on-hand quantity and representing more than $5 in value, then 27 of the 99 discrepancies would not be counted as errors and the error percentage would be 100(72/508) = 14.2%.

A more elaborate scheme might call for assessing the seriousness of each on-hand quantity discrepancy in terms of the actual quantity on hand. Such a scheme recognizes the difference between a discrepancy of 10 units when only 5 units are actually on hand versus the same discrepancy when 500 units are actually on hand. Let us define, for the $i^{th}$ item, $a_i$ and $r_i$ as the actual on-hand quantity and recorded on-hand quantity respectively. We then define

$$\Delta_i = |a_i - r_i| \quad , \text{ and}$$

$$m_i = \max(a_i, r_i) \quad .$$

The error measure for individual items is then $\Delta_i/m_i$, $0 \leq \Delta_i/m_i \leq 1$, $m_i > 0$. If $a_i = r_i$, then $\Delta_i = 0$ and no contribution is made to the error measure. If the total error for a population of $N$ items is

defined as

$$1/N \sum_{i=1}^{N} \Delta_i/m_i \quad ,$$

then the total on-hand weighted error will also lie in the unit interval and

$$100\left\{\frac{1}{N} \Sigma \Delta_i/m_i\right\}$$

is the on-hand weighted error percentage.

Applied to the sample data, the on-hand weighted error percentage is 7.8%. An item with an on-hand quantity discrepancy of 890 units, but actual on-hand quantity of 7000 units, had an error measure computed to be 890/7000 = 0.11. While the discrepancy was large in absolute terms, it was small in a relative sense. We have, of course, not considered the financial implication of the discrepancy. Another difficulty or shortcoming of the on-hand weighted error measure is its inability to discriminate between serious errors. Within the sample are three items which, for present purposes, we label items 1, 2, and 3. Item 1 had a recorded on-hand quantity of 0 units and an actual on-hand quantity of 800 units. The actual and recorded amounts for the other two items were $a_2 = 1$, $r_2 = 0$; $a_3 = 0$, and $r_3 = 1$. The on-hand weighted error measures for all three of these is 1.0, the maximum possible error, though intuitively the quantity discrepancies are not all equally significant.

The financial aspects of on-hand quantity discrepancies can be seen in costing the individual discrepancies. The records indicated a total

value for the sample inventory of 508 items of $67,648. The actual total investment was $70,762. If the unit cost of the $i^{th}$ item is denoted as $c_i$ and if $a_i$, $r_i$, and $\Delta_i$ are as defined previously, then we compute the net dollar error percentage as

$$100 \left| \frac{\Sigma c_i(a_i - r_i)}{\Sigma c_i a_i} \right| .$$

For the sample inventory data, the net dollar error percentage was $3114/$70762 = 4.4% .

However, if we consider the total or gross dollar error in investment, the error percentage is much higher. In the net dollar error percentage an overstatement of investment on one item may be canceled out by an understatement of investment on another item. Adding all investment discrepancies, regardless of their sign, results in a gross dollar error percentage defined as

$$100 \frac{\Sigma c_i \Delta_i}{\Sigma c_i a_i} .$$

For the sample the gross dollar error percentage was $13637/$70762 = 19.3% .

Another way to look at investment discrepancies is by means of a breakdown of the discrepancies by dollar amount intervals. For the sample the breakdown of the 99 discrepancies is as follows:

| $ Interval | Number of Stock Records |
|---|---|
| 0 - 1.00 | 32 |
| 1.01 - 10.00 | 30 |
| 10.01 - 100.00 | 22 |
| 100.01 - 1000.00 | 9 |
| 1000.01 - 3000.00 | 6 |

One third of the discrepancies had a value of $1 or less, and nearly two thirds of the discrepancies had a value of $10 or less. A relatively small percentage of the items contributed most of the total investment discrepancy.

Finally we address inventory record error measures which are directly related to short-term supply effectiveness. On-hand quantity errors may have a direct short-term influence on effectiveness if the discrepancies can give rise to a warehouse refusal or an unnecessary referral. A warehouse refusal may be generated anytime there exists an $r_i > 0$, $a_i = 0$ situation; i.e., the records indicate that stock is on hand, but in fact the on-hand balance is zero. An unnecessary referral may be generated by a $r_i = 0$, $a_i > 0$ situation.* In the sample there were at least nine discrepancies which could generate warehouse refusals and at least sixteen discrepancies which could have generated needless referrals. Thus 25 of the 508 item

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* The discussion of warehouse refusals and referrals should consider the requisition quantity. A warehouse refusal could be generated by an $r_i = 8$, $a_i = 4$ situation if the requisition was for 5 units of the item. However, the available data did not include requisition size information. The $(r_i > 0, a_i = 0)$ and $(r_i = 0, a_i > 0)$ conditions used above put only a lower bound on the loss of effectiveness due to error caused refusals and referrals.

records had discrepancies which would have lead directly to a degradation of short-term supply effectiveness. What we might call the short-term effectiveness degradation measure, a percentage, would then be 25/508 = 4.9% .

We have shown that for the sample inventory record data error measures of between 4.4% and 19.5% may be computed. One could choose his measure to fit his needs, but the question of inventory record accuracy is not simply a numbers game. One conclusion that might be drawn from this section is that no single error measure is entirely satisfactory. At a minimum, one would probably want to know the inventory error situation in terms of the percentage of major errors, the net investment discrepancy, and the outlook for short-term supply effectiveness.

## 7. Conclusion

Inventory record accuracy is currently the number one problem confronting NAVSUP. We have attempted to indicate certain requirements for the reporting and interpretation of record accuracy statistics. The discussion has not been entirely satisfactory in the sense that firm conclusions about the appropriateness of various measures were not drawn. Further it may be that different measures are appropriate at different echelons in the supply system.

Consider just two supply echelons: the inventory control point (ICP), and the stock point. For "push" items the ICP acts as the

inventory manager, handles procurement, and pushes the material out to the stock points. Demands are satisfied from the stock points. The stock point is end-user oriented and is primarily interested in record accuracy so far as it affects the stock point's ability to satisfy demands. Appropriate error measures for a stock point involve those discrepancies which degrade its ability to satisfy demands.

The ICP is system oriented. Inventory record accuracy is important to the ICP because of its ultimate effect on supply effectiveness, but the influence on effectiveness is realized primarily through the procurement process. For procurement purposes the ICP requires accurate information on the inventory position of individual items, not only the system on-hand quantity, but also system backorders and the quantity on order. The physical inventory process verifies and reconciles only the on-hand quantity information. If the item inventory position has a negative error (more assets indicated on the record than is actually the case), the procurement will be delayed and supply effectiveness will be less than planned. If a positive error in the inventory position of an item exists, the procurement will be initiated too soon and result in an investment level which is higher than planned. However, a positive error in inventory position also adversely affects supply effectiveness.

A positive error in stock record inventory position affects supply effectiveness because the individual items stocked by the

Navy supply system cannot be considered independently. Dependence between items is created by the procurement budget. Procurement budgets are allocated to each material cognizance class (cog) and thus establish a dependence between the items within a cog. Procurement funding over the last five or six years has been at very low levels, especially in Navy Stock Fund cogs. Negative safety levels and item risk of shortage) levels of up to 50% have come to be a part of standard operating policy at the ICPs. Indeed one can claim that funding has been too austere to operate an inventory system at all and that the ICP's have become procurement offices rather than inventory managers. In this climate of a severe budget constraint on inventory operations, monies spent needlessly on an item whose inventory position exhibits a positive error will almost surely deprive the system of the legitmate procurement of some other item.

The physical inventory process verifies and/or reconciles only the on-hand quantity information of the item stock record; location audits are performed to expedite the physical inventory process. We have suggested that other bits of information on the item stock record must also be accurate. We have noted the performance and error definition aspects of the problem of formulating goals for inventory record accuracy. Several error definitions or measures were suggested and illustrated. It was further suggested that the appropriate error measure may differ in different echelons of the supply system.

In closing we note that a central problem in inventory record accuracy is to determine the cost of operating an inventory system with inaccurate stock records. Once this cost is quantified, the amount of resources which ought to be expended on record accuracy can be rationally determined. This report has sought to add understanding of the nature of the problem and the terms involved as a first step toward the control of inventory record accuracy.

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13. ABSTRACT

An inventory stock record is in error when the information on the stock record is not in agreement with the actual state of affairs. We address the questions of what is meant by inventory record accuracy as reported in the literature and in official documents and what should be meant by this term, in the context of the inventory record accuracy problem defined by the Naval Supply Systems Command. The need for, and suggestions of, operational definitions of error measures are demonstrated in terms of the reporting of accuracy statistics, the formulation of inventory record accuracy goals, and the determination of corrective measures.

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| Accuracy Goals. | | | | | | |
| Error Definitions. | | | | | | |