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EVALUATION OF THE SHIPYARD MANAGEMENT INFORMATION SYSTEM (MATERIAL MANAGEMENT FUNCTIONS) AT THE LONG BEACH NAVAL SHIPYARD

by

John A. Rackliffe

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Thesis Advisor: Joseph G. San Miguel
Co-Advisor: Dan Trietsch

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This thesis examines yet another aspect of the problem, the shipyard management information system's material management function. An evaluation of this function against a theoretical "ideal" is made and recommendations for improvement provided. Results indicate that the information system has surpassed its useful life time and should be upgraded. Nevertheless, an information system alone is not going to solve the material management problems. Rather, top management must develop a strategic business plan based on modern production management principles such as just-in-time and material requirements planning that encompasses the entire repair process from planning to production. Once developed, this plan could then be used to develop an information system based upon the required controls set forth in the plan.

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by

John A. Rackliffe
Lieutenant, Supply Corps, United States Navy
B.A., Miami University, 1980

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Author: John A. Rackliffe

Approved by: Joseph G. San Miguel, Thesis Co-Advisor

Dan Trietsch, Thesis Co-Advisor

David R. Whipple, Chairman, Department of Administrative Sciences

ABSTRACT

Despite efforts to improve material management through the reduction of inventories and the modification of inventory management policies, naval shipyards continue to experience the same problems.

This thesis examines yet another aspect of the problem, the shipyard management information system's material management function. An evaluation of this function against a theoretical "ideal" is made and recommendations for improvement provided. Results indicate that the information system has surpassed its useful life time and should be upgraded. Nevertheless, an information system alone is not going to solve the material management problems. Rather, top management must develop a strategic business plan based on modern production management principles such as just-in-time and material requirements planning that encompasses the entire repair process from planning to production. Once developed, this plan could then be used to develop an information system based upon the required controls set forth in the plan.

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I. INTRODUCTION

A. PREFACE

The 1980's, under the leadership of President Ronald Reagan, will long be remembered as a decade of renewed patriotism, increased military interest, and federal deficit spending. From 1980-1987, defense spending grew faster than inflation, while modifications to the tax structure reduced excess revenues previously available to offset spending increases. Budget deficits grew year after year until Congress moved to force a balanced budget by 1992, enacting the Gramm-Rudman-Hollings (GRH) Deficit Reduction Act in 1985. Under GRH the president could no longer be as frivolous with the defense dollar. Congressional watchdogs began to scrutinize the Defense Department ensuring that the tax-payer was getting the most "protection" for his or her money.

Over the past several years a number of studies have been performed by the General Accounting Office (GAO), the Office of the Secretary of Defense (OSD), and various congressional appointees delving into many of the Defense Department's activities. These investigations have revealed such "horror stories" as overpriced ash trays, toilet seats and hammers, to the most recent conflict of interest charges filed against top-level Department of Defense (DOD) personnel for their dealings with contractors. In light of these reports, tighter congressional and executive controls have been imposed on military managers entrusted with public funds and materials.

The Naval Sea Systems Command (NAVSEA) operates within a budget of approximately $4.5 billion annually. With these funds NAVSEA executes its duties of overhauling and repairing Navy ships and submarines. Its Industrial and Facilities Management Directorate has management control of eight naval shipyards and 16 Supervisors of Shipbuilding, Conversion, and Repair (SUPSHIP) offices. The SUPSHIP offices plan and manage the overhaul of Navy ships in approximately 40 private shipyards located in their geographical areas. The Navy Industrial Fund (NIF) provides working capital to support naval shipyard operations and adequate materials to complete required repair and alteration work. In order to accurately account for such a large budget and avoid the GRH "deficit-reduction ax," NAVSEA and shipyard managers must exercise control over and monitor the "pulse" of the entire organization.

Given the task at hand, an automated management information system (MIS) must be used. The system should be designed using sound MIS principles and have software that is written with consideration for management policies, user needs, and timeliness of reporting. Today the eight naval shipyards utilize the Shipyard Management Information System (SYMIS) to fulfill the majority of its MIS requirements.

B. PURPOSE

The purpose of this research is to outline a framework of "ideal" automated material management information system principles, utilizing accepted material management and MIS theory and use it to evaluate the Material Management (MM) application of SYMIS in use at the Long Beach Naval Shipyard (LBNSY).

Creating an "ideal" standard from theoretical literature is a complex undertaking. After a substantial literary review and a review of previous studies highlighting the naval shipyard management function, this paper will create the framework from the most commonly accepted principles. Using this framework as a template for comparison, an analysis of the MM application at LBNSY will be made. The analysis is augmented with responses from management personnel to direct questions and the author's perceptions from on-site visits.

Specific questions addressed in this research are:

1. What information does the shipyard logistician require to make sound material management decisions?
2. What factors should be considered when evaluating a MIS?

3. What policies are in place at LBNSY for the management of materials for ship overhauls?

4. What are the capabilities and limitations of the MM software?

C. SCOPE

All eight naval shipyards are currently using the same automated MM application on the SYMIS. Therefore, in order to maintain a reasonable scope, this research will focus only on operations at Long Beach Naval Shipyard. This limitation allows for sufficient depth of study needed to provide a meaningful assessment. Additionally, the scope will be limited to non-nuclear surface ship overhauls and will exclude material requirements for other shipyard activities such as Public Works maintenance, capital projects, and overhaul of Depot Level Repairables.

Since this research was not sponsored, travel funds were provided solely from a limited pool controlled by the Administrative Sciences Curricular Office. As a result, shipyard visits and detailed personal interviews were limited to only two days. Given these limitations and the complexity of the shipyard organization this study provides only an introduction to a very complicated subject.

D. RESEARCH TECHNIQUE

Material management studies by GAO and other agencies as well as logistics management and MIS texts were the major sources of data for the study. NAVSEA and LBNSY instructions and computer user manuals were used as background material to formulate interview questions. Theoretical research and personal interviews at the shipyard enabled a comparison to be made between an ideal system and the SYMIS MM application. Subsequent to this comparative analysis, an evaluation of the system's effectiveness and recommendations for improvements and suggestions for alternatives are made.

E. THE THESIS ORGANIZATION

Chapter II is a summary of material management and MIS design theory that should be considered prior to designing an effective material management information system. Previous studies addressed in Chapter III summarize the major shortcomings of the past. When combined with the basic theoretical concepts of Chapter II the information forms a framework by which an analysis of the management information system is made in the remaining text.

Chapter IV begins with a brief background discussion of the Long Beach Shipyard organization, including important constraints under which managers operate. The analysis then moves to a comparison of the MM application against the "ideal" framework created in Chapters II and III.

Chapter V completes the analysis with an overall system assesment in terms of its ability to meet management's needs. Chapter IV then concludes with a summary, some recomendations, and the identification of future research topics.

II. A FRAMEWORK FOR ANALYSIS

A. BACKGROUND

In the 1970's, the average annual investment in business inventories was $305 billion, or about eighteen percent of the Gross National Product. The annual cost of maintaining that inventory was between $128 and $170 billion in 1979. [Ref. 1:p. 356] Trends in inventory management are changing in the 1980's. In a recent General Accounting Office (GAO) study, which examined the inventory management practices of seven private sector companies, it was discovered that top managers have established goals to significantly lower inventory in the future. [Ref. 2:p. 1] The Department of Defense (DOD), inspired by the Gramm-Rudmann-Hollings Act of 1985, has also been considering possible inventory reduction methods for its activities. Although different motives exist between DOD and the private sector, inventory management principles practiced by profit-making organizations can be applied to the military (in particular the public shipyard) to improve material management.

In this section, two fundamental research questions will be addressed:

1. According to modern material management theory, what information does the shipyard logistician require to make sound material management decisions?

2. What factors should be considered when evaluating a management information system used by a material management division?

Answers to these questions will form the framework for analysis of the Shipyard Management Information System (SYMIS) as it applies to material management at the Long Beach Naval Shipyard.

Before constructing the framework, a review of how organizations make decisions within the context of a productive system like the shipyard will be made. Additionally the systems approach to decision-making will be studied to explain how automated information systems are designed and how they can be helpful to management.

B. ORGANIZATIONAL DECISIONS AND THE SYSTEMS APPROACH

Organizational decision-making can be broadly categorized into two types, decisions that require mathematical and quantitative techniques and others that are qualitative in nature. Quantitative decisions are the more relatively understood of the two classifications and hence are mostly relegated to the lower level of an organization where they can be monitored by mid-level managers. Qualitative decisions are usually more complex and not routinely defined and therefore, reside in the upper and middle management levels.

Management information systems (MIS) are generally designed to automate quantitative processes by applying preprogrammed calculations based on the functions performed by lower level employees in their daily operations. The computer-based MIS allows for rapid processing and mass storage of important data that are used to make both types of decisions. However, given that qualitative decision-making involves individual preference and affects the personal objectives of the organization's members, consensus is difficult and programming even more so.

The question of how an information system should be designed, therefore, is complex and widely debated. Norbert Weiner, who saw the information system as an integral part of an organization, much like the brain and the nervous system act as an information system in the human organism, said,

> ...any organism is held together....by the possession of a means for the acquisition, use, retention, and transmission of information. [Ref. 3:p. 224]

A system, as defined by Webster's New Collegiate Dictionary, is "a group of devices or artificial objects or an organization forming a network especially for distributing something or serving a common purpose." The linkage, connecting these devices create the system and the "common purpose" establishes a boundary around the linked components.

The systems approach is concerned with a whole entity and all of its components. It recognizes the activities of the components while simultaneously considering the entire system activity for which they serve. "The systems approach is primarily a philosophy of structure that coordinates in an efficient and optimum manner the activities and operations within any system." [Ref. 4:p. 75] This allows for analysis of complex problems and situations because it is concerned with the examination of individual components emphasizing their role in the system rather than as separate entities.

A particularly useful system for this analysis is a "productive system" whose function is to convert a set of inputs (materials, personnel, capital, utilities, and information) into a set of desired outputs (products and services). The productive system uses a conversion subsystem to change inputs into outputs monitored by a control subsystem that provides corrective action if necessary. [Ref. 5:p. 18]

Figure 1 depicts a comprehensive view of a productive system where outputs take two forms: tangible (automobiles, lamps, refrigerators, etc.) and intangible (education, haircuts, repair services, etc.). The shipyard application of the model involves taking environmental factors such as shipyard policy and budgets, market factors such as the Type Commander's desires and competition with other yards, and resources and converting them into a repaired ship. Such a fleet support service is controlled by managers within the

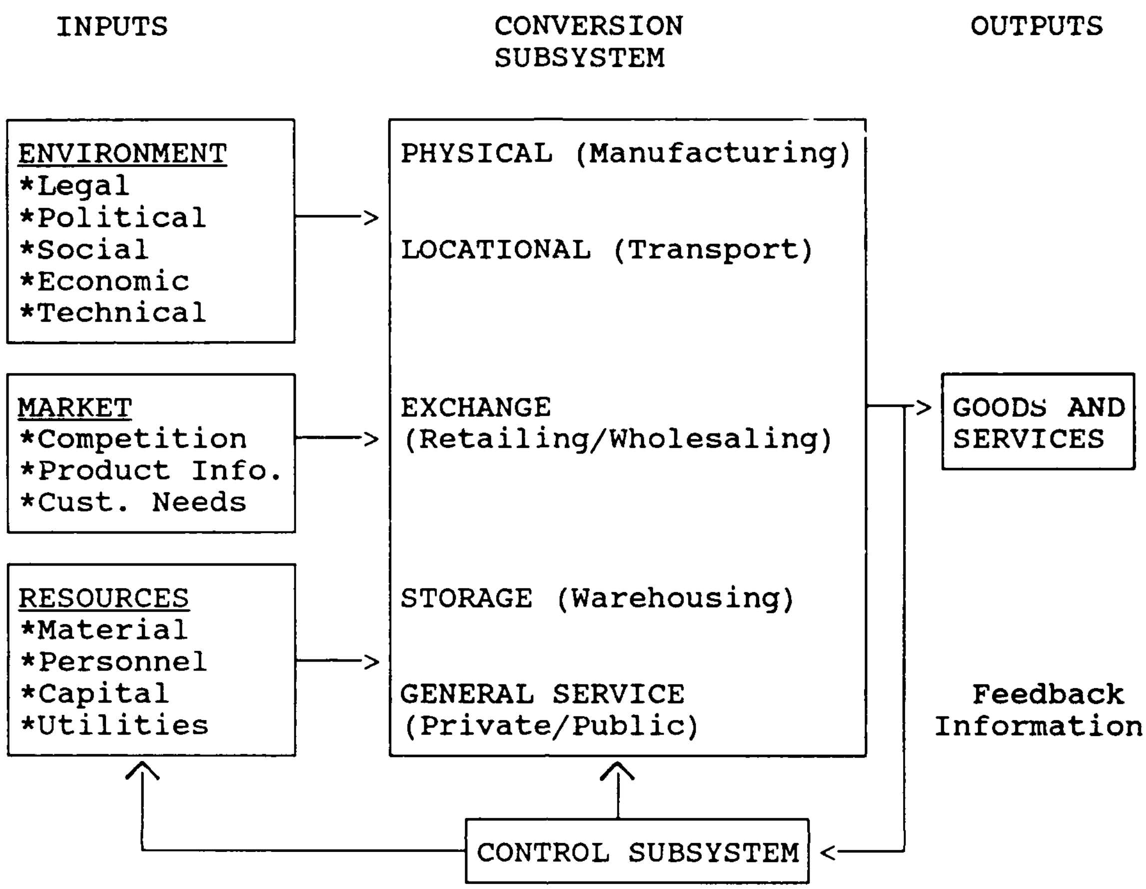

Figure 1. Productive System Model [Ref. 5:p. 19]

shipyard organization using information systems to monitor scheduling, labor use and material flow throughout the process.

The core of a productive system is its conversion subsystem which is present in some form in all organizations whether their primary function is manufacturing or service-related. This concept allows us to apply the principles of production management to a service system. [Ref. 5:p. 23]

By fitting service systems into productive system models, straight-forward applications of production management fundamentals that govern material management in manufacturing can be achieved. Let's now examine these fundamentals in detail and apply them to shipyard repair.

C. MATERIAL MANAGEMENT FUNDAMENTALS

> Materials Management is all of the management functions related to the complete cycle of materials flows, from the purchase and internal control of materials to the planning and control of work in process to the warehousing, shipping, and distribution of the finished products. [Ref. 5:p. 18]

More and more organizations are centralizing the material management function under a single department that coordinates material activities and accepts responsibility for performance.

Centralization requires that the material management department control material purchasing, logistics, warehousing inventory, and expediting slow-moving requirements. An effective management information system must function to coordinate these activities and provide management with useful accurate material information.

Material purchasing, movement and storage represent a significant investment. Depending upon the nature of the business, materials exist in many forms. In a production environment material is held as:

1. Raw Materials The basic building blocks (steel, bricks, aluminum, etc.) that will be used to construct the final product.

2. Work-In-Process Partially completed products awaiting next production step or final assembly.

3. Finished Goods Final products that have yet to be sold, usually held as a hedge against the uncertainty of demands in the marketplace. [Ref. 5:pp. 444-445]

In addition, materials in the logistics channel are held for four other reasons:

1. Pipeline Inventory Because transportation is not instantaneous inventory ends up in the pipeline between stocking points or finished goods warehouses of final destinations.

2. Speculation Inventory Although not a factor in DOD, inventories of raw materials with speculative value, i.e., gold or silver, are held as much in anticipation of rising value as for the needs of manufacturing.

3. Regular or Cyclical Inventory Necessary to meet average demand during the time between successive replenishments.

4. Safety Stock Inventory held as insurance against being out of stock because of varying demand and replenishment leadtime, in addition to regular or cycle stocks held. [Ref. 1:p. 357]

Regardless of form or reason, the total dollar value of material inventories in DOD have risen significantly in the last ten years, a trend that must be examined and at least slowed down. "Just-in-time" (JIT) concepts are only one of the mechanisms being used to combat rising inventories in the private sector that may have an application in the service-oriented public shipyard. JIT requires delivery of the right material in the right quantity at the right time and to the right place using minimum resources. [Ref. 6:p. 2]

Just-in-time implies minimum inventory for the operation it supports. In manufacturing and assembly operations work-in-process inventory levels would be held at zero or near zero quantities. In retail, service, and support operations (including public shipyards) finished goods inventory levels would be maintained at an amount necessary to overcome pipeline delays and maintain the operation's level of customer service. Therefore, when a part is needed on the production line or to complete a repair, it arrives just in time, but not before it is needed. [Ref. 2:p. 6]

Purchasing activities acquire the raw materials, parts, machinery, supplies and all other goods and services required to operate the organization. The proper conduct of this function is vital to material flow throughout the productive system. Managers within this division must maintain accurate data on all available suppliers including their delivery leadtimes and pricing information. In the DOD, particularly the shipyard, purchasing agents must be familiar with material availability both from government sources and commercial vendors. To accomplish this, buyers must have complete technical descriptions of requirements so that the correct material is purchased.

The first step in controlling inventory levels, therefore, rests with the purchasing division. If buyers can acquire materials of the right quality, in the right quantity deliverable at the right time, then material flow will be improved and levels of reserve material in inventory can be lowered.

1. Right Quality

The first step in the manufacturing or repair process is to obtain the correct parts and materials to perform the scheduled work. Material quality is related to suitability and cost (including not only price but transportation, incremental costs, installation costs, etc). [Ref. 6:p. 33]

According to Lee and Dobler quality is determined by balancing two major considerations: (1) the technical consideration of suitability and (2) the economic consideration of price and availability. This requires a coordinated effort between the production engineers, who ensure the correct material is requested on the Job-Materials-List (JML) and the material managers (purchasing) who ensure the economics of price and availability are maximized. After the technical decision has been made, the buyer must determine if the materials selected can actually be purchased on a competitive and often continuing basis. [Ref. 6:p. 35]

A material manager's responsibility with respect to quality involves the right to challenge technical decisions for economic reasons. But, the ultimate right to determine quality, including the right to change, correctly rests with the department responsible for performance that is the user of the material. [Ref. 6:p. 35] If management is integrated, working together for the common goal of achieving the "right quality," then the challenge and change procedure between the material and the engineering departments should be one of cooperation, not conflict.

Communication and cooperation between the logistician and the engineer is a key factor to ensuring that incoming material meets all requirements (suitability, availability, and price). If technical requirements cannot be met by available sources of supply, then engineering should consider modifying technical requirements or making it "in-house." If this is not feasible perhaps new sources of supply can be developed by contracting vendors to create the material in accordance with specific technical data. (JIT) demands close cooperation with trusted vendors who can supply exactly the right material when it is required, under all circumstances.

Current and accurate specifications are also crucial to quality determination. By definition, specifications are detailed descriptions of materials, parts and components used to make a product or perform a specific repair task. Although purchasing and inventory controls are usually the targets of cost reductions, "material refusals" caused by improper specifications may be of more significance to the material manager. Material refusals (material purchased that cannot be used) are not only costly in direct dollar terms, but also cause production delays, increased administrative order costs, and disruption to the entire production schedule. In JIT systems suppliers share in the loss (by paying some type of penalty) if the material refusal is the result of their error. Therefore, there is a profit motive that ensures quality.

2. <u>The Right Quantity</u>

As mentioned earlier, inventory management has undergone a fundamental change in this decade. Most significantly, is the view that inventory should be maintained at the lowest level consistent with the operation it supports. In the naval shipyard this means inventory levels should be the minimum to support repair operations. To achieve this objective, many companies are eliminating various contingency stocks that were maintained in the past. [Ref. 2:p. 6] Therefore, planning and ordering required materials correctly the first time is crucial to the overall management plan.

Managerial planning, organization, coordination and control are essential for obtaining the necessary quantities of material to support production and minimize inventory holding costs. The inventory control system must be integrated with organizational goals and controlled within the budget, production, planning and scheduling activities.

Ironically, at a time when inventory control has come to the forefront of industrial management, it is becoming increasingly difficult to achieve this goal. Because of the growing complexity of the systems we build and maintain, the dollar value of the average repair part is increasing at an alarming rate. Therefore, the dollar value invested in inventory is growing faster than the number of items held. [Ref. 6:p. 257] This is a dilemma that is not easily resolved even with better material management techniques. More attention to requirements planning, especially when high cost items are being considered, may be the only means by which the problem of rising costs can be managed.

Buying the right quantity of material reconciles a natural conflict of objectives between major departments. Usually, the production department desires a high inventory because they assume it will minimize work stoppage thereby lowering production costs. Conversely, the comptroller and top management want low inventories which represent less capital investment. The purchasing department, on the other hand, may be ambivalent, recognizing the cost reduction potential (i.e., quantity discounts) inherent in high inventories while simultaneously experiencing departmental inefficiencies from pursuing an excessively tight inventory. It is imperative that management carefully consider the effect of different approaches to their inventory problems and adopt policies which balance its two major objectives: (1) to minimize capital investment in inventory; and (2) minimize work disruption while sustaining quality.

As alluded to earlier, it is theoretically desirable to create an economic balance between the quantity of items in inventory, the frequency of purchase order transactions, and the quantity of items per order. Inventory management models attempt to create such a balance by examining how inventory levels vary over time in order to determine what quantities of material should be purchased. Figure 2 presents one such theoretical inventory model.

The common terms used to describe basic inventory principles are defined briefly below:

1. Operating level describes the quantity of required materials to support normal operations in the interval between material orders and receipts.

2. Safety stock is used to allow for unexpected demands, procurement leadtime, and unforeseen delays.

3. Reorder cycle is the interval of time between successive orders.

4. Procurement leadtime is the period of time from the date material is ordered until it is received. It usually includes:

    a. Administrative time to complete required paperwork, and ensure adequate government contracting requirements are met;

    b. supplier production leadtime is sufficient if the material must be manufactured; and

    c. delivery leadtime, including shipping time.

5. Order point is the time when orders are initiated for additional quantities of material. [Ref. 7:pp. 56-57]

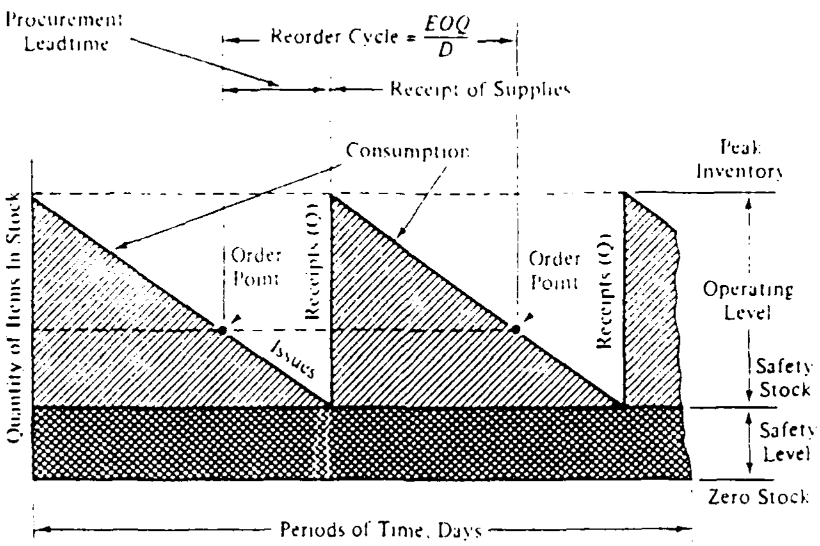

Figure 2. Theoretical Inventory Cycle [Ref. 7:p. 56]

According to Figure 2, the goal is to have the correct amount and type of material available at the lowest cost. Procurement costs vary with the number of orders placed. The economic inventory principle optimizes the decision whether to place many orders for fewer items, resulting in high acquisition costs, or to place orders less frequently for larger quantities resulting in higher levels of inventory along with the associated holding costs. The economic order principle equates "cost to order" and "cost to hold" and the point at which the combined costs are minimized indicates the optimal order quantity. Graphically, this economic order cost is represented in Figure 3:

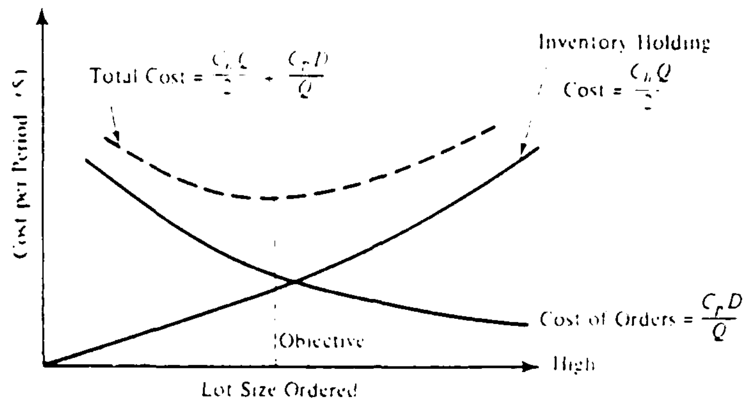

Figure 3. Economic Order Cost [Ref. 7:p. 58]

The total cost curve in Figure 3 is expressed as:

$$\text{TOTAL COST} = 1/2(ChQ) + CpD/Q$$

where, Cp = Average ordering cost (dollars per order)

Ch = Inventory carrying cost
D = Annual item demand
Q = most economical quantity

By differentiating and setting the equation equal to zero and solving for Q, the following equation, known as the "economic order quantity (EOQ)," results [Ref. 7:pp. 58-59]:

$$Q^* = EOQ = (2CpD/Ch)^{1/2}$$

The EOQ model makes no allowance for uncertainties in inputs to the inventory decision problem. For example, when the level of demand is random it is usually economical to provide a certain level of safety stock as insurance against the unexpected demand that could deplete the inventory and cause and "out-of-stock" condition. (see Figure 4)

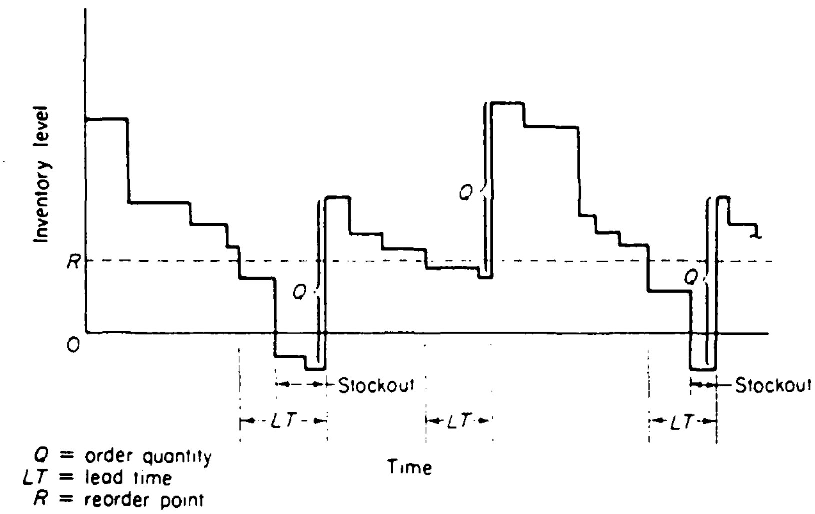

Figure 4. EOQ Model with Demand Uncertainty [Ref. 1:p. 381]

To overcome the uncertainty of demand one must go beyond the basic EOQ formula and determine the amount of safety stock required, by utilizing the principles of probability distributions. Reorder points are then calculated by adding forecasted demand plus safety stock estimates that are based on distributions of the demand during the time between reorder and receipt (leadtime demand), as shown in Figure 4. The automated inventory control system detects when stocks fall below the r-order point and places a replenishment order automatically when requested the inventory manager. [Ref. 1:pp. 410-411]

Since inventories represent a large investment in terms of material and control systems, management of inventory levels is essential. In addition, timing of material deliveries, especially for items which are not held in inventory, is also of concern to the shipyard material manager.

3. The Right Time

The Production Department and the Supply Department share a common interest in the timing of materials flow into production. The material manager influences the production schedule through inventory policy, while the production schedule affects the average inventory level. [Ref. 1:p. 467] From an organizational efficiency prospective, inventory costs and those production costs directly affected by inventory policy must be balanced through an integrated material management strategy. The logistician must be involved in the production scheduling process if the timing of material flow is going to meet the demands of the Production Department.

Generally, the material manager has two methods of meeting customer demand for raw materials and spare parts. He or she may either time material deliveries using such techniques as material requirements planning (MRP) or the Japanese method of just-in-time. Or, production materials may be supplied through material inventories maintained by the material department in which case, required inventory levels, reorder frequency, economic order quantities, and material handling requirements are specified through inventory policy. These techniques (MRP, JIT and EOQ), although different, are often combined to achieve desired customer service levels. [Ref. 1:p. 470]

a. MRP vs. JIT

One of the most often implemented techniques developed to deal with the unique problems of manufacturing inventories is MRP. It incorporates the production schedule into the material ordering process by obtaining the production requirements from the bill of materials for each scheduled job and plans material orders so that they arrive exactly when needed by the Production Department.

Texts and papers, advocating the benefits of Material Requirements Planning, imply, however similarities between it and just-in-time. In fact, the two oppose each other in the way they create material flow through a productive system. MRP is a system which "pushes" material toward the final product according to forecasted leadtimes regardless of the individual shop capacities enroute whereas, a JIT production system controls material flow by "pulling" it through production stations. This prevents work-in-process inventories from accumulating in front of bottlenecks.

The results, therefore, vary greatly between the two approaches. Under MRP the load on the system is not balanced. That is, resources are sent to job sites regardless of the ability of the site to perform the work. Instead of scheduling material resources, MRP may cause overloads in certain time periods even when there is enough capacity on average. This often tends to overload the individual shops. By itself, MRP creates its own "scheduling bottlenecks" and is limited, in practice, as a production planning tool.

b. MRP Fundamentals

MRP provides the logistician a means by which he or she can avoid holding excess inventory. Theoretically, inventories do not need to be created when the quantity and timing of the end product are known. Therefore, MRP is an important alternative to inventory control as a method of having the right materials in the right place at the right time. In fact, statistical inventory control (that is, EOQ) methods do not perform as well in the physical supply channel as they do in the physical distribution channel, because the assumptions on which they are based are often not met (see pages 17-23). That is, demand is not random, independent, and unbiased. Rather, demand patterns for manufacturing materials are derived. [Ref. 1:pp. 471-472]

Derived demands result from the manufacturing process because, in most cases, a predetermined number of required materials are specified by the bill of materials. In a high leadtime production environment this creates lumpy demand patterns. If statistical inventory control methods are used to set inventory levels, the inventory levels would be unacceptably high due to the variance of the lumpy demand patterns. If the timing of inventory depletions can be roughly anticipated, materials may be ordered accordingly to realize substantial savings in inventory carrying costs. [Ref. 1:p. 472]

The MRP methodology begins with the bill of materials that defines the quantity relationship between the materials and the end product (i.e., a completed repair job). If it is known when each repair job will be accomplished and in what quantities repair materials are required to complete the job, then an acquisition schedule for the materials can be developed. The advantages of such are: (1) an extended planning horizon; (2) system flexibility with changes in the master schedule; and (3) providing the material manager the opportunity to shift delivery and reorder times either forward or backward. [Ref. 8:pp. 49-50]

The flow of materials is controlled by offsetting the purchase or requisition from the requirements by the extent of the leadtimes which are <u>assumed</u> to be known. However, uncertainty in the level of requirements and material leadtimes is always present as are transportation delays and partial shipments. The MRP approach, therefore, must be modified to handle these realities. [Ref. 1:p. 477]

c. Demand Uncertainty

Using MRP under conditions of demand uncertainty requires that some safety stock be kept to protect against unpredictable requirements fluctuations. A fixed, on-hand inventory level, determined by practical experience or some other means, is one common alternative. Once a minimum quantity is established, requisitions are triggered in the normal MRP manner except that the on-hand quantity drops to the established minimum rather than to zero. Given the peaks and valleys of derived demand this approximation is likely to be sufficient in this situation.

Material leadtimes, like demand, are not likely to be known with complete certainty. To prevent over-or under-stocking, requests for materials under these conditions must be correctly timed. For example, suppose that the average purchase leadtime for 1/4" gate valves is normally distributed with a mean of fourteen days and a standard deviation of three days. There is a penalty cost for delaying or interrupting production of $5,000 per day for each gate valve that does not arrive in time. Additionally, if gate valves arrive early they must be stored in a warehouse at a $50 per day holding cost.

The question here is to determine how much additional time should be planned into the requisition schedule to compensate for leadtime uncertainties. Let us call the time T* and establish it as a point on the leadtime distribution shown in Figure 5 below:

T* - purchase order LT

Pr - probability of not having material when needed.

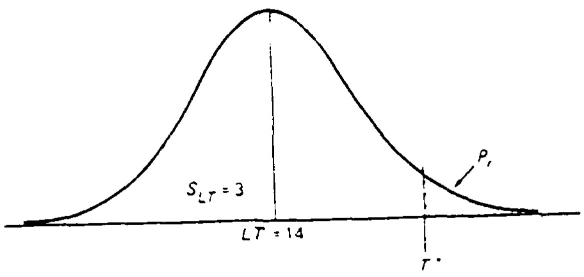

Figure 5. Leadtime Distribution [Ref. 1:p. 479]

T* can be found by determining the probability (Pr) of not having a gate valve available according to:

$$Pr = 1 - (Pc \backslash Cc+Pc)$$

where,

Pc=cost of having materials after they are needed ($per unit per day)

Cc=cost of having materials before they are needed ($per unit per day)

Then, the order leadtime (T*) is:

$$T^* = LT + ZS$$

where,

LT=mean leadtime (days)

S =standard deviation of leadtime demand (days)

Z =number of standard deviations between LT and T*

Using the example data,

$$Pr = 1 - (500\backslash 50 + 5000)$$
$$= 0.01$$

Z @ 0.01 = 2.33 Therefore,

$$T^* = 14 + (2.33)(3)$$
$$= 21 \text{ days before production.}$$

[Ref. 1:pp. 477-480]

Theoretically, material under these conditions should be ordered 21 days prior to production and it should arrive in time for production in 99 cases out of 100. Of course, to be able to determine leadtime distributions and apply these principles, a tracking mechanism must be in place that can gather and process material leadtime and historical vendor delivery data. Due to the large number of parts required for ship repair and the numerous suppliers involved, this function should be automated and imbedded in a material management information system.

d. JIT Fundamentals

JIT was developed to give management a means to control the flow of materials and inventory levels within the production system. Under the right circumstances it:

1. stimulates productivity improvements,
2. reduces inventory, and
3. reduces leadtimes.

Its application, however, requires a production schedule that is repetitive and that operates at a constant rate for a long time. JIT cannot generally respond rapidly to irregular product changes and is intolerant of fluctuating production rates. While JIT advantages are tempting to any manager who is trying to control costs, its application in a non-manufacturing environment may be somewhat limited.

Hybrid systems that combine MRP and JIT fundamentals may be useful in these non-manufacturing situations. Service organizations, like a shipyard, are just as concerned with lowering costs, through inventory reduction, as the manufacturer. In the short term, MRP can solve long leadtime raw material ordering problems. But, given the complexity and certainty of the ship repair function, not all of the material requirements are known in advance of disassembly. Therefore, some inventory must be carried as a safety measure to prevent work stoppage and deliver the ship on schedule. In the long run, a combination of the principles of MRP, JIT and EOQ may provide the solution to this complex shipyard problem.

e. Other Material Management Considerations

Besides managing inventory flow through the use of MRP and JIT principles, GAO has also discovered in their studies that inventory accuracy goals of successful private companies have become a day-to-day concern for their operating managers. Many companies are counting inventories throughout the year rather than during the traditional annual "wall-to-wall" inventory.

Instead of completely closing down operations to conduct inventory counts, many companies have adopted cycle inventories. Under this procedure, a physical inventory is taken on every item at least once a year, with more frequent counts performed on selected items such as fast movers or expensive goods. Cycle counting allows a company to expose transaction and human error patterns while simultaneously verifying accuracy. [Ref. 2:p. 9]

GAO found that companies who implemented cycle counting not only increased inventory accuracy but, found inventory discrepancies sooner thereby, making reconciliation much easier. Additionally, company service stocks, essential to maintaining high customer service levels, showed improved accuracy and made management personnel more aware of their operation. [Ref. 2:p. 10]

Improved coordination of inventory management functions within the company and between it and its suppliers and customers, are also important aspects of successfully run businesses. Logistics managers, seeking to reduce inventory while maintaining high customer service levels, must establish integrated planning processes with their peers in production, design, finance, and planning. The maximization of customer service requires that supply departments know what production needs and when the planners want it to be there. This requires coordinated planning by all cognizant department heads.

Inventory management based on the just-in-time concept requires close coordination between a company and its suppliers. GAO revealed that most private sector companies surveyed were establishing more partnership-like relationships with suppliers by offering them longer term contracts including clauses that required packaging, delivery performance, product quality, and penalties for non-conformance. [Ref. 2:p. 15] In addition, private firms are reducing the number of suppliers and are ordering fewer items at higher frequencies.

Although government contract regulation and law precludes preferential treatment of any contractor, it does provide for award criteria based upon delivery performance and product quality. The use of cost-type incentive contracts that reward contractor quality and delivery performance established to provide indefinite delivery of commonly used material may closely approximate this JIT company-supplier relationship found in the private sector.

Finally, operating discipline and accountability should be available to top management through performance measurement. In order to make routine decisions required to apply just-in-time principles and lower inventory levels, timely information is critical. Systems must provide information to managers at all levels of the organization with equal timeliness and accuracy. Many systems in use by successful private sector companies automate routine managerial decisions, freeing them to concentrate on the exceptions. [Ref. 2:p. 17]

Performance measurement provides managers yet another tool to improve material management. In the private sector individual managers or departments are measured by return on investment and profit or loss. Inventory levels by material categories, processing backlogs, and late deliveries are just some of the measures in the shipyard that can be monitored to analyze effectiveness and provide a basis for corrective action. Whatever the objective, whether it be profit-making or cost reduction, the decisions that face the material manager are complex and varied. MRP and economic order quantity calculations encompass many variables and are far too complicated to be performed by hand. The personal cost and time delay associated with manual computation would more tnan offset any inventory management savings that could be gained by using these techniques. Therefore, the material manager must have an adequate automated management information system that can gather, store, and assimilate data if he or she is to effectively apply the theoretical concepts thusfar ment.oned.

As shown earlier in Figure 1, supervision is performed by a control system which often takes the form of an automated information system. Information gives managers a means of monitoring each system facet and its contribution to the overall production effort. Information is the glue that holds the organization together. Without it, the flows and processes that combine to produce an output would cease to function effectively.

In assessing the usefulness of an information system in terms of material management, one must consider some of the theoretical factors that are generally used to characterize a management information system. What are these factors and how do they apply? In the following section these issues, and their application to the naval shipyard, will be discussed.

D. ORGANIZATIONAL INFORMATION SYSTEMS

Information is used differently depending upon the operating level of the user. Information, therefore, is broadly categorized into two groups, operational information and management information.

Operational information is used routinely to conduct day-to-day organizational tasks such as calculating payroll and updating inventory records. Whereas, management information supports the decision-making process for all functions at all management levels. It includes for example, determining the costs of alternate distribution routes or calculating economic order quantities for maintaining inventory levels.

Information systems, which are usually computerized, produce both operational and managerial information. While the creation of operational information is no more than the automation of manual tasks, the derivation of management information from these systems, is much more complex. An information system that supports operations provides standard, routine, and current reports created from compilation of daily transactions. A management information module, on the other hand, provides customized data that meets decision-maker needs drawn from both routine internal transactions and data from sources outside the organization.

A management information system (MIS) can be defined according to the types of decisions it supports. Processing inventory transactions and reordering optimal replenishment quantities, for example, are structured decisions which can be made automatically by the system. More complex unstructured decisions are supported by computers that perform rapid calculations and produce management reports. These outputs are the tools which enable the managers to make their decisions.

Building upon this concept, K. J. Radford proposed broad specifications of an information system to serve the organization decision process:

1. Administrative and Operational Systems serving routine decision processes such as personnel administration, production scheduling, and so on;

2. Management Reporting Systems providing periodic, structured reports to managers based on summary data from the administrative and operating systems;

3. Common Data Base which stores data and information used by more than one part of the organization;

4. Information Retrieval System from which historic data and information may be retrieved for use in planning and decision-making;

5. and a Data Management System which arranges and controls the flow of data and information between components of the information system. [Ref. 3:pp. 225-226]

1. User Interface

For analysis purposes, one must decide what characteristics make up a satisfactory management information system and whether they are active in the system being evaluated. Regardless of the environment in which the MIS is operating, the primary design consideration should be its interface with the user. Interface is concerned with screens, keyboards, reports, languages, and other means by which a human user and the computer system exchange inputs and outputs.

Users can be classified by their level of system experience and their general knowledge of computer concepts. Ideally, a system should be flexible enough to allow both novice and expert use. Screens should have enough information on them to assist the beginner as he or she moves through the system functions, but, should also have adequate flexibility so that the expert may bypass unnecessary instructions and still perform the tasks. [Ref. 9:pp. 530-533]

Screen design should therefore be clear and free of irrelevant information. It should contain, according to Galitz [Ref. 10], only information essential to decision-making or the performance of an action; and it should provide all data related to one task on a single screen. In other words, the user should not have to memorize data from a previous screen to use the current one.

In an article entitled, "Guide to MIS User Satisfaction," in the Journal of Systems Management of June 1977, Schewe and Weik provide some characteristics of a management information system that are considered important to the system user:

1. depth of information,
2. width of information, the number of different information categories in the database,
3. analytic sophistication, system capability to analyze data,
4. access delay time,
5. response time,
6. completeness of data input, the capability of the system to retrieve all requested information,
7. information overload, the amount of unnecessary information given the user,
8. information currency, the degree to which the data base is up to date,
9. output accuracy, and
10. output complexity (difficulty in interpreting the output). [Ref. 10:p. 76]

From this list those characteristics most important to management will be the focus of the analysis along with the material management fundamentals discussed earlier. The condensed list includes:

1. analytic sophistication
2. information overload
3. information currency
4. output complexity.

Within the system context, the thesis will examine how the shipyard material management division uses the MIS to interface with other departments and divisions. An analysis of the system effectiveness will be made by comparing what information is required with that which is provided by the SYMIS. Additionally, it will be shown that new methods of material management may be needed to improve inventory accuracy and reduce excess inventory levels. The impact of these changes on the current system configuration will be assessed to determine recommendations for future changes.

Before turning to the analysis, a review of some recent studies concerning shipyard management, growing inventory levels, public/private competition, and trends for the future will be made. As budgets are cut to respond to growing federal deficits the cost saving measures proposed in these studies must be given serious consideration. Reform must not be a "band-aid" to cover up symptoms of underlying system problems; rather, it must be carefully orchestrated by the highest levels of management to cure a navy-wide problem of material waste by the public sector shipyards. New ideas for more efficient methods of inventory management, material flow and information system design must be considered if the conditions described in these studies are to be remedied.

III. SCOPE OF THE MATERIAL MANAGEMENT PROBLEM [PREVIOUS STUDIES]

A. "MUCH ADO ABOUT MAINTENANCE"

Since 1978, numerous studies of shipyard material management have been conducted. The General Accounting Office, and several contracted commercial consultants have found many discrepancies in shipyard inventories. In fact, the volume of discrepancies is so great that those who must solve them are overwhelmed.

Rather than add to this proliferation of discrepancy lists, the objective of this section is to summarize the research done to date and attempt to form a general material management problem scope.

In June 1989, Secretary of Defense Cheney made a statement establishing long term goals to cut thousands of low-level acquisition jobs and attack the "perennial spare parts problem." In a The Wall Street Journal article of June 6, 1989, GAO officials were reported to say, "...military stockpiles of excess or unusable spare parts around the world...have now topped $29 billion, up from $10 billion in 1980." In that same article, Representative Les Aspen, democrat of Wisconsin and Chairman of the House Armed Services Committee, said "Study after study has diagnosed the same problems and prescribed the same remedies." [Ref. 11:p. A-24] The question to be addressed here is; What are these problems, and specifically how do they affect material management in the naval shipyard?

As Mr. Aspen noted, no matter who performs the study, they usually call out the same general problem areas. The areas, listed here, common to most shipyard studies will be examined below:

1. Shipyard Material and Workload Planning
2. Material Management Information Systems
3. Procurement Constraints
4. Inventory Management
5. Supply System Constraints.

B. SHIPYARD MATERIAL AND WORKLOAD PLANNING

According to a GAO study conducted on 105 regular ship overhauls performed in private shipyards from fiscal year 1982 through May 1985 overhaul costs increased significantly between contract award and contract completion. Increases in contract costs resulted from contract changes for additional work that was not anticipated at the start of the overhaul. According to the Navy representatives interviewed, growth work accounted for seventy-six percent of the cost increases on fixed price contracts and sixty-six percent on cost type contracts. [Ref. 12:p. 1] It is clear that no matter who does the planning or the work, shipyard repair is difficult to predict with reasonable accuracy.

An outside observer, who is unfamiliar with public shipyard management, would probably make a logical assumption that when a shipyard estimates the cost of an overhaul it considers all possible cases (best to worst) based on past experience with overhauls of similar vessels. Additionally, one would assume that managers carefully review historical demands for spare parts and construction materials along with vendor and supply system leadtimes, trying to coordinate material arrival with the anticipated start of a particular overhaul job.

Contrary to this assumption, GAO discovered, first in 1978 and again in 1985 that historical data for direct material was incomplete, inaccurate and not being utilized for material planning. Without accurate usage data shipyards continued to order materials for future overhauls that were not actually required. [Ref. 13:p. 4] As a result, unused material stocks increased by sixty-three percent during the period 1979 to 1983. In fact, during a recent visit to Long Beach Naval Shipyard (May 1989) computer records showed an excess material inventory value of $30 million, which represents over fifty-four percent of the total inventory value ($55.2 million).

Coopers and Lybrand, who were contracted by the government to uncover shipyard management problems, stated in their recent comprehensive study:

> Shipyards do not have an effective planning base from which to establish accurate material requirements for ship availabilities or to measure actual performance of material ordering vs. material usage. [Ref. 14:p. MM-3]

Coopers and Lybrand found that in addition to inflating excess material inventories in dollar terms, ineffective materials planning impeded shipyard operations. Poor planning created a more difficult management task due to the increase in the number of line items to be managed. In addition, more indirect personnel were required to order, purchase, expedite, receive, warehouse, distribute and eventually dispose of (excess) material.

> There was an intermittent idle labor cost when Production was impeded for lack of material with no 'work around;' there is a continuing indirect labor cost for personnel managing excess material that is never needed. [Ref. 14:p. MM-4]

Prior to a February 1988 policy change, all Direct Material had to be on hand before the start of a repair availability. This policy drove materials planning by a single date and disregarded unnecessary inventory holding costs. Despite the change, material planners are still not guided by the overhaul scheduling system and material leadtimes. Rather, the Planning Department determines material requirements based on the total work package regardless of the start and stop times of the jobs for which they are ordering material. Job-Material Lists (JML's) associated with individual jobs are released for material sourcing with no consideration for procurement leadtimes and/or required delivery dates (RDD). For the Supply Department, requisition priorities are difficult to determine because material planning is not tied to the automated production schedule within SYMIS as the MRP fundamentals, outlined in Chapter II, require. Therefore material delivery is expedited for items not required until later in the production schedule, while critical production material is often overlooked thereby disrupting work-in-process. Unnecessary costs are incurred for warehousing and maintaining inventory before they are required for production. The result is increased indirect personnel costs that contribute to higher overhead costs. [Ref. 14:p. MM-6]

C. MATERIAL MANAGEMENT INFORMATION SYSTEMS

The shipyard manager needs information in usable formats to measure past performance, assess current performance, and plan future work and resource requirements. Management information systems at naval shipyards are primarily utilized to collect and process both engineering and business data. Under the organization at Long Beach, data processing is the principal function of Code 110. They provide centralized data processing support for business and logistics systems. Engineering data is generally the responsibility of the design division (Code 240). Engineering data, however is beyond the scope of this study.

Coopers and Lybrand found that "shipyards do not have effective and efficient information systems," citing obsolete hardware, lack of comprehensive MIS planning, inconsistent leadership, ineffective organizational structures, and a complex acquisition process as major contributors. [Ref. 14:p. MIS-1] MIS hardware upgrading was outlined as a "total package" in the study. The plan required formulating an overall MIS strategy, upgrades of both hardware and software and a greater emphasis on system training at all organizational levels. According to Coopers and Lybrand, if modernization is to be successful in terms of increased productivity at lower cost, the business and engineering functions must be integrated.

D. PROCUREMENT

Although specific contract regulations and statutes are beyond the scope of this study, they are critical to the material management problem. Procurement systems, in past studies, were found to lack provisions to consolidate requirements of commonly-purchased items to eliminate acquisition costs and take advantage of quantity discounts and bulk transportation rates. Procurement personnel were generally found to be excluded from the decision-making process primarily because the automated systems used did not provide access to current procurement history or vendor performance data. Finally, past studies also revealed that vendor performance data was not being used to evaluate sources of supply. Instead, competition and lowest bidder were the primary considerations when selecting a supplier of material not stocked by the government supply system. Often material received under these circumstances did not meet the requirements of production and was rejected and reordered. This caused additional manhour expenditure and delayed the production schedule.

E. INVENTORY MANAGEMENT

Inventory management policy at Naval shipyards was extensively researched by LT Rory Souther in a graduate thesis. Commenting upon previous studies and the resulting corrective actions taken by NAVSEA, he pointed out that increased management attention in the area of inventory management area has reduced the growth rate of inventories across all shipyards. [Ref. 15:p. 91]

Historical material usage data, that was previously not used for planning, is now being collected. This data helps the material manager determine material requirements and estimate when the material will be required for production. It was believed that this would reduce inventory by eliminating early deliveries and requisitions for unnecessary material.

Despite these efforts, excess material remains a significant problem in the shipyard. For example, Long Beach still holds $30 million of excess material even with Management's concern and their use of historical data for planning. Obviously, historical usage data is not the complete solution to the excess inventory problem.

Recent policy changes have established performance goals for Direct Material usage, service level, and stock turn for

Shop Stores Material. The requirement to have all production material available prior to the start of an overhaul has also been removed. Additionally, each shipyard is required to establish its own goals and procedures for controlling and lowering inventory accounts. [Ref. 15:p. 92]

The theme which underlies the studies of the past decade is that investment in inventory is too high. Safety stocks, particularly in the Shop Stores account, could be reduced by relying more on stocks of standard materials held at nearby Navy stock points. Historical usage data, procurement leadtime information, consolidation of requirements in the Ship Stores and improved communication with suppliers would all serve to lower inventory levels. In addition, improved interdepartmental communication particularly between planning, production and material would improve material delivery timing and reduce material rejections.

F. SUPPLY SYSTEM CONSTRAINTS

The final area of materials management that has been criticized in past studies is the supply channel used to obtain standard stock materials. Generally, supply sources include the Navy's own system managed by the Ship's Parts Control Center (SPCC), the Defense Logistics Agency (DLA) which supplies material common to all services, and outside vendors who supply non-standard materials not available at SPCC or DLA. [Ref. 14:p. MM-24]

Coopers and Lybrand were critical of Navy and DOD spare parts-provisioning policies, citing that they were not designed to support shipyard overhaul and repair requirements for hull, mechanical, and electrical equipment. Many of the Allowance Parts Lists (APL's) developed for navy equipment contain requirements for organizational level repairs but are not broken down into depot level piece parts support. Shipyard-specific material is not stocked at the supply centers unless identified by a special program. When shipyards make demands on the Federal Supply System stocks, they may exceed expected demands from combined organizational level requirements. Additionally, studies have shown that materials received from SPCC and DLA do not meet form or fit requirements and often, even though stock numbers were the same, were not interchangeable.

The studies have been numerous since the late 1970's and the corrective action process has continued with each one. Naval shipyard material management will always be difficult and certainly will never be perfect. With the framework constructed and the scope of the problem examined, the MIS at Long Beach will be explored to determine whether or not it is providing the material manager with the information needed to implement the corrective actions and improve material flow to support production. The analysis will attempt to show if SYMIS has developed along with the wide range of policy and procedural changes or whether it too needs to be modified.

IV. SYMIS AND THE LONG BEACH NSY ENVIRONMENT

Before we can analyze SYMIS, the environment in which it operates must be established. To accomplish this, two additional research questions will be addressed:

1. What policies at the shipyard influence material decision-making?

2. What are the capabilities and limitations of the current MIS material management function?

A. LONG BEACH NSY MISSION AND ORGANIZATION

> The mission of Long Beach Naval Shipyard is to provide surface ships of the U.S. Pacific Fleet with production, engineering, logistics, and facilities maintenance resources to accomplish ship repair, overhaul, modernization, activation, and specifications at a fair and reasonable price within the designated scheduled time frame. [Ref. 15:p. 1]

To this end, the shipyard is organized as shown in Figure 6 with the Supply Department (Code 500), primarily responsible for material management (Figure 7).

The Supply Officer (Code 500) reports directly to the Shipyard Commander on all material matters. He is assisted by five major division heads each of whom performs a subfunction under the purview of the Supply Officer (Logistics Systems, Control, Purchasing, Technical, and Material). Because of their complexity, the Material and Control Divisions as well as Code 500 each have civilian deputies. These positions were designed to provide a

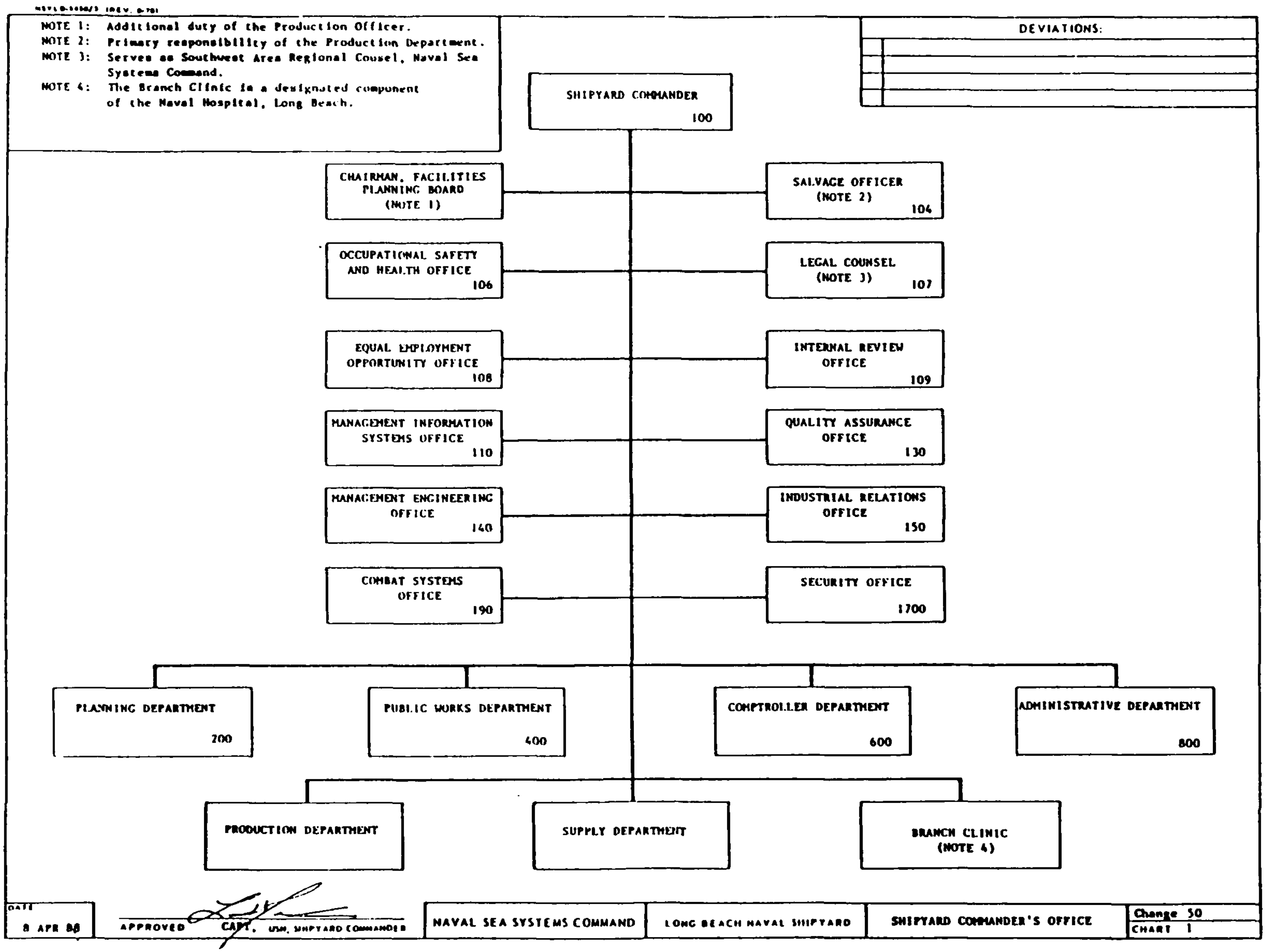

Figure 6. Long Beach NSY Organization

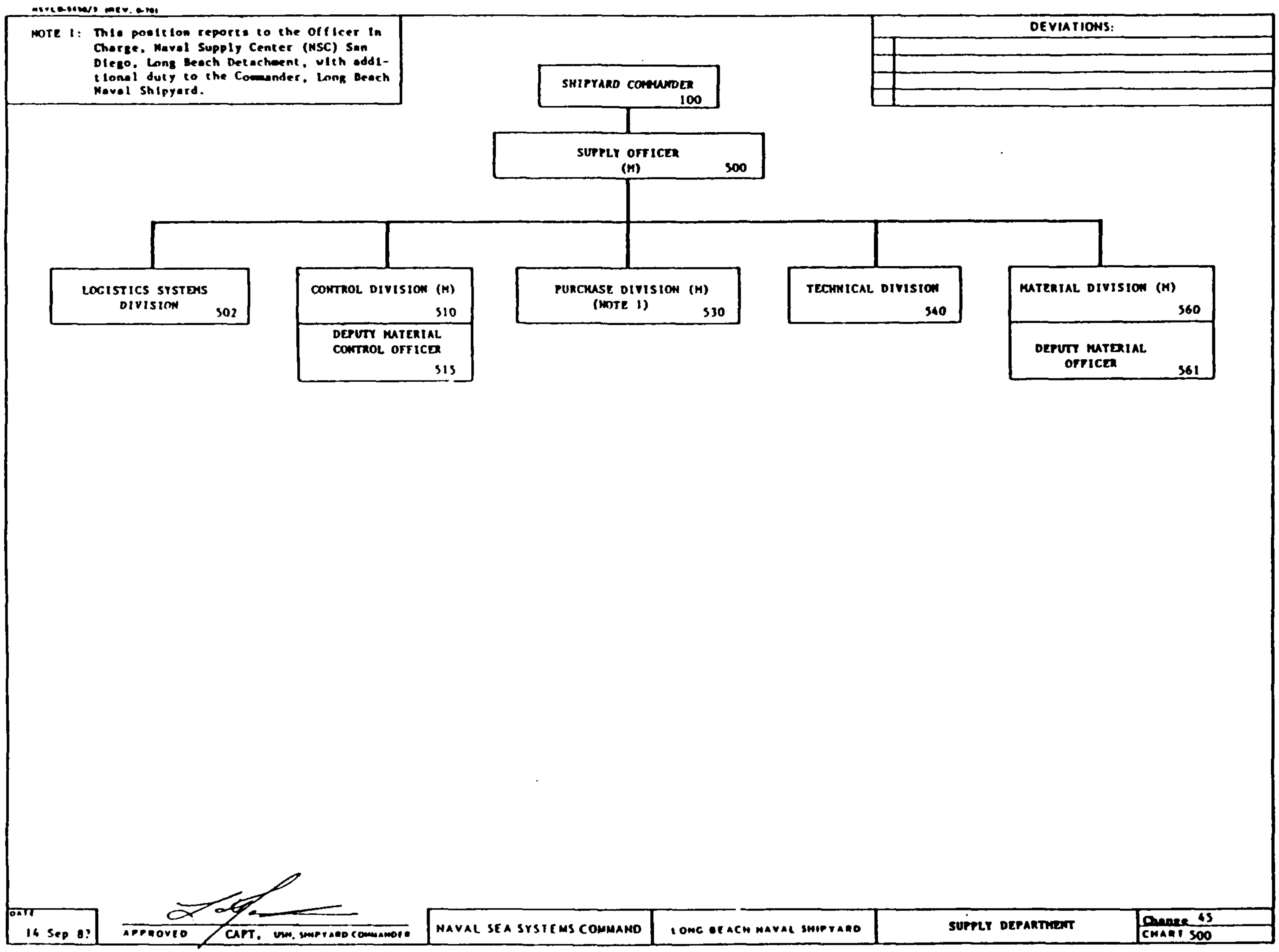

Figure 7. Material Management (Supply Department) Organization

continuity of operations when the respective military division heads are transferred.

"Efficient and effective management of industrial materials," is critical to the organization's success. [Ref. 15:p. 1] Policies filtering down from all echelons of the shipyard hierarchy are designed to promote better financial management of industrial materials and on-time quality performance at competitive cost. Let's now briefly look at these policies to see how they influence the shipyard manager.

B. SHIPYARD MATERIAL MANAGEMENT POLICY SUMMARY

Responding to all of the recent Naval Sea Systems Command policy revisions alluded to previously, the Shipyard Commander at NSY Long Beach issued NAVSHIPYDLBEACH Instruction 4400.4 on June 3, 1989. Its purpose was to "establish policies, identify functional areas of responsibility, and establish performance goals for effective and efficient management of industrial materials within Long Beach Naval Shipyard." [Ref. 16:p. 1] It addresses the functional areas of material requisition, receipt, storage, issue, inventory, accounting and disposition of excess material, and provides performance measures to assess material management effectiveness.

The instruction is divided into four areas: Shop Stores (SS); Direct Material Inventory (DMI); Materials and

Supplies Reserve Materials (formerly Unassigned Direct Material [UDM]); and Receipt and Storage.

1. Shop Stores (SS)

By definition, Shop Stores material includes items with recurring demand and those held as insurance. Recurring demand is further defined as "four or more issues per year;" whereas, an insurance item is one that must be stocked to prevent work stoppage even though the item has only occasional or sporadic demand. According to the Comptroller of the Navy Manual, Volume V, which governs accounting within the Navy Industrial Fund (NIF), stock levels for SS material are:

90 days - Demand-based Material (except raw material)
150 days - Demand-based Raw Materials
180 days - Forecasted Workload Material [Ref. 17:pp. 4-51].

It is incumbent upon the Supply Department, with assistance from the operating departments, to review insurance material annually to "keep the stock of such items to a minimum." The Supply Department is also responsible for SS planning and organization. Material for the shop stores is established, ordered, received, stored and issued by Supply personnel. They also perform level setting and requirements determination. [Ref. 16:encl. (1), pp. 1-3]

2. Direct Material Inventory (DMI)

DMI is material which is assigned to a specific availability or project. This includes Government Furnished Material/Equipment (GFM)/(GFE), ship-specific material for overhauls and repairs, project-specific material for Public Works maintenance, capital projects, and Depot Level Repairables (DLR) overhaul material. [Ref. 16:encl. (1), p. 3]

The physical distribution, handling, and custody of DMI is the sole responsibility of the Supply Department until it is issued for use. Supply Department also performs technical screening, submits requisitions, expedites outstanding orders, receives, stores, and issues the material. The operating departments are responsible for determining quantities and providing requirements based upon valid Job Orders appearing on JML's. These requirements must be sourced through all shipyard assets, including SS, before they are ordered as DMI. [Ref. 16:encl. (1), p. 3]

3. Materials & Supplies Reserve Material (M&SRM)

Formerly known as Unassigned Direct Material (UDM), M&SRM is an account within DMI for the management of unused material (excess). The account is established to "control and record selected inventories for possible future use or disposition." [Ref. 16:encl. (1), p. 5] M&SRM is an accumulation of excess material from:

1. Unused DMI, standard and non-standard stock;
2. Unused GFM/GFE; and
3. Material recovered from production sites.

Before material can be transferred to this account, it must be screened semi-annually, for transfer back to the Navy

Stock Fund (NSF) for a two year period. In addition, shipyard policy requires that M&SRM be provided "maximum visibility through the improved use of ADP systems." The shipyards exchange magnetic tape files of M&SRM assets to each other so that new requirements may be screened against them before acquiring additional material.

Disposition of unused DMI is determined by the Planning Department within 60 days of customer validation that a particular repair job has been completed. M&SRM is retained in the custody of the Supply Department for a period of two years unless it is turned back to the NSF for credit (standard material only). [Ref. 16:encl. (1), p. 5]

Performance measures established by the shipyard commander to control these materials are varied and complex. Rather than separating them throughout the text, they are summarized as Table 1.

4. Receipt and Storage

Material receipt and storage procedures are established to minimize inventory accuracy errors and improve customer service. Material handling policy requires that a record of delivery and a "clear audit trail," be maintained for each item from requisition to issue. Further, receipt and issue processing must be done as quickly as possible to support the industrial operation.

TABLE 1
[Ref. 16:encl. (1), pp. 1-6]

Material Category	Measures
1. Shop Stores	(a) STOCK TURN = Value of Issues/Inv. Value *Goal: two or more stock turns per year (b) Ratio - Insurance items:Demand-based SS *Goal: less than three percent of Inv. (c) Service level (Percent Req filled by stk) *Goal: 99% or higher (established items) 97% or higher (plus new items) (d) Inventory Record Accuracy: *Goal: Quantity - 90% or higher Location - 97% or higher **Gross Monetary Adjustment - Absolute Value of inventory gains and losses. *Goal: 10%
2. DMI	(a) All DMI will be on hand in time to support the industrial process. (b) Percent DMI Unused *Goal: 10% of Dollar value of DMI received (c) Outstanding requisition at end of avail. *Goal: 1% or less (d) Inventory Record Accuracy: *Goal: Quantity - 98% or higher Location - 98% or higher **Gross Monetary Adjustment - 2% or less
3. M&SRM	(a) Inventory Record Accuracy: *Goal: Quantity - 98% or higher Location - 98% or higher **Gross Monetary Adjustment - 2% or less (b) Total Dollar Value (ceiling) *Goal: $23 Million

The goal for processing received material, which does not require formal quality assurance inspection and/or issuing it to a customer, is three working days for 95% of the transactions. Material requiring a formal QA inspection has a goal of 15 working days for 90% of the transactions. [Ref. 16:encl. (1), p. 7]

These policies represent the extent to which management oversees shipyard production material flow. Most performance measures are reported at least monthly to the Supply Officer. He reviews them to assess the effectiveness of his material divisions and make future strategic decisions such as:

1. Whether to add transportation assets to improve material deliveries from the warehouse to production shops.
2. The need to hire additional personnel or reorganize divisions.
3. Determine how excess material should be disposed.
4. Determine what Shop Store Inventory may be eliminated due to low stock turn.
5. Determine future Supply Department Budgets.

At the heart of the control system is the Shipyard MIS (SYMIS) that collects data from all transactions and accumulates it in the database. It displays the data both on the screen and in printed formats. Daily reports are used to monitor processing backlogs, research inventory discrepancies (such as losses or gains) expedite critical requisitions, and evaluate employee performance. Therefore, as required by written policy, the SYMIS Material Management subsystem and Shop Stores subsystem are used to the maximum extent possible in the Supply Department. Its usefulness, however, is limited to tracking what has already happened and does not provide much information that can be used to change the trends of growing inventory and poor inventory accuracy.

C. OVERVIEW AND ANALYSIS OF THE SYMIS MATERIAL MANAGEMENT FUNCTION

The computer-based Shipyard MIS supports shipyard management by providing data processing capability in four major areas: Industrial Planning and Control, Financial Accounting, Administration, and Material Management. Within the Material Subsystem, SYMIS includes three major applications:

1. Material Requirements (MR)
2. Shop Stores (MS)
3. Material Management (MM) [Ref. 18:p. I-1]

Each of these functions is critical to the control of materials within the shipyard and will be analyzed separately. Figure 8 is a system flow chart showing the entire Shipyard MIS and how the MR, MS, and MM application interface with the system.

1. Material Requirements Application

The MR application is designed to assist the Planning Department with the identification of material

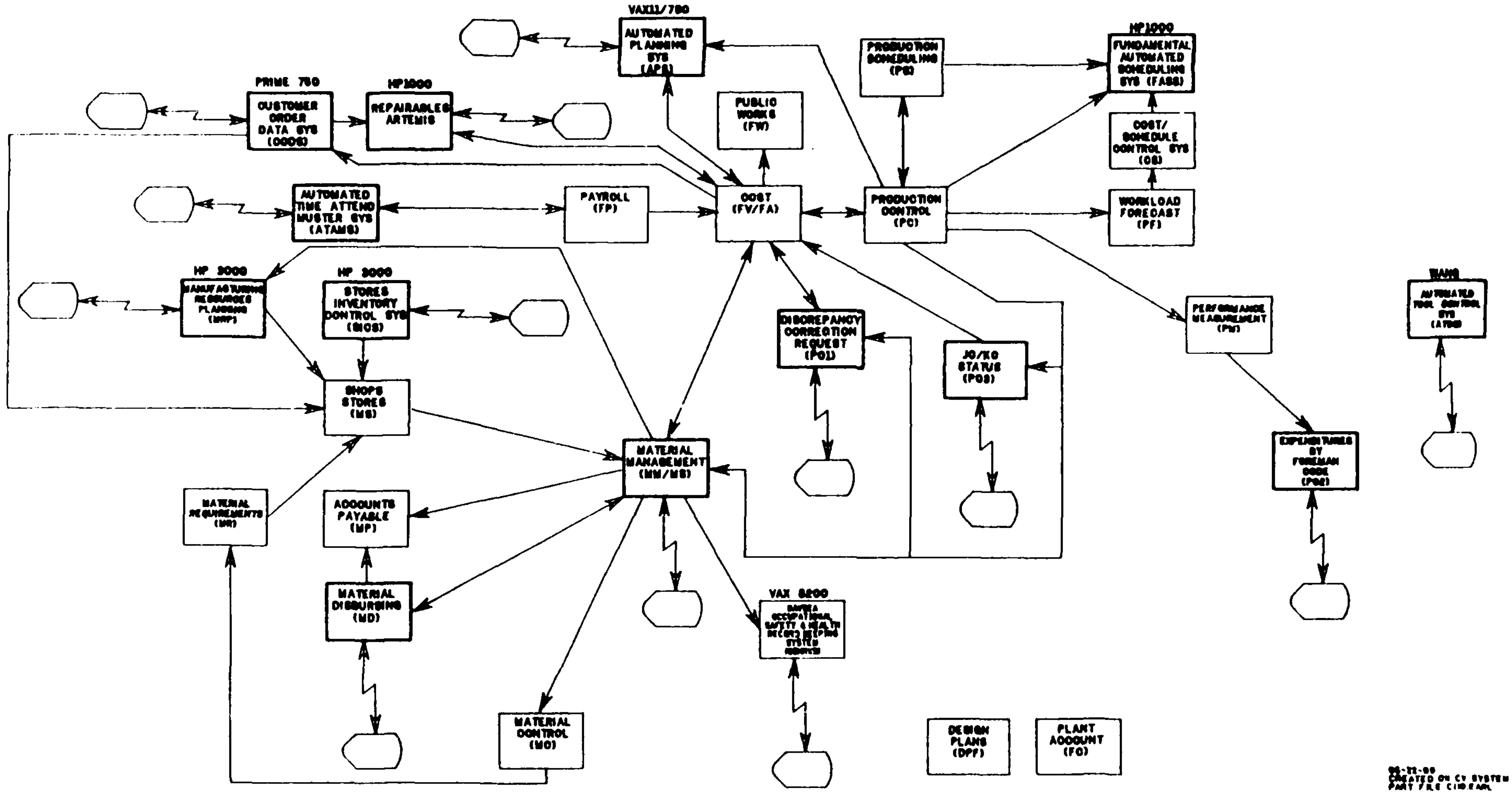

Figure 8. General Overview of the Shipyard Management Information System (SYMIS)

required to complete the scheduled work packages associated with a ship overhaul or repair and to initiate the ordering of that material. It assists managers in streamlining material identification by sorting through the vast array of numbering systems that are used to identify repair parts. In order to accomplish this task MR performs these primary functions:

1. Extracts all material requirements for a repair availability by line item from various automated source files;

2. Converts commercial part numbers into National Stock Numbers and screens them against shipyard assets;

3. Validates requirements by adding in accurate pricing information and other required data;

4. Generates Scratch Material Sheets (SMS) that are used to identify material;

5. Passes requirements to MS/MM to initiate an order; and

6. Provides statistical information developed from historical data from similar work packages to assist in making future material budgeting (purchases) decisions. [Ref. 19:p. I-1--I-4]

MR is used primarily at the working level in the Planning Department. Essentially it is a collecting point for many sources of material identification. Material source files from the Ship's Parts Control Center (SPCC), commercial sources, Navy designers, industrial material history (issued material only), and other planning sources are combined in the MR database. The MR programs search the source data files, extracting material identification data for each requirement identified by the planner.

Although this application eliminates most tedious catalog and microfiche review, it requires considerable user data entry. The Scratch Material Sheet, generated by the initial data search, must be manually reviewed and annotated to tailor it to the specific repair package being planned. The updated data must again be entered into SYMIS to update the MR master file so that it can be sent to the MS/MM applications for screening and ordering.

Besides the user interaction time required, MR has another drawback. Even though it is the primary tool for the planner to initiate requirements for scheduled shipyard work, MR does not interface with the automated scheduling system. The material manager and the planner do not have an automated means to coordinate order deliveries, using historical leadtimes, with the scheduled job start date in order to avoid unnecessary storage and handling costs. Neither material leadtime nor scheduling information is an input to MR even though the Required Delivery Date (RDD) is a mandatory entry on all requisition documents. Without this information, the planner must review hardcopy schedules and "estimate" leadtime of delivery, manually, in order to make an estimation of the RDD. This procedure is time consuming, contributes to abuse of the requisition priority system, and indirectly leads to "inflated overhead charges by raising inventory holding costs. Additionally, if material is received excessively early, and if for some reason the job is cancelled, the shipyard is left with excess material and overhead costs used to expedite it.

2. Shop Stores Application

Shop Stores are "retail" outlets, located near the production shop which they support. They are responsible for issuing and storing the type and quantity of material required by their "customer" shops. The Shop Stores Application supports this function by automating financial and inventory control functions for management and operations personnel.

As most SYMIS applications, Shop Stores is a batch process. Five major tape files retain the data utilized by MS: the Master Stock Item Record (SIR) file, the Shop Stores Ledgers file, the Shop Stores Description file, the DMI Description file, and the Shop Stores Feedback file. File data include quantity balances, material descriptions, receipts, issues, rejection records, financial records, quality assurance inspection labor/material cost information and much more. [Ref. 20:p. II-3]

MS sorts; performs basic arithmetic; prints; edits; searches files; and performs several related routines such as reordering, JML screening and determining inactive items. It also provides management controls to monitor inventory performance and ensure maximum industrial support by minimizing the number of stockouts while investing the least amount of NIF capital.

The primary management tool provided by MS is the "Inventory Manager Analysis Data" (report number MS455Q). As shown in Figure 9, the Inventory Manager Analysis Data report displays the financial and quantitative performance of the Shop Stores, and can be summarized in various ways according to the type of material in inventory. The Supply Officer is required to review the information in this and other reports periodically (monthly and weekly) to isolate problem areas and monitor performance goals addressed in Table 1.

Careful inspection of Figure 9 shows that MS-455Q is comprised of a large amount of data. In order to obtain useful information from such a "noisy" report, the manager must be thoroughly familiar with it and willing to invest a significant amount of time reading it.

Rather than carefully studying MS-455Q and the other print outs from SYMIS, the Supply Officer is given a monthly summary called the "Shop Stores Performance Report," which is locally prepared by his staff. Supply Department personnel review several SYMIS reports, extract pertinent data, and consolidate it on a locally prepared form. The monthly report summarizes the performance of the fourteen shop stores. The following data elements are included in the report:

INVENTORY MANAGER ANALYSIS DATA

MS-455Q

ISSUE DATE 29 APR 89
DATA DATE 28 APR 89

LL SHOPS TOTAL
ACTIVE AND PRE-EXPENDED ITEMS COMBINED

OTAL ITEMS 16064 ON HAND $14,616,040 DUE $2,152,919 YEARLY SALES $15,551,790 STOCK TURNOVER RATE 6.367

ISSUES THIS MONTH 9486 SALES THIS MONTH $ 1,067,796 NUMBER NEW ITEMS 57 NUMBER DELETED ITEMS 71

MANUAL REPLENISHMENTS		OUTSTANDING DUES		REPLENISHABLE ACTIVITY							
PRIORITY	COUNT	NR DUES	NR ITEMS	ISSUES	CUR MO	1ST MO	2ND MO	ISSUES	CUR MO	1ST MO	2ND MO
01-03	0	0	14263	0	2671	1945	2925	5	79	114	62
04-08	0	1	1555	1	2064	2387	1893	6	38	64	41
09-15	42	2	209	2	670	830	658	7	24	46	24
16-20	0	3	25	3	296	377	251	8	13	36	11
		4	12	4	134	171	132	9 + OVER	75	94	67
TOTAL	42	TOTAL	16064								

AUTOMATIC REPLENISHMENT INHIBITED	NUMBER OF ITEMS	ON HAND VALUE	REPLENISHABLE ISSUES COUNT	REPLENISHABLE ISSUES VALUE	DUE VALUE
CODE - SITUATION BASIS	76	$ 61,343	25	$ 41	$ 24,380
CODE - DELETE AT ZERO	1902	$ 1,040,403	137	$ 2,603	$ 13,167
CODE - REPAIR ITEM	0	$ 0	0	$ 0	$ 0
CODE - ORDER ON REQUEST	38	$ 581,486	2738	$ 6,980	$ 27,609
CODE - SEASONAL	0	$ 0	0	$ 0	$ 0
CODE - SUBSTITUTE	0	$ 0	0	$ 0	$ 0

INACTIVE ITEMS MONTH	COUNT	VALUE
CURRENT	229	$ 289,294
FIRST	409	$ 505,059
SECOND	215	$ 445,530
**OVER	4957	$ 4,705,038

UNIT PRICE INTERVAL	NBR ITEMS	INVENTORY MOS	INVENTORY VALUE	THIS MONTHS SALES COUNT	THIS MONTHS SALES VALUE	THIS MONTHS RECPT VALUE	EXCESS MOS	EXCESS VALUE	PROJECTED MAX MOS	PROJECTED MAX VALUE	PROJECTED MIN MOS	PROJECTED MIN VALUE
.00 - .10	1058	893	$ 83,109	429	$ 7,355	$ 5,635	886	$ 46,410	6	$ 37,308	3	$ 17,810
.11 - .25	1049	559	$ 118,052	372	$ 7,079	$ 3,968	553	$ 85,549	5	$ 32,223	3	$ 14,199
.26 - .50	1182	617	$ 330,019	603	$ 37,458	$ 12,250	613	$ 177,529	4	$ 151,880	2	$ 68,842
.51 - 1.00	1559	453	$ 519,604	3466	$ 86,537	$ 83,132	444	$ 205,650	8	$ 312,805	4	$ 126,336
1.01 - 2.50	2683	496	$1,052,336	1206	$ 72,70[illegible]	[illegible],466	491	$ 657,725	4	$ 351,176	2	$ 155,792
2.51 - 5.00	2174	330	$1,258,761	1062	$ 222,693	$ 197,299	325	$ 533,383	4	$ 685,374	2	$ 311,185
5.01 - 10.00	1888	374	$1,376,489	747	$ 63,236	$ 95,628	230	$1,057,583	4	$ 312,459	2	$ 143,141
10.01 - 25.00	1709	166	$1,372,983	726	$ 117,009	$ 88,774	161	$ 954,983	4	$ 403,139	2	$ 175,690
25.01 - 100.00	1727	177	$2,933,384	683	$ 266,528	$ 371,517	173	$1,935,862	4	$ 967,190	2	$ 460,806
100.01 - OVER	1035	93	$5,571,300	192	$ 187,189	$ 459,529	89	$4,307,199	4	$1,089,910	2	$ 539,688

INVESTMENT MONTHS OF STOCK INTERVAL "MOS"	NR ITEMS	"MOS" VALUE
.00 - .25	5044	$ 2,519,940
.26 - 2.99	1345	$ 673,176
3.00 - 5.99	1359	$ 876,805
6.00 - 8.99	888	$ 598,747
9.00 + OVER	7428	$ 9,947,371
TOTAL	16064	$14,616,039
AVERAGE STOCK LEVEL		8 DAYS

OVERAGE DUES INTERVAL "DAYS"	NR ITEMS	VALUE
1 - 14	196	$ 101,971
15 - 29	125	$ 62,337
30 - 44	97	$ 61,008
45 - 59	41	$ 74,259
60 - 89	69	$ 203,609
90 + OVER	500	$ 694,615
TOTAL	1028	$1,197,799

NUMBER OF ITEMS CARRIED IN OTHER SHOPS

THIS SHOP	ONE SHOP	TWO SHOPS	THREE SHOPS	FOUR SHOPS	FIVE SHOPS	OVER FIVE
16063	4361	1200	285	116	40	61

NAVSHIPS MAXIMUM	NR ITEMS	AVG STOCK ON HAND
90 DAYS:	9361	1691 DAYS
150 DAYS:	53	1567 DAYS
180 DAYS:	2381	8513 DAYS

DISTRIBUTION: SEQUENCE: SHOP

Figure 9. Sample SYMIS Report (MS-455Q)

1. Number of Inventory Line Items
2. Inventory Value (dollars)
3. Value of Material issued for the month reported
4. Value of Material receipts for the month reported
5. Stock Turn Over
6. Number of Issues
7. Effectiveness (Number of Material Requests Filled divided by Number of Requests Submitted)
8. Number of Line Items showing a balance of zero
9. "Not-in-Stock" Rate for the shop store.

At first glance, these particular data fields are not visible by reviewing Figure 9. In fact, report MS-455Q contains many more data fields than a top-level Manager could effectively monitor.

There is yet another compilation of data that is reviewed by the Supply Officer in his weekly meeting with his division Managers. This information is once again pulled from SYMIS-produced reports and, in this case, entered into a microcomputer operating a commercial software package and subsequently output in a color graphics format. This data set includes:

1. Inventory Balances by Material Classification (DMI, SS, M&SRM)
2. Excess Material Usage
3. JML Submissions by Material Classification (DMI, SS, M&SRM)
4. Shop Stores Inventory Report (described above)
5. Receipt Processing Time

6. Receiving Backlog
7. Receipt Inspections Backlog
8. Physical Storage Backlog
9. Storage Call-Outs Backlog (Material from DMI Warehouse to shop)
10. Supply Department Budget (Total, Labor, Material and Other).

In order to produce this graphic presentation to the Supply Officer during the weekly meeting, data is drawn from several MM and MS reports. This step, like that for the Shop Stores performance report, is necessary because SYMIS has poorly designed report formats and no graphics capability. A significant amount of time is spent to create useful information from the shipyard information system, something that was not anticipated or desired when the system was designed.

MS is a batch-oriented processing system relying on keypunched cards and tape inputs for updating. Therefore current information is not always available to the user "on-screen." Database updating by batch-processes is performed during slack operating hours; at Long Beach it is done in the evenings (Monday through Friday) and on weekends. This is a significant drawback because, without accurate realtime information, it is difficult to plan material flow accurately and make sound material management decisions.

Batch processing creates an additional problem. After a batch of jobs has been processed errors are reported via printed reports indicating that some of the data were rejected by the system. Exception reports, as they as sometimes called, must be reconciled to find the errors and enter the correct data into the system immediately. Correction of the database consumes a large portion of time at Long Beach and backlogs are monitored by the Supply Officer on a weekly basis. Inventory accuracy suffers considerably from these backlogs because the database correction process takes time away from routine receipt and issue processing functions. If error messages could be received upon data entry, as in most realtime systems, much of the routine work could be accomplished and inventory accuracy would be improved.

When time is spent on exception reports and receipt/issue processing backlogs are created, inventory accuracy suffers. This may not seem obvious at first but, if the data base does not reflect what is in the warehouse inventory accuracy is degraded. Therefore, when location counts are physically changed the data base must be updated to maintain inventory accuracy. Because MS is not a real time system it is not unusual to encounter situations where material has been issued from a Shop Store which has a zero balance on the computer records because not all receipts have been processed. Normally when a receipt is processed through MS, the computer program validates that all of the information entered is correct and complete. Receipts are rejected for missing or incorrect data entry. MS programs search outstanding replenishment records in the Master File attempting to match the inventory record document number with the receipt document number. If a match occurs, the system completes the transaction by removing the outstanding order record from the material outstanding file. If the system cannot match the document numbers, it processes the receipt but produces a "special notice card." The card is forwarded to Supply Department for manual review against the Inventory Action Listing (MS135B Part 1) and for appropriate correction. In addition to this report MS generates the Daily Transaction Listing (MS135A Part 1) and various history reports which must also be reviewed to see if the computer was properly updated during the receiving process. [Ref. 20:pp. II-15--II-16]

The manual procedure of correcting transaction errors must be done daily to ensure that both the inventory and financial records are kept current. Material managers therefore, spend much of their time on this function. However, no matter how much effort is put into the database it is always at least a day behind. If an inventory is introduced, as is done daily under cycle-counting, reconciliation of discrepancies is difficult and inventory accuracy suffers considerably.

Although the system eliminates much of the recordkeeping that is required in the management of inventory, batch-processing and listing-reconciliation creates its own paperwork backlog. This backlog often offsets any time-savings gained by automating material records offsets.

3. Material Management Application

The objective of the MM Application is to "improve the capabilities of the Shipyard MIS," and to support material control by improving the accuracy, timeliness, and accessibility of information. MM, which replaced the old Industrial Material (MC) Application, is designed to:

1. Permit positive control of all material;
2. Provide a single repository of information about the status of material;
3. Avoid delays in database updating by providing on-line updating capability;
4. Produce timely reports for monitoring performance;
5. Provide statistical and historical information;
6. Reduce clerical effort; and
7. Provide a more efficient means of accomplishing physical inventories. [Ref. 18:p. I-3]

The MM application maintains a complete record of all Direct Material Inventory (DMI) from the time requirements enter the system until the material is issued. It retains information on unshipped material (rip-outs), excess material, and M&SRM assets. Additionally, it tracks the status of DMI material requests sent to Shop Stores to be filled.

MM uses more modern data processing than does MS. It provides on-line access and updating of material data in a centralized data base from remote terminals. That is, users have access to the same realtime information. MM virtually eliminates the need for punched cards and huge paper listings which are time consuming and vulnerable to error. [Ref. 18:p. I-4]

Material Management performs many of the same functions on-line that MS does in a batch mode. So, rather than repeating the same discussion, a review of some of the more unique MM features is in order.

a. Purchasing

MM provides complete status on all outstanding contracts and purchase orders for non-standard overhaul material. It maintains an historical record of vendor contract delivery performance data and it provides all of the information to the user on-line.

b. "Rip-out" Material

MM tracks the status of material which has been removed, for refurbishment or storage, from a ship in overhaul.

c. Status Processing

The material ordering statistics, information on material received but not moved, the backlog of purchase requisitions, and the status of critical items are all available on screen or can be produced in printed form.

d. Excess Material

MM identifies excess material upon completion of work and allows the processing of this material as a turn-in for credit, a turn-in to disposal, a transfer to another open job order, or retention as M&SRM.

e. Physical Inventory

MM produces reports that provide locations and quantities of all items stored in a particular warehouse or row within that warehouse. It produces inventory count cards used by inventory personnel to annotate physical counts that will be entered into the computer for automatic reconciliation with inventory records. After inventory reconciliation is complete the computer generates adjustment transaction records, which management can use to track gross monetary adjustments. [Ref. 18:p. I-5--I-7]

The Material Management Application is at the heart of the material information flow within SYMIS. It gives management positive control, from request to issue or disposal, of all overhaul material. As shown in Figure 8, MM receives inputs from the Shop Stores, Cost, and Production Control Applications directly, updating each of them as well as the Accounts Payable Files. Interface between the various applications is performed by magnetic tape and key punched card. Transaction reports are produced to list processing exceptions, which are then manually researched and corrected to ensure database integrity. [Ref. 18:pp. I-8--I-10]

D. HARDWARE AND SOFTWARE CHANGES

System changes are centrally controlled by Naval Sea Systems Command's Automated Data Systems Activity (SEADSA). Suggestions for change from individual shipyards are one source used; other sources include NAVSEA audits, policy changes outside of NAVSEA control, and results of deficiencies found by system users or SEADSA personnel. Regardless of the source, after a cost-benefit analysis is prepared by the activity proposing change, SEADSA evaluates the proposal to assess its impact upon NAVSEA policies. Each analysis considers the cost of making the change both in terms of programming effort and of its impact on the entire Shipyard MIS; it weighs the hardware requirements in terms of system performance; and it determines how the change would fit within the implementation schedule of previously approved software changes in accordance with OPNAVINST 5231.1, "Procedures for the Management of Automated Data Systems Development." [Ref. 19:p. I-5]

SEADSA at this stage, exercises its control over the system by either accepting or rejecting the proposal. If approved, a detailed specification, which becomes the blue print for analysis and programming, is written. Once a program is completed, it is compiled, tested, and approved for implementation by SEADSA. It then becomes a part of the approved Shipyard MIS programs library and copies are forwarded to each of the shipyards where they are implemented by the individual Data Processing Offices. [Ref. 18:p. I-6]

If conclusions about SYMIS' effectiveness as a management tool are to be made, the system must be assessed both in terms of the framework established earlier and of its usefulness to the manager. Shipyard policy and a general description of the material management functions within SYMIS have defined the environment and management's expectations of the system. Now, the attention will shift to the ability of SYMIS to meet those management needs.

V. ASSESSING SYMIS EFFECTIVENESS

The primary question, "Does the MIS at the Naval Shipyard Long Beach provide useful decision-making information?," is the focus of this study. Thusfar, the fundamentals of material management and MIS have been reviewed to construct a model that will help answer such a question. Today's material manager must have an information system that enables him or her to control the flow of production materials. Historical data including vendor performance, material rejection rates, requirements and leadtimes should be available. Accurate job material lists from the planning department, that are readily available to purchasing, will enhance vendor selection (for non-standard material) and reduce incidences of ordering the wrong material. The MIS should help improve inventory accuracy by generating usable inventory aids; provide a user interface that promotes virtually error-free receipt and issue processing; and produce inventory reports that are timely, accurate and well-formatted, highlighting problem areas for management attention. The system should enhance interdepartmental coordination by allowing communication between all users with minimal disruption; it should automate routine decisions and provide useful information for solving more complex problems; and should be a planning tool that links material requirements to the production schedule (assuming that the shipyard is given more control over its planning horizon).

Using the four characteristics (analytic sophistication, information currency, information overload, and output complexity) along with the material management concepts (MRP and JIT), a final assessment of SYMIS as a Management tool will be made.

A. INFORMATION NEEDS

Although it was mentioned earlier, the types of decisions that Material Managers must make bears repeating. In order to lower inventory levels and improve inventory accuracy SYMIS must do more than just track material history. It must assist the Supply Officer in making strategic decisions for the future.

Table I outlines the performance measures required by shipyard policy. Currently SYMIS produces the data to show the Supply Officer how his department's performance compares to these goals but offers no forecasting or planning information to answer these strategic questions:

1. Should additional transportation assets be added to improve warehouse to shop deliveries in the future?
2. Are additional/personnel required to meet material division workload increases/decreases?
3. How can excess inventory be reduced from $30 million to $23 million? How can it be reduced further?

4. Based on future material needs and leadtime information how many Shop Store line items can be eliminated or what quantity reduction can be made?

5. What will be budget input for next year based on my projected material needs?

6. What can be done to achieve the stated inventory accuracy goals (Table I)? How can 100% accuracy be achieved?

Without improving the level of analytic sophistication, by upgrading hardware and software, SYMIS will be ineffective as a strategic planning tool.

B. ANALYSIS

The Shipyard Management Information System is primarily a second generation, batch-oriented system. It relies on old technology which makes communication between subsystems cumbersome and often impossible. Despite the fact that SYMIS has both an EOQ model (see Chapter II) and a model for selecting items for inventory, its degree of analytic sophistication is low. Only the MM Application operates in real time with an interactive data base. Since only MM controls DMI, Ship Stores Material is left under the control of a batch-oriented system.

SYMIS, because of its lack of analytic sophistication, causes more problems for the individual material management employee that it seems to prevent. That is, every desk was covered by reports of data refections, backlogs of receipts and issues, and other computer-related administrative actions that required manual intervention and research. One manager said that her biggest problem was not inventory accuracy or excess material accumulation, it was "poor desk procedures." The average employee spent an inordinate amount of time researching exception reports of rejected data from past batch runs. Often the reports were quite long and required a great deal of manual research. While this task was being performed receipts and issues were not being processed and the daily backlogs were increasing. One of the measurements the Supply Officer looked at was receipt backlog, and although it showed a downward trend it was still about three or four days. The system is hurting performance needlessly because its level of technical sophistication and design is inadequate to keep up with demands placed on it by its users.

Information generated by the batch-process is usually a day or more behind.

> The systems/processes...are poorly integrated, leading to a situation where the various departments operate as individual entities. The data used by one department is difficult, if not impossible, to share. [Ref. 21:p. 2]

Further, data inputs and outputs are not coordinated and decision-making information is <u>not</u> available on-line to either top management or the first echelon material manager. In short, with SYMIS there is no centralized database that contains current information on all aspects of the material management function.

SYMIS material management reports, like its technological shortcomings, do not help the strategic management process either. The reports are complex and overloaded with unnecessary data. To the typical manager who is bombarded with information from many sources a complex MIS output serves only to complicate the job. Simple report formats and graphic displays reduce information overload and improve management effectiveness.

At Long Beach, the Supply Department accumulates several statistics that are used to monitor material flow throughout the shipyard (see Chapter IV). Data that are used to create these statistics come from the hundreds of transactions and reports generated by SYMIS, e.g., MS-455Q (Figure 9). In order to obtain all data requirements, many other reports must be produced and reviewed. As is the case with MS455Q, most of the reports are laden with secondary information that is of little interest to a busy manager. Since the Supply Officer does not have the time to read extraneous data, management reports are compiled, and selected information from each report is processed and graphically displayed on an off-line microcomputer. This extra step helps to overcome the output complexity problem by displaying key data elements making it easier to visualize trends, and track departmental performance.

The Shipyard Management Information System is primarily a material tracking system. It accomplishes this task fairly well given its antiquated technology and limited subsystem integration capability. Outputs are generally complex and usually at least a day behind, but do provide the Supply Officer and Shipyard Commander an accounting of the whereabouts of shipyard materials. Without significant hardware and software upgrades that would give managers a fourth generation, real time system however, the users must be satisfied with tracking. Unless the system provides a more integrated planning function and an on-line database that can be visible to all users, lowering current inventory levels and improving inventory accuracy will be virtually impossible.

The shipyards are experiencing a new age of both competition with commercial and with other naval shipyards. Coopers and Lybrand (see Chapter III) explained that excess material inventories not only are costly in dollars spent but, contributed to increased indirect personnel costs to order, purchase, expedite, receive, warehouse, distribute and eventually dispose (excess) material. Unless inventory levels are lowered and these holding costs reduced, overhead charges will continue to rise and adversely affect the ability to compete.

Another attribute of a useful management information system is its ability to assist in the planning process. In a quote from NAVSEA's request to the Chief of Naval Operations for a new management information system:

> Responsive management information systems (MIS) represent one of the most important tools needed to support improved production, scheduling, and planning functions at the Naval Shipyards.... The Navy must

adopt managerial techniques and technologies similar to private industry. [Ref. 21:p. 1]

C. INFORMATION SYSTEMS FOR THE FUTURE

If the shipyard wants to plan its material requirements it must have the automated capability that techniques such as MRP and, to some degree, JIT require. In its current form, SYMIS does not link scheduling and material management modules through an interactive data base. Instead, work schedule information is passed to MM through the batch process. Unfortunately the information is not timely and cannot be used to plan material flow. As a result, stated goals for inventory excesses are consistently exceeded.

MRP and JIT requires that schedule information, JML's supplier performance data, material leadtimes and historical usage data must come together in a centralized database. Key operations, the basic work planning tool used by the planning department to construct work schedules, are three to four month time blocks which break work down by major pieces of equipment (see Figure 10). Key operations may contain many individual tasks for which JML's are created. JML creation begins the material flow for which the Supply Department is responsible.

Key operations have been criticized in past studies for being too comprehensive. It has been said that,

SHIPYARD	SHIP	JOB ORDER NO.	KEY OPERATION NO.	SCHEDULED SPAN			ALLOWANCE	ACTUAL EXPENDITURE
				START	COMPLETE	MONTHS		
PEARL HARBOR	PINTADO SSN 672	161305 1701 STEAM DIS-TILLING PLANT	221 REPAIR PUMPS	07/07/82	12/10/82	5	694	1,421
			222 REPAIR COMPRESSOR	08/26/82	02/18/83	6	486	500
			223 REPAIR VALVES	08/26/82	12/17/82	4	1,117	1,095
		161305 5201 MAIN & VITAL HYDRAULIC	222 REPAIR A/C	06/03/82	01/19/83	7	1,293	1,541
LONG BEACH	HOEL DDG 13	16257 25111 #4 FDB FMD	420 SHOP REPAIR	11/08/83	02/10/84	3	1,656	1,873
			460 REPAIR GOVS.	11/07/83	01/27/84	2½	758	759
	BRADLEY FF1041	16866 55152 H.P. AIR COMPRESSOR	420 SHOP REPAIR	08/25/83	01/10/84	5	828	776
	NEW JERSEY BB62	14462 5551 MAIN COND. PUMPS	420 REPAIR PUMP #2	01/25/82	05/13/82	4	684	909

Figure 10. "Key Operation Size and Scheduled Span Times" [Ref. 14:Exhibit 7-OPS]

> The Key op[eration] is vulnerable to mischarging, and when inaccurate charging is entered into the MIS, future work estimations will be incorrect. [Ref. 22:p. 23]

When the size and span of a work element is too large, it is impossible to effectively manage work and evaluate performance.

Key operation size can be equated in a theoretical sense to batch size in a pure manufacturing organization. That is, the larger the batch, the more difficult production management and efficient operation are to maintain. Thus, according to the JIT fundamentals addressed in Chapter II, smaller batches (smaller work breakdown unit) yield more efficient production.

This idea was recommended by Coopers and Lybrand and is being implemented experimentally at Puget Sound NSY. That is, scheduling work at the individual task level (i.e., small batches) to give the shop manager (foreman) more control and improve the planning and cost estimating process.

For the material manager scheduling work in smaller time units creates the possibility of applying some of the techniques (MRP/JIT) discussed earlier. For example, assume that SYMIS had an interactive real time database that contained supplier performance data, leadtimes (for both government and commercial sources) and schedule broken down into individual tasks. The material manager could then review the JML's given him by the planner on line dividing parts requirements into two categories: standard material, furnished by government assets; and non-standard material, purchased commercially. Then, using the leadtime data standard, material could be ordered through the Navy Supply System with an assigned RDD and requisition priority that would ensure delivery (ideally) in time to meet the job start date (MRP application). Non-standard material could then be ordered from a commercial source who could deliver in lot sizes small enough to meet production requirements and satisfy the shipyard work schedule (JIT Purchasing).

Material flow planning, as in this scenario, would then give the Supply Officer the flexibility to plan his inventory requirements and begin to reduce his excess material. Obviously, some inventory will have to be maintained to smooth the irregular demand patterns within a production environment. Nevertheless, Material planning will contribute to lowering these levels by eliminating unnecessary material requests caused by poor work planning.

Another aspect of planning that must be considered, with respect to reducing excess materials, is engineering and design. In order to create a useful JML, from which the right production material can be ordered, drawings, technical manuals and other technical documentation must be accurate. Coopers and Lybrand found that engineering information was often inaccurate and that it directly resulted in the wrong material being ordered. Since the specifics of this issue are beyond the scope of this study, it is sufficient to say that SYMIS must contain sufficient random access memory capacity to retain large volumes of part number information. Such data will help planners to cross reference part number information on drawings to Navy stock numbers or commercial manufacturers part numbers. Off-line data bases such as "Haystack" or "Parts Master" are also available on the commercial market. These systems allow the use of modems to download part numbers and ensure the correct material is ordered. These commercial data bases have both commercial and Federal Supply System stock numbers.

If the planning and production functions can integrate and more clearly define the work package, then more accurate material orders and delivery schedules can be made from leadtime and vendor performance data held in the material history files. Material Requirements Planning and Just-in-Time techniques described earlier could then be used to reduce the need to carry as much inventory and eliminate a source of excess material.

In order to apply this type of theoretical thinking to material management in the shipyard integration of all departments must be achieved. An upgraded version of SYMIS offers such an opportunity. If the system shown as Figure 8 was interconnected by a single, real time interactive database and communication between all functions was possible, then SYMIS could be easily programmed to meet management's needs. But, automation alone is not the answer.

If the shipyard organization is going to be able to successfully compete with other shipyards, an overall business plan must be developed. Strategic planning, built upon a framework of attainable short and long-term goals which can be monitored and controlled by management is the first step toward reducing inventories, improving inventory accuracy or lowering overhead costs. By itself, an information system (no matter how sophisticated) cannot improve a poorly managed organization. So, prior to investing in expensive hardware and software, a complete business plan must be created and, as part of that plan, information requirements established.

VI. SUMMARY AND RECOMMENDATIONS

A. SUMMARY

Given the rising costs of overhauling and repairing ships and the attention that is being paid to lower government expenditures, finding solutions to shipyard inventory problems is important. Holding costs and direct outlays for excess materials drive overhead costs up which weakens a shipyard's competitive position. New initiatives to solicit bids for overhaul work that force public shipyards to be competitive with each other and with private yards make cost reduction even more critical to the yard's very survival.

The purpose of this thesis was to answer the primary question: Does the Management information system at Long Beach NSY provide material managers useful decision-making information. In order to answer it four basic research questions were addressed to ascertain:

1. Theoretical information needs of the material manager.
2. Factors that should be considered when evaluating an information system.
3. What material management and MIS discrepancies were discovered by the many studies of the past few years.
4. What policies by higher authority are influencing managerial decision-making in the Supply Department.

Answers to the questions came from information that was gathered from background literature, analysis of previous shipyard studies, analysis of current shipyard and NAVSEA instructions, and personal and telephone interviews with key material and MIS managers at the shipyard.

Several problems concern Materials Management Division at Long Beach NSY. Among these, rising inventory levels (18.37 percent over the past five years); low inventory accuracy percentages (particularly in the Shop Stores Account); and reliance on outdated, batch processing computers, head the list as the most troublesome.

Currently, Long Beach Shipyard has an excess inventory account that comprises over fifty percent of the total shipyard inventory, representing about $30 million. At present this material is destined to be returned to the Navy Supply System for credit or to a DOD disposal activity. Although listings of excess materials are shared between shipyards, they are usually not reviewed prior to ordering by most managers. Therefore, once material is ordered and not used it is usually wasted.

The lack of an adequate planning function within SYMIS is the largest contributor to the growing excess material inventory. SYMIS does not link scheduling information to the material management modules through an on-line database. Instead, work start and stop dates are fed into MM through the batch process, and are usually too late to prevent orders of unnecessary material from leaving the shipyard or give the material manager enough notice to cancel orders before they arrive. Stated goals for excess material percentages are exceeded during each new overhaul as the problem steadily worsens.

SYMIS, in its current configuration, offers no solution to this problem. Without information integration between the Planning Department and the Supply Department, material deliveries can never be coordinated with schedule requirements. Furthermore, without adequate information in the opposite direction, current requisition status information is not available to the Production Department to inform them of possible delays due to material nonavailability. Managers have some information but it is not timely enough to support strategic decision-making.

Timing of information flow is critical particularly at the final stages of an overhaul when scheduled departures press everyone for time. Many manhours are wasted expediting materials that are already in the warehouse but not so designated on the data base. Wasted manhours add up to increased operating expenses and detract from the performance of the entire shipyard needlessly.

A second problem of the highest priority to the shipyard manager is poor inventory accuracy. Unofficial estimates of the top management of the Supply Department show inventory accuracy in the Shop Stores Account at fifty to sixty percent and eighty-five to ninety percent in the DMI

Account. Although this was a rough estimate, the same figures were echoed by several different managers during two days of personal interviews. Recalling that policy required inventory accuracy goals to be above ninety-five percent in all categories, this is a significant problem for the Supply Department to overcome.

Once again, SYMIS seems to be at the root of the problem. Although the MM application has an on-line data base, which is probably why it shows a higher individual inventory accuracy for the DMI account, its performance is overshadowed by the poor performance of the batch-oriented MS application. Batches are processed, in the best case, the evening after a particular stock number transaction was made. Therefore, information in the data base is always at least one day behind. Multiple issues, receipts, transfers, and spot inventories against a fast moving line item may occur simultaneously on any day. In a batch processing system, rejected transactions can lead to numerous errors in this situation. Then on the next day the error will appear on a rejection report showing that something did not process correctly. The inventory then is erroneous. In the absence of a real time database that is updated when transactions occur, the probability of having ninety-five percent shop store inventory accuracy is virtually zero, unless manual records are kept.

In addition to unsophisticated analytic sophistication and the lack of information currency, SYMIS contributed to information overload because of its output complexity. Poorly designed management reports forced users to create their own reports off-line. Also, the volume of exception reports to be processed daily, after the previous evenings batch run, contributed to workload backlogs desks.

Obviously, when SYMIS was designed, it was hoped that the workload would be reduced and performance would be improved. Rather SYMIS seems to have created additional work for its users. It is apparent, therefore, that it may be time to reevaluate its usefulness.

NAVSEA has recognized the problems with SYMIS and is taking steps to upgrade the system. However, funding will be the biggest obstacle to overcome. The SYMIS network is a piece-meal compilation of computer hardware that grew from a series of short-term "fixes" resulting from inadequate funding to upgrade the entire system. Large organizations, like the system of naval shipyards, require a strategy and goals to achieve it that include a comprehensive information architecture based on the needs and performance measures set forth by key management personnel. SYMIS cannot be fully improved until such a strategy is formulated and the role of the entire system established within that strategy. Since funding always seems to fall short, however, NAVSEA may never be able to execute such a grandiose plan and may have to settle for a "bits-and-pieces" solution.

B. RECOMMENDATIONS

When considering improvements to computer systems the quest to have the "latest and greatest" equipment regardless of the need or the cost seems to influence decision-making the most. Where computers are involved people feel that buying state-of-the-art equipment is going to solve all of the organization's problems without any procedural changes outside the management information system. Obviously this is false, but still some fail to see this and, although I concluded by showing the need for a new system I will offer some recommendations that should be considered well ahead of purchasing any new system.

The problems mentioned throughout this study are not going to be solved solely with a computer unless fundamental production, material management, and accounting procedures are challenged and an overall organization strategy established. In other words, NAVSEA must design a "manual" operational system based on sound principles and a business strategy and then consider whether or not it should be automated.

The following actions are recommended to assist in the creation of an improved Shipyard Management Information System for Long Beach and other naval shipyards:

1. Strategic Planning

1. The first step must be to develop a sound business strategy or an overall vision for management to establish goals to execute the strategy.

2. Create a comprehensive list of all problems, real and perceived that must be corrected and incorporate them into the strategy-building process.

3. Determine whether or not to continue with the current accounting-based management system. Many private sector firms are considering techniques used by the Japanese which are based upon concerns for quality, inventory levels, productivity, innovation, and the skills, training, and morale of the workforce. Traditional accounting-based systems, with performance measures based on pure financial controls are being found by researchers to be inadequate in production environments and even some service organizations.

4. Request assistance from commercial sources, specifically shipyards, to see how the private sector formulates strategy and what performance measures they use.

5. Consult with experts at leading academic institutions, including the Naval Postgraduate School, who can offer fresh ideas consistent with the most current theories of shipyard production and material management.

6. Review the current literature discussing shipyard, industrial, and material management to see what ideas may be applied to the naval shipyard.

7. Have representatives from <u>every</u> aspect of the shipyard be involved in formulating the strategy so that a fully integrated and comprehensive plan is created and full management support for it is achieved.

8. Develop a set of performance measures that are consistent with the strategic plan. The measures should be easily understood; applicable to the goal achievement they are controlling; and consistent with improving production, lowering excess inventory, and solving other important shipyard problems.

9. Once a plan and performance measures are established, examine SYMIS to determine if it can support the plan in its current configuration and identify what modules should be changed.

2. System Design

1. Hardware should be capable of providing a real time iterative data base and should have a mass storage capability, like CD-ROM, that can hold the enormous amount of data that must be accessed quickly.

2. Modem connections with parts identification services such as "Haystack," should be included to assist planners to more accurately identify part numbered and stock numbered material for the generation of new requirements.

3. Networking between shipyards should be considered. Information sharing, other than by mailing magnetic tapes, especially sharing records of excess material inventories, as required by policy, is necessary to lower inventory levels.

4. System design must be done by the users and managers--not left to the computer programmers. The new system must fulfill user needs if it is to be accepted.

5. The new design must help managers plan material requirements better. It should link scheduling and the material ordering process directly so that accurate material lists with valid required delivery dates can be created. In addition, the new software must be able to forecast and have an MRP capability that fully integrates scheduling, planning, production, and purchasing. It must also include upgrading of the Shop Store (MS) Application so that all categories of shipyard material can be managed on-line.

6. Report formats should not be as rigid. Rather the user should have the ability to build his or her own reports. In addition, a graphics capability should be included so the data presentation is more visual and trends are easily seen.

7. The new system architecture must be fully integrated, enabling all departments to freely transfer and share data with one another.

3. Policy Considerations

If sweeping changes finally do result from this process policy change must be made in a timely manner. As is often the case, strategic changes are made but are not communicated to system users. Whatever business plan results it must be endorsed by the highest levels of the organization and passed on to all levels of the shipyard organization.

C. SUGGESTIONS FOR FURTHER RESEARCH

This area offers many possibilities for research. The shipyard of the twenty-first century should be the primary focus. The feasibility of implementing Just-in-Time manufacturing principles seems to be most appropriate at the present time. Also, studies that lead to the determination of appropriate performance monitoring measures should also be performed. Contracting research that would apply just-in-time purchasing within the context of government contract law would also inspire new ideas for improving delivery times and reducing inventory levels.

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