[redacted]

DEPARTMENT OF THE AIR FORCE

AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT/GEM/LSM/90S-6

AN ANALYSIS OF THE AIR FORCE GOVERNMENT OPERATED CIVIL ENGINEERING SUPPLY STORE LOGISTIC SYSTEM: HOW CAN IT BE IMPROVED?

THESIS

Robin Davis, B.S. Captain, USAF

AFIT/GEM/LSM/90S-6

The opinions and conclusions in this paper are those of the author and are not intended to represent the official position of the DOD, USAF, or any other government agency.

AFIT/GEM/LSM/90S-6

AN ANALYSIS OF THE AIR FORCE GOVERNMENT OPERATED CIVIL ENGINEERING SUPPLY STORE LOGISTIC SYSTEM: HOW CAN IT BE IMPROVED?

THESIS

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Engineering Management

Robin Davis, B.S.

Captain, USAF

September 1990

Acknowledgements

My greatest appreciation goes first to my wife for her help with this thesis and graduate program as well. Her outstanding proofreading enabled me to write exactly what I meant. I would like also to extend my thanks to Lt Col James R. Holt and Major Bill Martin. Lt Col Holt's leadership as my advisor motivated me to do my best on this thesis. Major Bill Martin provided me with extremely rational, objective, and constant guidance towards the completion of this thesis.

Robin Davis

Table of Contents

List of Figures

List of Tables

AFIT/GEM/LSM/90S-6

Abstract

This thesis researched ways to improve the timeliness and consistency of CE logistics and methods to reduce inventory holding costs. The study focused on the Base Contracting local purchase channels used by the Government Operated Civil Engineering Supply Store (GOCESS) logistics systems throughout the Air Force. The results indicate that the average response time for GOCESS systems is 18.6 days with a standard deviation of 14.6 days. The high standard deviation in relation to the average response time indicates local purchase channels are difficult to control. The overall logistics efficiency was 4.2%. This indicates that materials ordered through Base Contracting are not received by the date required 95.8% of the time.

Annual warehousing holding costs to CE are approximately $15.5 million. Material Requirements Planning (MRP) is a method that may reduce those warehousing costs. The emphasis of MRP is to minimize inventory by arranging for the delivery of the exact amounts of materials from vendors as required in manufacturing. An expert panel was formed with experts from each major command to derive a method to implement MRP into CE logistics. No consensus was achieved. However, the process introduced MRP to the logistics experts in each major command.

AN ANALYSIS OF THE AIR FORCE GOVERNMENT OPERATED CIVIL ENGINEERING SUPPLY STORE LOGISTIC SYSTEM: HOW CAN IT BE IMPROVED?

I. Introduction

The mission of Air Force Civil Engineering (CE) is to prepare and sustain bases for the projection of aerospace power in peace and conflict (6:3). This mission includes the maintenance of base facilities which is the responsibility of the Base Civil Engineer (BCE). To support maintenance activities, CE purchases and manages many different commercially available materials such as electrical and plumbing supplies, paint, and lumber. Within CE, the Material Control section is responsible to procure, warehouse, and distribute these materials. Their goal is to obtain the right materials at the right time, and at the least cost to enable the organization to accomplish its mission as effectively and efficiently as possible.

In fiscal year (FY) 1987, Air Force Civil Engineering (CE) spent over $500 million for construction materials to maintain Air Force bases (1:1). The timely and consistent availability of these materials is essential to the productivity of over 30,000 Civil Engineering craftsmen located throughout the world. Materials must be available when needed for efficient work scheduling and to meet customer requirements.

From November 1988 through January 1989, the Air Force Audit Agency performed an evaluation of the management of Air Force Civil Engineering (CE) materials. They reviewed 14 bases representing six major commands. In their review, they found that the value of material in the work/job order storage areas of these bases was approximately $6.9 million or an average of $496,000 per base (1:1).

The approximate CE inventory holding cost rate is 33% (14). There are roughly 100 major Air Force installations in the world. The approximate annual work/job order holding costs are:

$$\text{Annual Holding Cost} = (100\ \text{bases}) \times \frac{(\$469{,}000)}{\text{base}} \times (.33) = \$15.5\ \text{million}$$

If the amount of materials in storage areas can be reduced throughout the Air Force by 50%, CE could save approximately $7.7 million in annual holding costs.

The purpose of this thesis is to research ways to improve the timeliness and consistency of CE logistics and methods to reduce the inventory holding costs.

Problem Areas and Possible Solutions

Currently, approximately 70% of all Air Force CE organizations use the Government Operated Civil Engineering Supply Store (GOCESS) method of logistics management (17). GOCESS is a material management, sales store, and acquisition system established within CE to purchase, receive, maintain, and issue authorized items (7:57).

Within most CE organizations, Material Control personnel use the Civil Engineering Material Acquisition System (CEMAS) to manage GOCESS. The CEMAS is an automated organizational inventory management system used for the identification, acquisition, and inventory control of material requirements. CEMAS is the computer software used to manage GOCESS.

Major William Martin, Chief of Integrated Logistics, HQ Air Force Engineering and Services Center, stated the following:

> The Government Operated Civil Engineering Supply Store logistics operation using the Civil Engineering Material Acquisition System has improved the CE logistics support. But, there's still room for improvement as far as the responsiveness and efficiency of the system and the effort necessary to operate it. (17)

Major Martin points out two problem areas with GOCESS and CEMAS. First, the responsiveness and efficiency of the system needs improvement. And second, the level of effort necessary to manage the system needs to be reduced.

Responsiveness and Efficiency. A responsive logistics system not only provides rapid delivery times but consistent delivery times (21:39). Responsiveness is the time required to obtain an asset through a logistics system. Systems with fast and consistent response times can reduce inventories and warehousing costs. Efficiency may be measured by comparing the time in which requirements are received to the time they were required.

GOCESS is a flexible method of logistics support. There are several variations that may increase the responsiveness and efficiency of a given GOCESS. For instance, some bases make extensive use of Blanket Purchase Agreements (BPAs). A BPA is a simplified method of filling anticipated repetitive needs for supplies or services by establishing a "charge account" with qualified sources of supply. BPAs are designed to reduce administrative costs in accomplishing small purchases by eliminating the need for issuing individual purchase documents (11:16,709). Some CE organizations do not use BPAs and route all material requirements through Base Contracting. Other bases have the contracting buyers physically located in the CE organization instead of in the Base Contracting office.

By measuring all GOCESS systems in the Air Force, the most responsive, consistent, and efficient systems may be identified and modeled throughout the Air Force.

Level of effort. Currently, most material requirements for CE routine work orders are ordered, received, and stored well in advance of the time they are actually needed. The amount of materials in the work/job order storage areas may be reduced by incorporating innovative logistics concepts such as Material Requirement Planning (MRP).

The MRP concept uses computer capabilities to time phase ocurement. The emphasis is to minimize inventory by arranging for delivery of exact requirements from vendors as required (3:51). Essentially, MRP emphasizes timing the arrival of manufacturing requirements so as to minimize on-hand stock of material (and thus minimizing inventory investment).

If the on-hand stocks are thought of as water in a river covering a be. of boulders, where the boulders represent problems, it is logical that lowering the water level (inventory) exposes the boulders (problems), making them easier to find and remove. By likening the river bed to our work/job order storage areas, the analogy conveys a powerful message: The way to detect what is holding back production is to reduce stock levels enough to expose operating inefficiencies that are normally masked by buffers of stockpiled materials.

MRP concepts are most effective in repetitive manufacturing environments. CE is a Job Shop environment which means that each product is unique and produced only after receiving a customer's order.

Job-shop work may come from different sources and for different quantities and designs. The time allowed for production may also vary as a result of delivery promises (18:544). Nonetheless, while CE is a job shop versus a manufacturing environment, the basic MRP concepts may be incorporated to a degree and thereby reduce CE operating costs.

Research Questions

The following research questions will be examined in this thesis:

1. Of the varied applications of GOCESS in the Air Force, which variation is most responsive, consistent, and efficient?

2. Can MRP concepts be incorporated into CE logistics?

Chapter III will describe the procedures used to gather this information and provide the results.

Scope

CE may obtain materials from the Standard Base Supply System (SBSS) or from local vendors through Base Contracting. This thesis will focus on the improvement of the local purchase channel of GOCESS.

II. Literature Review

This chapter provides a background of CE logistics, explains the operation of GOCESS, and describes methods to improve GOCESS.

Background

The background information consists of a description of the Material Control Section and the various logistics systems designed for CE.

Primarily, Material Control obtains materials for Work Orders (WOs) and Job Orders (JOs). Within CE, a WO is used for work that requires detailed planning, specialized pricing, and close coordination among the different CE shops. JOs are used for work that requires very little planning and only one shop to complete.

Material Control Section. A Material Control section normally consists of a receiving area, WO/JO and residue storage areas, Material Control Office, and Sales Store as illustrated in Figure 1.

The Receiving Section is responsible for the receiving and inspection of all materials used by a CE organization. Typically, the Receiving Section is located adjacent to the WO/JO storage area. By locating the WO/JO storage area near the receiving area, Material Control personnel may immediately transfer incoming materials for WOs or JOs to designated storage areas. Materials for WO/JO's are normally stored in individual bins or areas. The residue storage area maintains materials that are surplus after a WO or JO is completed. Usually, the residue area is located near the WO/JO storage area to facilitate the transfer of materials.

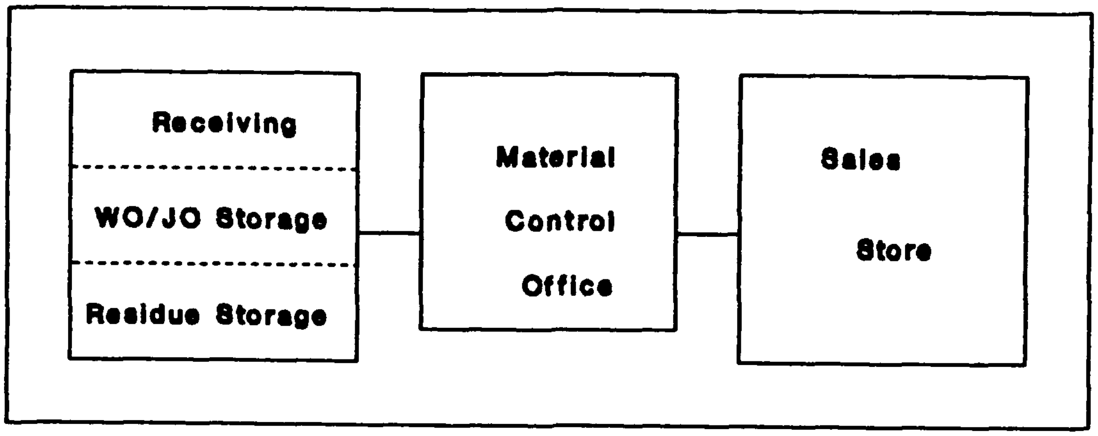

Figure 1. Material Control Section

The Material Control Office is responsible for research, ordering, and follow-up of all materials required for WO's, JO's, and the Sales Store.

The Sales Store is a consolidated bench stock that is used to maintain daily, high-use items for all shops within CE. The Sales Store is often referred to as the "CEMAS" store. The CEMAS store is designed to support 90% of the material requirements for WO/JOs (17).

Logistics Systems. Prior to the mid 70's, CE relied entirely on the Standard Base Supply System (SBSS). With this arrangement, CE forwarded all of its material requirements to the Base Supply Squadron. The SBSS primarily supports weapon systems. However, it is often used to support organizations such as CE (5:4-5).

Three logistics systems have evolved to improve CE logistics support. These systems are:

1. Logistics Civil Engineering Support (LOGCES)
2. Civilian Operated Civil Engineering Supply Store (COCESS)

3. Government Operated Civil Engineering Supply Store (GOCESS).

LOGCES, COCESS, and GOCESS are dedicated CE supply systems. Dedicated systems are systems designed specifically for a particular organization. The determination of which system to use depends on several factors. These factors include items such as Material Control manpower, the availability of material vendors within the local metropolitan area, and the relationship of CE with the local Base Contracting Office. Each of these systems has certain advantages and disadvantages.

The LOGCES was designed to improve material procurement for CE with the SBSS. With LOGCES, all routine material requirements are obtained through the SBSS. However, LOGCES expedites priority material requirements being purchased locally through SBSS thus improving CE logistics support. While LOGCES improves CE logistics support, COCESS is more effective.

The COCESS consists of a civilian firm which is contracted to stock and procure CE materials. The firm has exclusive rights to establish a base store of selected prepriced items required to support the base. Space and utilities for the store are furnished by the base. The store stocks an inventory of negotiated items and under some contracts will order items to fill CE requests (2:L-4.1). There are several advantages and disadvantages to COCESS.

COCESS provides full dedicated contractor support to CE, reduces paperwork by eliminating CE interaction with Base Supply and Base Contracting, and reduces inventories maintained for CE by Base Supply. However, the Government Accounting Office reported that COCESS's have been plagued by pricing irregularities, contract abuses, and repeated allegations of fraud. As a result, the GAO has discouraged the use of COCESS and encouraged the use of GOCESS (13).

As mentioned in Chapter I, GOCESS is a material management, Sales Store, and acquisition system established within CE to purchase, receive, maintain, and issue authorized items (7:57). With GOCESS, requirements are obtained through the SBSS or from local vendors through the Base Contracting Office.

Material Control personnel use the Civil Engineering Material Acquisition System (CEMAS) to manage GOCESS. As mentioned in Chapter I, the CEMAS is an automated organizational inventory management system used for identification, acquisition, and inventory control of material requirements. It is a subsystem of Civil Engineering's Work Information Management System (WIMS). Both the WIMS and CEMAS reside on a CE squadron's Wang mainframe computer system. The CEMAS enables CE to use the GOCESS, COCESS, LOGCES, or SBSS. At most bases, WIMS interfaces with the Base Contracting Acquisition System (BCAS).

BCAS supports both automated and nonautomated customers. It will accept MILSTRIP format requisitions from the SBSS, the CEMAS, and the Medical Material Management System. For nonautomated customers, the system enters purchase request data through work stations either in the Base Contracting Office or at the customer's location (19:15).

GOCESS Operation

Initially, a Real Property Building Manager (RPBM) submits a request for real property maintenance to the CE Customer Service Unit (CSU) as illustrated in Figures 2 and 3. The RPBM is responsible for the repair, use and care of facilities, as well as energy and environmental

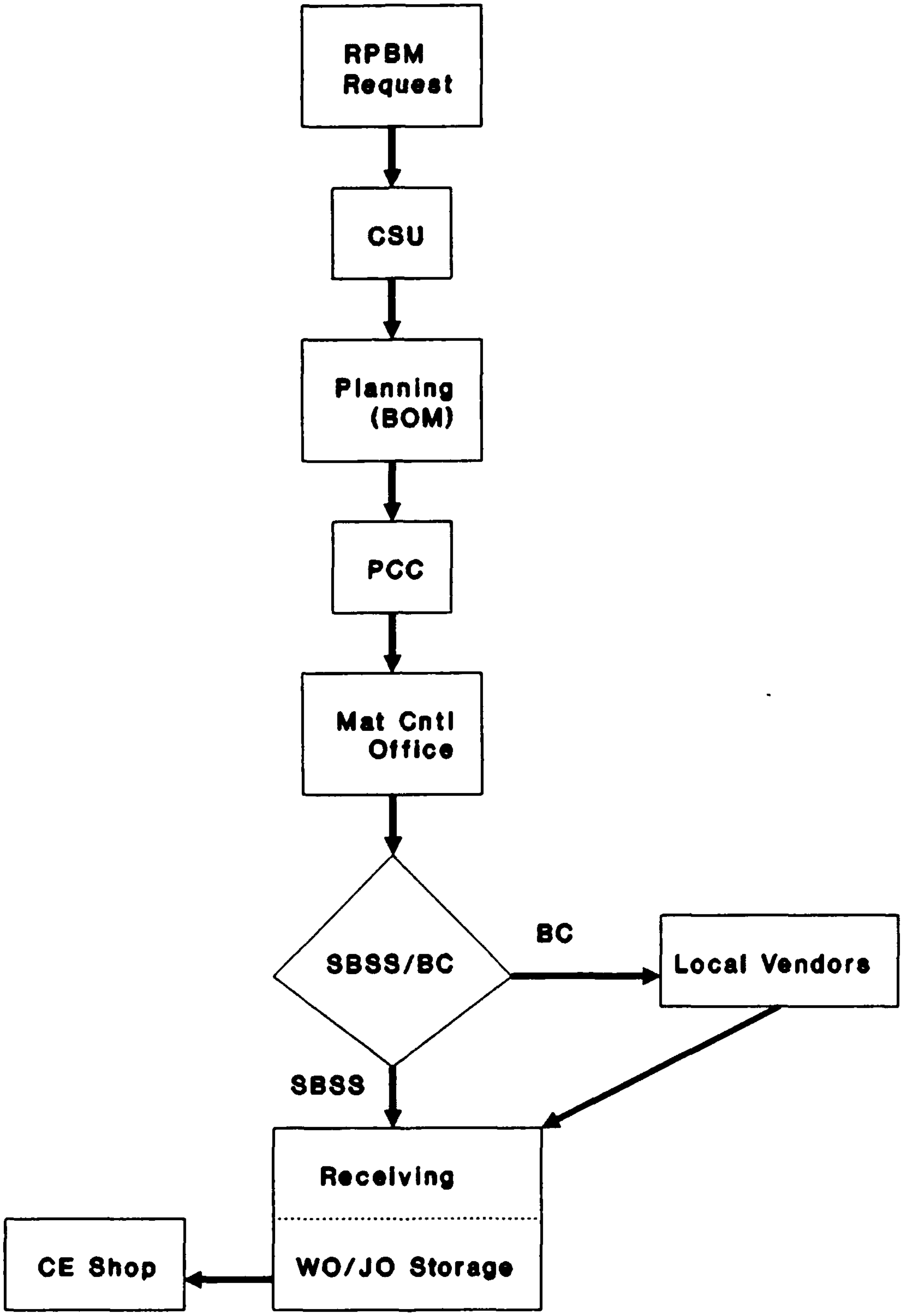

Figure 2. Typical WO Processing in GOCESS Operation

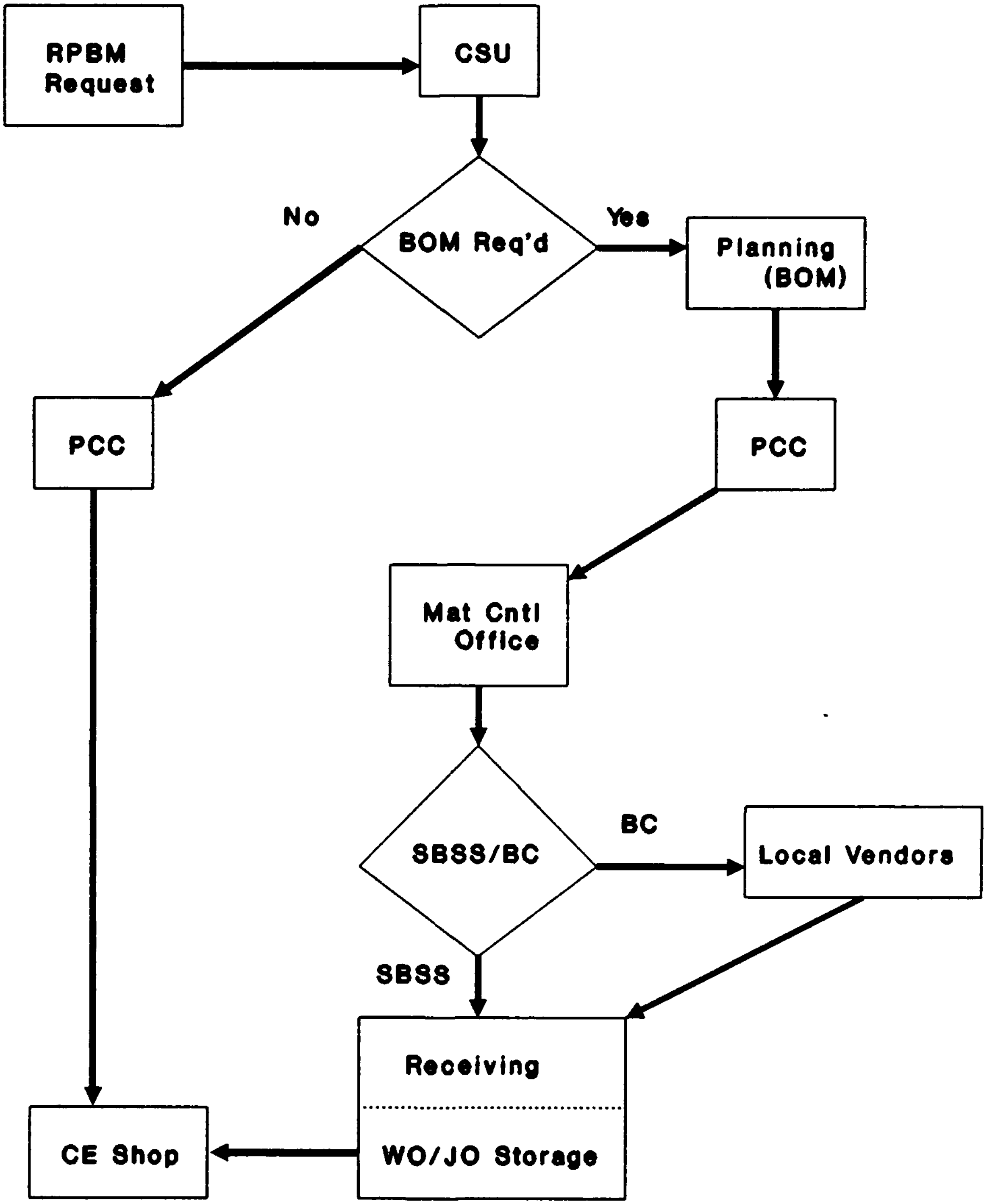

Figure 3. Typical JO Processing in GOCESS Operation

management in each facility (10:1) Real property is defined as follows:

> Real property includes lands and interests therein, leaseholds, buildings, structures, improvements, and appurtenances thereto. It also includes piers, docks, warehouses, right-of-ways; and easements, whether temporary or permanent, and permanently attached improvements. (9:74)

Within the CSU, the request is classified as a work order or job order. The processing of work orders and job orders to the Material Control Section will be discussed separately.

Work Order Processing. Figure 2 illustrates typical WO processing in a GOCESS operation. This process may vary from base to base. If the customers' work request is classified as a work order, the planning section will provide the CSU with a "ballpark" estimate of the manhours and material costs necessary to perform the work. After the work order is approved, the planning section performs detailed planning. During the detailed planning phase, the planning section creates a Bill of Materials (BOM). The BOM is an itemized list of materials for a specific WO or JO. BOMs are created within CEMAS. Once the WO is planned, it is sent to the Production Control Center (PCC).

The PCC determines the Estimated Start Date (ESD) and Required Delivery Date (RDD) for the materials. The ESD is the date that the work is expected to begin. The RDD is the date that the materials are required to be on hand. Typically, the RDD is established to receive delivery of materials 45 days before the ESD (7:34).

Once the RDD is established, funds equal to the amount estimated for materials are memo committed and are no longer available for day to day CE operations. The term "memo-committed" implies that funds have been "earmarked" within CEMAS. The term "committed" implies that funds have been transferred to the SBSS or Base Contracting for the purchase of materials. At this point, the WO is forwarded to Material Control Office.

When WO's with required delivery dates (RDD) are received from Production Control, Material Control establishes a WO folder in WO number sequence and researches part numbers, stock numbers, and item descriptions to ensure the correct items are acquired through on-hand assets, SBSS or from local vendors through Base Contracting (2:B-1).

After all research has been completed, the Material Control personnel place the items on order in CEMAS. On-hand assets are issued from the CEMAS store or residue holding area to the WO/JO holding area. Requirements for items not on hand are passed to SBSS or Base Contracting (BC) who procures the required materials. When these items are passed to the SBSS or BC, the WO firmed. The term "firmed" implies that funds equal to the estimated material costs of the WO are committed and are no longer available for other purchases.

The decision to use SBSS or Base Contracting is subjective and is normally based on the RDD. AFM 67-1 states that if an item cannot be obtained by the RDD, CE is authorized to obtain the item through local purchase (8:31-44). Normally, Base Contracting purchases CE materials from vendors within the local metropolitan area.

Once the items are received in Material Control, the receiving clerk updates the item records by computer. This information is passed to the PCC, who in turn schedules the work.

Once the research has been completed, all items are ordered with the SBSS or Base Contracting or transferred from the holding area or CEMAS store to the WO/JO storage area. Meanwhile, those items that were available for day to day use in the CEMAS store are transferred to the holding area and must be reordered for the CEMAS store. If the items that were ordered through SBSS or Base Contracting are received within a few days, they must be warehoused until the work begins.

After all materials are received, Material Control notifies the PCC who in turn schedules the work.

When the WO is complete, all excess materials are transferred to the residue holding area. This completes the WO process through the logistics function. The JO processing is similar.

Job Order Processing. Figure 3 illustrates typical JO processing in a GOCESS operation. As with WOs, this process may vary from base to base. Initially, the CSU determines if the JO will require detailed planning in which a BOM would be created. If detailed planning is not required, the CSU, by using the Engineering Performance Standards (EPS), which are resident on the WIMS, makes an estimate of the labor hours required to complete the JO. The JO is then forwarded to the PCC.

In the PCC, the JO is scheduled and sent to the CE shop who will perform the work. As with WO's, any excess materials which are not CEMAS store items are transferred to the holding area.

If a BOM was required for the JO, the process to obtain the materials through the Material Control Section is the same as the WO process.

Methods to Improve GOCESS

This section presents information on improving the responsiveness and efficiency of GOCESS and implementing MRP concepts into CE logistics.

Responsiveness.

As mentioned in Chapter I, a responsive logistics system not only provides rapid delivery times but consistent delivery times (21:39).

Variance is a measure of the consistency of a logistics system. One of the major objectives of logistical management is to reduce variance in day-to-day operations.

Figure 4 illustrates the responsiveness of a logistics system with a high variance versus a logistics system with a narrow variance. In this diagram, both systems A and B have an average response time of 24 days. System A has a narrow variance while system B has a high variance. In system A, an order is usually received in 24 days and may take as long as 40 days to be received. Whereas in system B, an order may take as long as 70 days to be received. System A is more predictable.

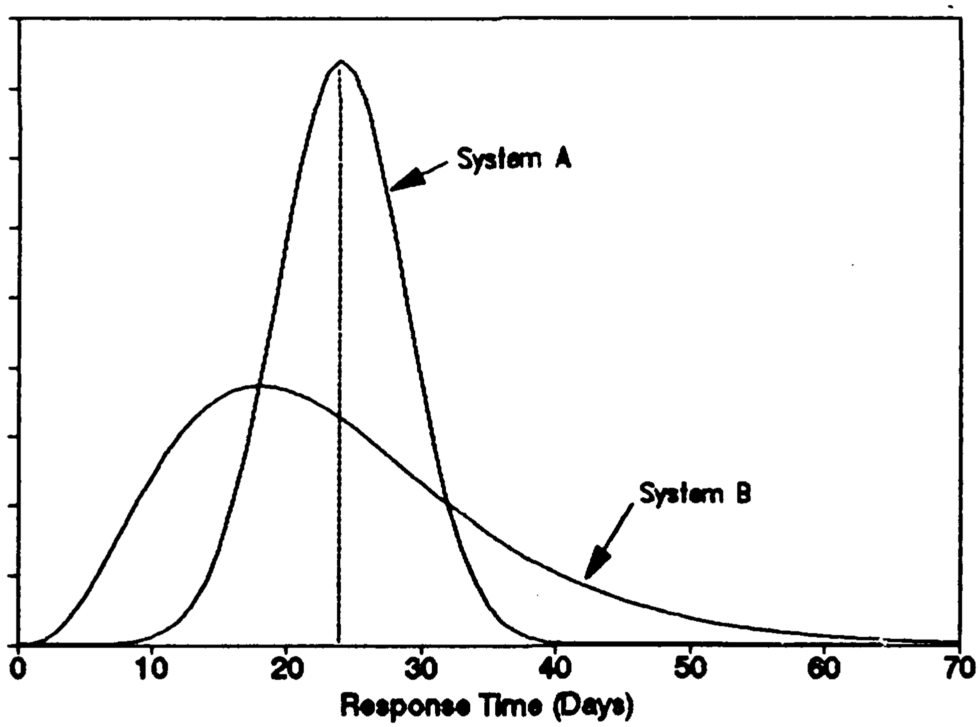

Figure 4. High Versus Low Variance in Logistics System Responsiveness

From an operating perspective, the materials should arrive when needed -- not early -- not late. Variance over and under the expected delivery times must be controlled. Time variances can result from workloads exceeding capacity of order processing and warehouse facilities, lack of inventory, transportation delays, and unexpected changes in desired delivery schedule and times. Each performance-cycle activity has an expected or standard time. A key to achieving logistical operational goals is to control overall elapsed performance-cycle time within accepted tolerances (3:46).

Figure 5 illustrates the CE local purchase process. Initially, the Material Control Office transmits an order to Base Contracting. Base Contracting (BC) determines the most economical source. Once selected, Base Contracting places an order with a commercial vendor. Normally, the vendors are located in the adjacent metropolitan area. In turn, the local vendors will obtain and deliver the materials to the CE Receiving Section.

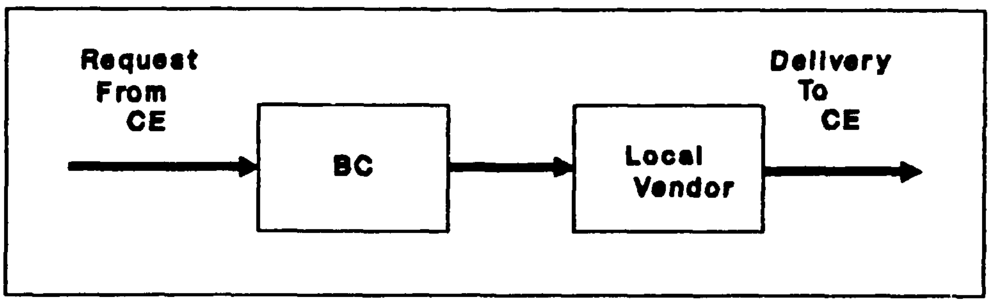

Figure 5. CE Local Purchase Process

Variance throughout the CE local purchase process must be controlled. Figure 6 illustrates Bowersox's performance-cycle time distribution model as modified for the CE local purchase process (3:46). This model provides an illustration of variance that can occur.

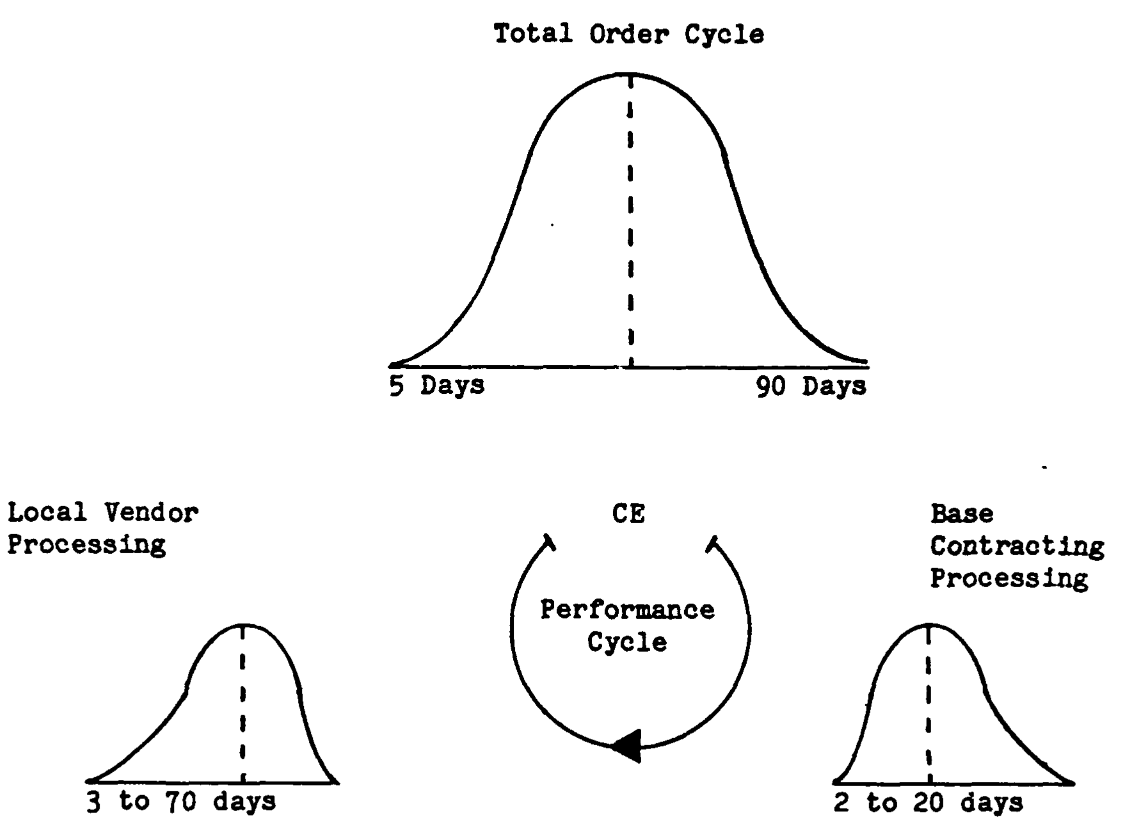

Figure 6. Performance Cycle Time Distribution

The total order cycle diagram in Figure 6 represents the entire local purchase process from CE through Base Contracting to a local vendor and back to CE. Beneath the total order cycle diagram, the process is broken into two segments. These are the Base Contracting processing time and the local vendor processing time. Bowersox's model is viewed in a clockwise fashion. By subdividing the CE local purchase process in this manner, statistical analysis is possible. Analysis may be performed on the total order cycle time, Base Contracting processing time, and local vendor processing time.

In Figure 6, a single order could require as few as 5 days and as many as 90 days to complete the cycle. This type of analysis permits the process to be analyzed for the areas of greatest variance.

Ordering Efficiency. For optimum scheduling of work forces, CE's logistics systems must be efficient. CE logistics ordering efficiency is measured by comparing the date material orders are received as compared to the date they were required (17). For a CE Material Control Section, an efficiency measurement is obtained by the following formula:

$$\text{Efficiency} = \frac{\text{Material Orders Received on or before the RDD}}{\text{Total Material Orders Received}}$$

Improvement of GOCESS Responsiveness and Efficiency. There are several techniques that may increase the responsiveness and effectiveness of a given GOCESS. Each technique listed below may increase logistics support to CE:

1. Imprest Fund
2. Standard Form 44
3. Bank Card Procedures
4. Blanket Purchase Agreements (BPAs)
5. Collocated Buyers.

Imprest Fund. The Federal Acquisition Regulation (FAR) describes "Imprest Fund" as follows:

Imprest Fund - cash fund of a fixed amount established by an advance of funds, without charge to an appropriation, from an agency finance or disbursing officer to a duly appointed cashier, for disbursement as needed from time to time in making payment in cash for relatively small purchases. (11:Subpart 13.4)

In other words, an imprest fund is a "petty cash" fund. The fund may be used for transactions that do not exceed $500 or limits approved by the Contracting Officer (CO). Its use must be considered advantageous to the Government. To establish an imprest fund, each organization must establish the need for the fund, develop regulations for its use, and designate personnel authorized to make purchases using the imprest fund.

The primary advantage of the imprest fund to CE is that it can provide an immediate means to obtain material during off duty hours for emergency purposes. A disadvantage of an imprest fund is that CE must designate manpower to manage the program.

Standard Form 44. Part 13.505-3 of the FAR describes the Standard Form 44 as a pocket-size purchase order form designed primarily for on-the-spot, over-the-counter purchases of supplies and nonpersonal services while away from the purchasing office or at isolated activities. It is a multipurpose form that can be used as a purchase order, receiving report, invoice, and public voucher. The form may be used under the following conditions:

1. Except for purchases made under unusual and compelling urgency, the amount of the purchase is not over $2500. Agencies may establish higher dollar limitations for specific activities or items.

2. The supplies or services are immediately available.

3. One delivery and one payment will be made.

4. Its use is determined to be more economical and efficient than use of other small purchase methods.

The procedural instructions governing the use of Standard Form 44 are printed on the form and on the inside front cover of each book of forms (11:Part 13.505-3).

Primarily, the authorization of CE to use Standard Form 44 will enable a designated person within CE to make purchases for emergency repairs during off duty hours.

Bank Card Procedures. Bank card procedures are the establishment of a "credit card" to be used by authorized CE personnel. The card is for emergency purchases up to $2500. The purpose of the Bankcard program is as follows:

1. To accommodate small purchase procedures up to $2500 for decentralized contracting customers.

2. Supplement contracting support to activities using Standard Form 44 and Imprest Fund small purchase methods.

3. Supplement local purchase tools utilized by Base Contracting for centralized purchases up to $25,000, immediately available, over-the-counter items requested on Air Force Form 9 requisitions.

The types of purchases authorized are as follows:

1. Single purchases, using appropriated funds, for supplies and services, immediately available, over-the-counter, up to $2500 for decentralized customers and up to $25,000 for centralized purchases by the contracting office.

2. Single purchases may be comprised of multiple items; however, requirements will not be split to avoid local purchase by the Base Contracting Office.

At each base, the local contracting office manages the bankcard program. The local Accounting and Finance Office (AFO) maintains the bankcard accounting records. The individual cardholder is the sole user of the bankcard. This individual is identified by name on the card (23).

Imprest Fund, Standard Form 44, and Bankcard procedures are primarily intended for the purchase of emergency requirements. Emergency requirements comprise a small portion of CE requirements. The use of Blanket Purchase Agreements (BPAs) and Collocated Contracting Buyers are methods which enhance the purchase of routine CE materials (23).

Blanket Purchase Agreements. Subpart 13.2 of the FAR describes a BPA as a simplified method of filling anticipated repetitive needs for supplies or services by establishing "charge accounts" with qualified sources. BPAs were designed to reduce administrative cost by eliminating the need for issuing individual purchase documents. BPAs are established under the following criteria:

1. BPAs are created for a wide variety of items. The exact items, quantities, and delivery requirements are not known in advance and may vary considerably.

2. BPAs are established without a purchase requisition and do not cite accounting data.

3. BPAs should be made with firms from which numerous individual purchases will likely be made in a given period.

4. To the extent practical, BPA's for items of the same type should be placed concurrently with more than one supplier.

BPA's may be unpriced or prepriced. An unpriced BPA is essentially an agreement with a local vendor to do business. For each purchase, a person who has contracting authority must negotiate a price. With a prepriced BPA, the price of each item expected to be purchased is negotiated when the BPA is established. During the terms of the prepriced BPA, the buyer need only call the vendor and request a certain quantity (11:Subpart 13-2).

Collocated Buyers. The term "collocated buyers" implies a contracting buyer being physically located in a CE organization. The FAR does not address this procedure. Many CE organizations feel that the presence of a contracting buyer in CE improves the responsiveness and quality of contracting support to CE (17).

Material Requirements Planning. The amount of materials in the WO/JO storage areas may be reduced by incorporating Material Requirements Planning (MRP) concepts into CE logistics. MRP logic originated in the United States during the 1960s. The original MRP concept utilized computer capabilities to time-phase procurement of components and materials to support manufacturing. The emphasis was to minimize inventory by arranging for delivery of the exact amounts of materials from vendors as required in manufacturing. To achieve time-phased procurement, MRP developed logic to manage long lead times characteristic of a geographically dispersed supply base. MRP assumes the manufacturing demand can be classified as dependent. Dependent demand is based on the master production schedule interpretation of distribution requirements and need not be forecasted. Once the components and materials necessary to support a specific manufacturing schedule are identified, MRP provides a time-phased logic to manage their timely arrival (3:51).

Civil Engineering is not a continuous manufacturing environment, rather a Job-Shop service organization. For manufacturing, MRP consists of a complex system which links the planned production schedule with the bill of materials needed to make the product and examines the manufacturing inventory to see which parts and raw materials have to be ordered. For CE, MRP could be a method in which the CEMAS could automatically order materials a forecasted number of days prior to the RDD. This would avoid ordering short lead time materials in advance of the time they are actually needed.

Summary

This literature review provided a background of CE logistics, explained the operation of a GOCESS system, and described methods to improve GOCESS. The background information included a description of the LOGCES, COCESS, and GOCESS dedicated supply systems. The operation information described the GOCESS organization, WO material requirement process, and JO material requirement process. Methods to improve GOCESS such as BPAs, collocated contracting buyers, and MRP were described.

Chapter III will describe the methodology which will determine which variation of GOCESS is the most responsive and efficient. Chapter III will also describe the methodology to determine if MRP can be incorporated into CE logistics.

III. Methodology

This chapter outlines the steps which will be taken to answer investigative questions one and two.

Investigative Question 1

Of the varied applications of GOCESS in the Air Force, which variation is most responsive, consistent, and efficient?

Single factor analysis of variance and correlation analysis will be performed on data collected from Civil Engineering bases. The single factor analysis of variance will be used to determine if there are any differences between the average response times and efficiencies of the various GOCESS systems throughout the Air Force. The correlation analysis will be used to determine if there are any differences between the variances of the systems. Also, the correlation analysis will determine the effect of the various enhancement methods as listed in chapter two.

Solution Procedure. The following four step procedure will be used:

1. A questionnaire will be developed to determine the different variations of GOCESS in use. It will be sent to all CONUS bases by the Air Force Engineering and Services Center (AFESC) This information will be used to classify each base GOCESS.

Table 1 details the classification system that will be used. For instance, each base that does not use prepriced BPA's or collocated contracting buyers will be classified as N_1. A base which makes extensive use of prepriced BPAs and does not have collocated contracting buyers will be classified as N_2. A base which does not use prepriced

BPAs and has collocated contracting buyers will be classified as N_3. A base that has collocated contracting buyers and uses prepriced BPAs will be classified as N_4.

TABLE 1

GOCESS CLASSIFICATION SYSTEM

GOCESS Type	Classification
GOCESS which does not use BPA's or Collocated Contracting Buyers	N_1
GOCESS with BPA's and no collocated contracting buyers	N_2
GOCESS with collocated contracting buyers and no BPA's	N_3
GOCESS with collocated buyers and BPA's	N_4

Other factors may also influence the responsiveness and efficiency of a GOCESS such as the use of imprest funds, Form 44's, and Credit Cards. The questionnaire will request this information as well.

2. In addition to the information on the questionnaire, each bases's "CEMAS" data base will be requested by AFESC. A COBOL computer program will be written to determine the means and standard deviations of the performance cycle times from each base. The performance cycle time distribution will be divided into the total order cycle time, Base Contracting response time, and vendor response time for each base. Also, the program will measure the average local purchase ordering efficiency for each base as defined in Chapter II.

The program will select the records of requirements that were initiated and completed from the first day of Fiscal Year (FY) 1990 to the date that the data was extracted.

Table 2 below lists the dependent variables the computer program will calculate from each base.

TABLE 2

COBOL PROGRAM DEPENDENT VARIABLES

VARIABLE	NOTATION
TOTAL MEAN RESPONSE TIME	$\bar{x}$
TOTAL MEAN RESPONSE TIME STANDARD DEVIATION	s
BASE CONTRACTING RESPONSE TIME	$\bar{x}$
BASE CONTRACTING RESPONSE TIME STANDARD DEVIATION	s
VENDOR RESPONSE TIME	$\bar{x}$
VENDOR RESPONSE TIME STANDARD DEVIATION	s
LOGISTIC SYSTEM EFFICIENCY	eff

$\bar{x}$ Mean
s Standard Deviation

3. Figure 7 illustrates the procedure that will be followed to perform the analysis of variance to determine if there are any differences among the average response times and among the efficiencies of the GOCESS systems throughout the Air Force.

The analysis of variance (ANOVA) refers broadly to a collection of experimental situations and statistical procedures for the analysis of quantitative responses from experimental units (12:368). The question of central interest here is whether or not there are differences in true averages associated with the different treatments or levels of the factor. The null hypothesis states that there are no differences between any of the population means. The alternative hypothesis says

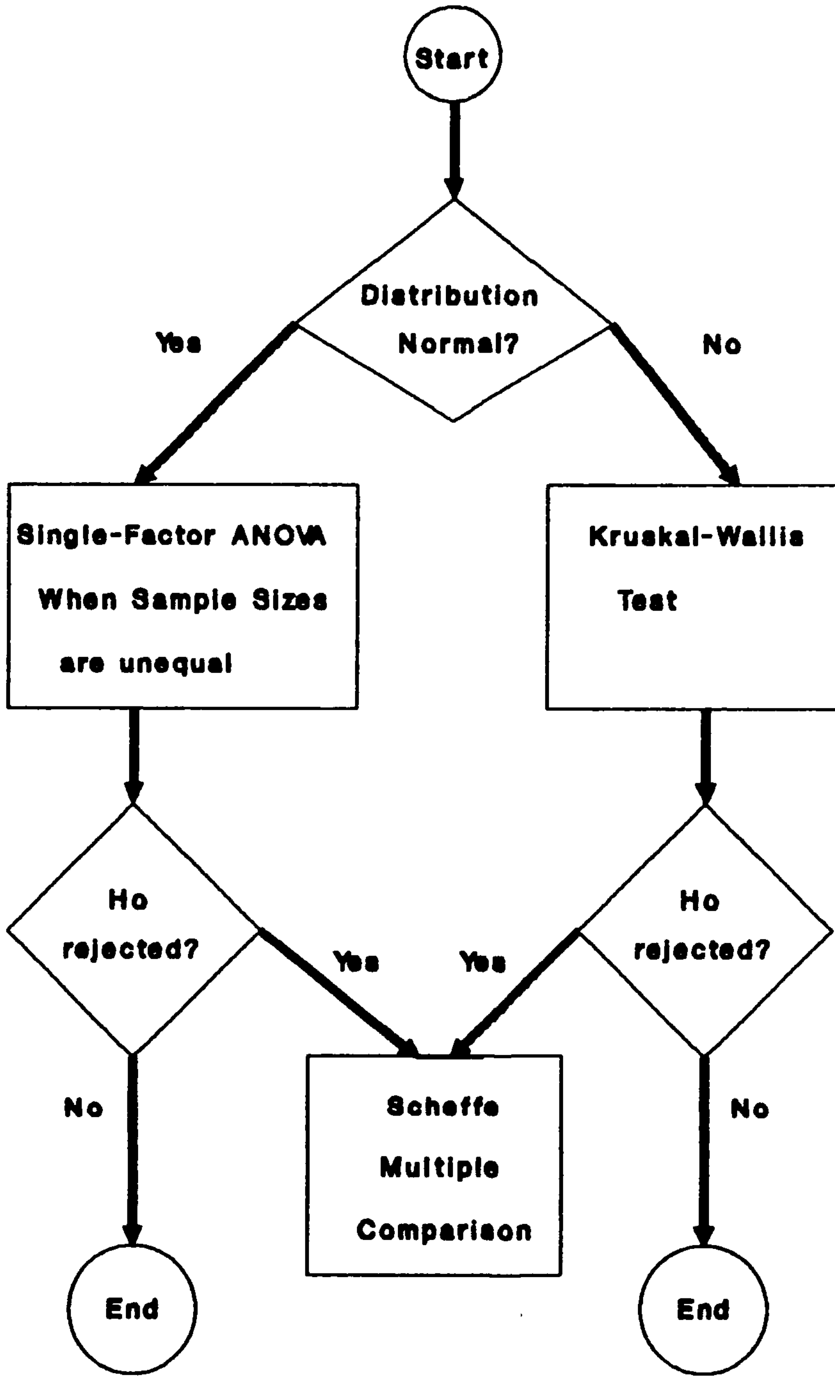

Figure 7. Analysis of Variance Procedure

that at least two of the population means differ from one another (12:369).

The hypothesis to be tested will be:

$$H_0: \mu_1 = \mu_2 = \mu_3 = . . . = \mu_r$$

versus

$$H_a: \text{at least two of the } \mu_i\text{'s are different.}$$

ANOVA depends on two assumptions. First, it is assumed that the individual means within any particular sample are independent (12:370). For this analysis, this is a valid assumption because the responsiveness or efficiency of one GOCESS system has no bearing on the responsiveness or efficiency of another GOCESS system at a separate base. Second, the treatment distributions are all normal with the same variance σ^2 (12:371). In other words, the distribution of sample means will approach a normal distribution even when the population itself is not normally distributed. The assumption of normality is reasonable by the Central Limit Theorem which is as follows:

> If a variable x has a distribution with a mean μ and a standard deviation σ, then the sampling distribution of the mean $\bar{x}$, based on random samples of size n, will have a mean equal to μ and a standard deviation
>
> $$\sigma_{\bar{x}} = \frac{\sigma}{(n)^{\frac{1}{2}}}$$
>
> and will tend to be normal in form as the sample size becomes large (16:111).

Before performing single factor ANOVA, each distribution will be tested for normality by using the Wilks-Shapiro normality statistic. If the Wilks-Shapiro normality statistic is greater than 0.9, the distribution represents a normal population. If the distribution passes the normality test, single-factor ANOVA when sample sizes are unequal will be performed. It is unlikely that equal sample sizes will be received from the data collection.

The software program STATISTIX will be used to perform the ANOVA. In addition to the traditional F statistic for ANOVA, STATISTIX also computes a P-value. The P-value is the smallest level of significance at which H_0 would be rejected when a specified test procedure is used on a given data set. Once the P-value has been determined, the conclusion at any particular level α results from comparing the P-value to α: Using P-value, the test statistic is as follows:

If P-Value $\leq \alpha$, reject H_0 at level α.

If P-Value $> \alpha$, do not reject H_0 at level α.

For this analysis, H_0 will be rejected at α level 0.05.

If the distribution fails the normality test, the non-parametric Kruskal-Wallis (K-W) test will be performed to test the hypothesis. The K-W test requires only that the observations have the same continuous distribution (12:622). For the K-W test, STATISTIX computes a "k" statistic. The H_0 is rejected if k is greater than or equal to the Chi Squared statistic at significance level α.

If the ANOVA or Kruskal-Wallis tests indicate that the null hypothesis should be rejected, the Scheffe method for multiple comparisons when sample sizes are unequal will be performed. Scheffe's method gives simultaneous confidence intervals for all possible contrasts in the classification means. The Scheffe analysis will judge which classifications of GOCESS systems are significantly different.

If the ANOVA or Kruskal-Wallis tests indicate that the null hypothesis cannot be rejected, the analysis will be ended. In this case, it will be determined that there is no difference in the responsiveness or efficiency of any GOCESS system.

4. Correlation analysis will be used to determine the relationship of all independent variables such as the presence of contracting buyers, the use of prepriced BPAs, or credit cards to the dependent variables, variance and efficiency, of the logistic systems analyzed. The most important aspect of this analysis will be the results obtained concerning the variance of GOCESS systems as described in Chapter II.

Correlation analysis is used in many situations in which the objective is to study the joint behavior of two variables. The correlation coefficient r is a measure of how strongly related two variables are in a sample (12:484).

STATISTIX will be used to perform the correlation analysis. STATISTIX will compute a correlation matrix which will simultaneously measure the correlation between all independent and dependent variables. For correlation analysis, the reasonable rule of thumb is to say that the correlation is weak if $0 \le |r| \le 0.5$, strong if $0.8 \le |r| \le 1$, and moderate otherwise (12:487).

Investigative Question 2

"Can MRP concepts be incorporated into CE logistics?"

The Delphi forecasting method will be performed to answer this question. Wentz describes the Delphi method as a panel of experts who are interrogated by a sequence of questionnaires in which the responses to one questionnaire are used to produce the next questionnaire. Any set of information available to some experts and not others is thus passed on to the others enabling all the experts to have access to all the information for forecasting. This technique eliminates the bandwagon effect of majority opinion (22:552). Dalkey stated that the results of a Delphi exercise are subject to greater acceptance on the part of the group than are the consensuses arrived at by more direct forms of interaction (4:17).

For this effort, the panel of experts will consist of a CE logistics expert from each major Air Force Command. The expert panel will consist of a mixture of "supply" type personnel and CE operations management personnel. This mixture may produce a MRP method for CE that will be accepted by Air Force commands.

This Delphi exercise will depart from the traditional method in that each expert may consult with his or her command counterparts. The reason is that the implementation of MRP will involve CEMAS software knowledge, Production Control experience, and Material Control operation experience.

Expert Panel Objectives. In order to implement MRP concepts in CE, the following problems must be solved:

(1) When should all materials for a WO be available prior to the ESD?

(2) How should the lead time be forecasted?

(3) How do we manage funds in a CE MRP environment?

The first proposal will consist of questions designed around each of these problems. The proposal will be sent to each expert. When returned, each response will be listed with each question. The responses will be consolidated into a collective opinion. Once consolidated, the initial questions, initial responses, and author's summation will be returned to the experts for further review. This process will continue until it is apparent that a method to implement MRP into CE can or cannot be derived.

Summary

This chapter described the methods that will be used to address the investigative questions in Chapter I. Analysis of Variance and correlation analysis will be used to determine which GOCESS systems throughout the Air Force are the most responsive and efficient. A modified version of the Delphi expert panel method will be used to determine if MRP can be implemented into CE logistics.

IV. Results of Statistical Data Analysis

This chapter reports the results of the statistical data analysis performed to determine which variation of GOCESS used throughout the Air Force is the most responsive and efficient. The results are explained in four sections: first, information concerning how the methodology was followed is provided; second, a summation of the raw data used in the data analysis is provided; third, the results of the statistical analysis are evaluated; and fourth, an evaluation of the overall analysis is provided.

Methodology

The four steps used in this data analysis are:

1. develop GOCESS classification questionnaire, request questionnaire information and CEMAS data from each Air Force Base

2. develop COBOL computer program

3. perform ANOVA

4. perform correlation analysis.

A statement of how each of these steps were followed, problems that were encountered, and an explanation of the modification to the procedure follows.

GOCESS Classification Questionnaire Data Request. A questionnaire was developed to determine the type of logistics system at each Air Force CE squadron. This questionnaire is contained in Appendix A. The questionnaire contained questions sufficient to enable the author to determine the classification of each GOCESS system, the type of BPAs in use, and the type of emergency procurement methods in use at each base.

HQ Air Force Engineering and Services Center disseminated the questionnaire and request for CEMAS data to all major Air Force commands. In total, 83 questionnaires and 63 data tapes were received. Their support resulted in an 83% return rate in questionnaires and a 69% return rate in CEMAS data tapes.

COBOL Computer Program. A COBOL computer program was developed to determine the total order cycles response times and variances and ordering efficiency from each of the data bases received. The program successfully calculated these variables from each of the data bases used in this analysis. The source code for this program is contained in Appendix B.

ANOVA. The ANOVA was performed as indicated in Figure 7 of Chapter III. Insufficient data was received to classify the GOCESS systems into four separate types. The analysis was narrowed into two classifications which were GOCESS systems which had collocated buyers and GOCESS systems which did not have collocated contracting buyers.

Correlation Analysis. The correlation analysis was performed successfully.

Raw Data Used in Analysis

In total, 63 CEMAS data tapes were received. Forty six data tapes were used in the analysis. Seventeen of the data tapes were not used because either these did not represent GOCESS systems or the data could not be retrieved. Figure 8 illustrates the percentage of data by Air Force major command used in the data analysis.

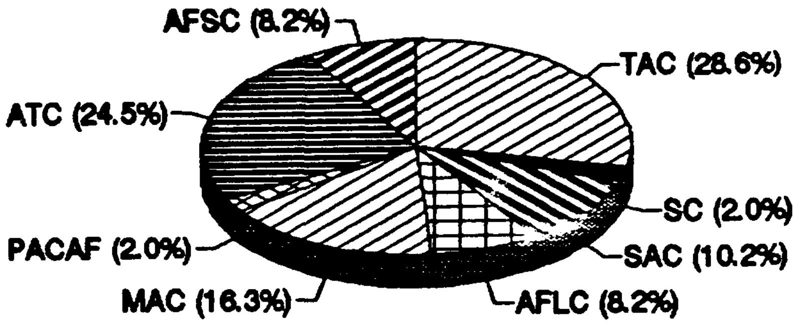

Figure 8. Data Used in Analysis by Air Force Command

Appendix C lists the individual means, standard deviations, and efficiencies used in both the ANOVA and correlation analysis. This information is listed by base installation code.

Table 3 lists the Air Force wide GOCESS statistics. As shown in Table 3, the average total response time for GOCESS systems is 18.6 days with a standard deviation of 14.6 days. The high standard deviation value indicates a gamma distribution for each base. All bases tested have similar distributions.

Figure 9 is a frequency diagram which illustrates the average total response frequency for GOCESS systems. Figure 9 indicates that the average GOCESS system obtains requirements within 18.6 days while some requirements take as long as the mean plus two standard deviations or 47.8 days. In addition, Figure 9 illustrates that approximately 3% of the requirements obtained by GOCESS systems are received after 50 days.

TABLE 3

Air Force Wide GOCESS Statistics

Variable	Average	s.d.
Total Response Time (Days)	18.6	14.6
Contracting Response Time (Days)	7.2	7.6
Vendor Response Time (Days)	11.5	12.0
Efficiency	4.2%	3.8%

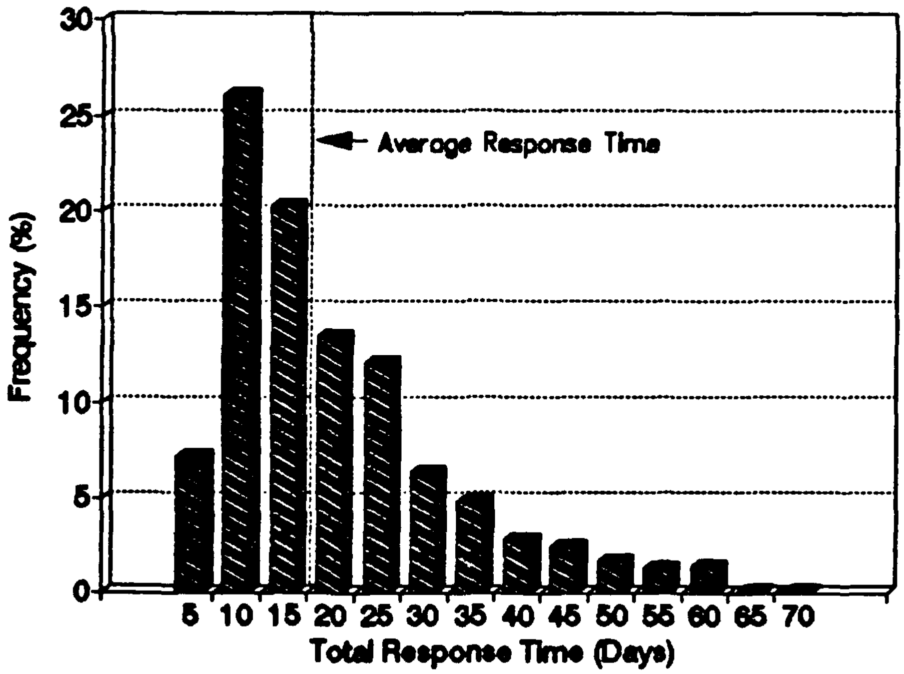

Figure 9. Average Total Response Frequency for GOCESS Systems

Results of Statistical Analysis

ANOVA. The purpose of the ANOVA was to determine if there are any differences between the average response times and efficiencies of the various GOCESS systems. As mentioned above, only two classifications of GOCESS could be tested because insufficient data was received. The GOCESS systems tested were N_1 and N_3. Classification N_1 represents GOCESS systems which do not have collocated contracting buyers or use prepriced BPAs. Classification N_3 represents GOCESS systems which have collocated contracting buyers and does not use prepriced BPAs. Basically, the ANOVA tested GOCESS systems with and without collocated contracting buyers.

As explained in chapter III, One-Way ANOVA requires that the distributions being compared represent normal populations. Therefore, the first step performed was to test each distribution for normality using the Wilk-Shapiro normality statistic. If the Wilk-Shapiro statistic was greater than 0.9, One-Way ANOVA was performed to determine if the means were statistically different. If the normality statistic was less than 0.9, the Kruskal-Wallis non-parametric test was performed. Table 4 lists the results of this analysis.

As shown in Table 4, four separate ANOVA analyses were performed. These analyses were performed to test for differences between the total response times, contracting response times, vendor response times, and efficiencies of GOCESS systems N_1 versus N_3. The response time analyses correspond to the performance cycle time distribution model in Figure 6 of Chapter II. Each of these tests will be discussed separately.

TABLE 4

Analysis of Variance Results

Dependent Variable	Wilk-Shapiro value	Mean	One-Way ANOVA P-value	Kruskal-Wallis k-value
N1 Total Response	0.9728	20.33 (Days)	0.0591	NA
N3 Total Response	0.9631	17.41 (Days)		
N1 Contracting Response	0.8029	8.3 (Days)	NA	3.4065
N3 Contracting Response	0.9076	6.5 (Days)		
N1 Vendor Response	0.9575	12.04 (Days)	0.3245	NA
N3 Vendor Response	0.9738	11.14 (Days)		
N1 Efficiency	0.8743	5.82 %	NA	2.594
N3 Efficiency	0.8698	3.28 %		

Total Response Time. The first analysis was performed to determine if the total response times of systems N_1 versus N_3 was statistically different. As shown in Table 4, the Wilk-Shapiro normality statistic for both distributions was greater than 0.9. Therefore, each distribution represented a normal population. One-Way ANOVA was performed to compare N_1 versus N_3. This analysis yielded a P-value of 0.0591. The null hypothesis, which stated that the means were equal, cannot be rejected because the P-value of 0.0591 is greater than the level of significance 0.05.

Therefore, this analysis proves that there is no difference between the average total response times of GOCESS systems with or without collocated contracting buyers.

These results verify the Central Limit Theorem which states that the distribution of sample means will approach a normal distribution even when the population itself is not normally distributed. In this case, the distributions of system N_1 and N_3 were both normal whereas the individual base systems are represented by gamma distributions.

Base Contracting Response Time. The second analysis was performed to determine if the Base Contracting response times of systems N_1 versus N_3 were statistically different. As shown in Table 4, the Wilk-Shapiro normality statistic for the N_1 system was less then 0.9. Therefore, the Kruskal-Wallis test was performed to compare N_1 versus N_3. This analysis yielded a k-value of 3.4065. The Chi Square value for a significance level of 0.05 and two treatments is 3.843. The computed k-value of 1.9055 is not greater than the Chi Square value of 3.843. Therefore, the null hypothesis, which stated that the means were equal, cannot be rejected.

This analysis proves that there is no difference between the average Base Contracting response times of GOCESS systems with or without collocated contracting buyers.

Table 3 indicates that the average Base Contracting response time for GOCESS systems is 7.2 days with a standard deviation of 7.6 days. In this case, the standard deviation is greater than the mean response time. This indicates that most requirements are awarded by Base Contracting within 7.2 days while some requirements may take as long as 22.4 days to be awarded by Base Contracting.

While this analysis indicated no difference between GOCESS systems, it does indicate a highly variant process. As stated in Chapter II, a responsive logistics system not only provides rapid response times but consistent response times as well. A standard deviation of 7.6 days with a mean 7.2 days indicates that Base Contracting support to CE is inconsistent.

Vendor Response Time. The fourth analysis was performed to determine if the vendor response times of systems N_1 versus N_3 were statistically different. As shown in Table 4, the Wilk-Shapiro normality statistic for both distributions was greater than 0.9. Therefore, each distribution represented a normal population. One-Way ANOVA was performed to compare N_1 versus N_3. This analysis yielded a P-value of 0.3245. The null hypothesis, which stated that the means were equal, cannot be rejected because the P-value of 0.3245 is greater than the level of significance 0.05.

Therefore, this analysis proves that there is no difference between the vendor response times of GOCESS systems with or without collocated contracting buyers.

Table 3 indicates that the average vendor response time for GOCESS systems is 11.5 days with a standard deviation of 12.0 days. Again, the high standard deviation as compared to the mean indicates a highly variant process. While there is no difference between GOCESS systems, this data proves that vendor support to CE, as obtained by Base Contracting, is inconsistent.

Efficiency Analysis. The last ANOVA analysis was performed to determine if the ordering efficiencies of systems N_1 versus N_3 were statistically different. As shown in Table 4, the Wilk-Shapiro normality statistic for both N_1 and N_3 system was less then 0.9. Therefore, the Kruskal-Wallis was performed to compare N_1 versus N_3. This analysis yielded a k-value of 2.594. The computed k-value of 2.594 is not greater than the Chi Square value of 3.843. Therefore, the null hypothesis, which stated that the means were equal, cannot be rejected.

Table 3 indicates that average ordering efficiency of GOCESS systems throughout the Air Force is 4.2% with a standard deviation of 3.8%.

Further analysis has indicated that the volume of business has an effect on the efficiency of GOCESS systems throughout the Air Force. The number of records selected for this analysis is an indication of the volume of business. Figure 10 illustrates the efficiency of GOCESS systems as a function of the number of records selected for analysis.

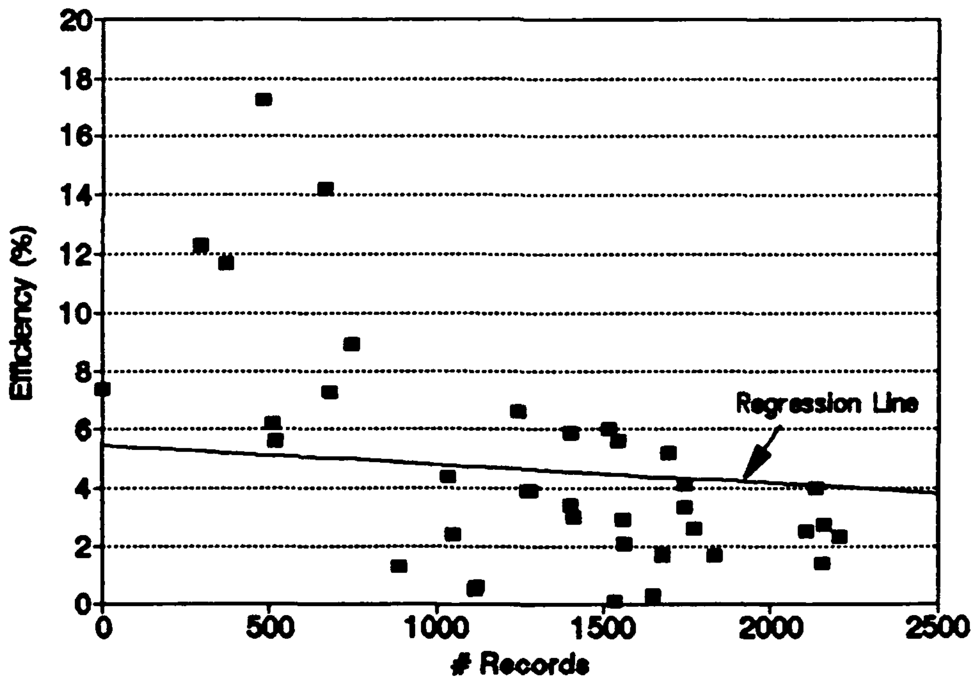

Figure 10. GOCESS Systems Efficiency versus Total Records Processed

In Figure 10, the regression line was computed from the efficiency data as a function of the number of records selected for this analysis. In Figure 10 and Table 3, two outlier efficiency data points were not included. These data points represented bases which had an efficiency of approximately 40%, but the total records selected were less than 200. A general rule says that if there are at least 10 individual values, then a value may be discarded as an outlier provided it lies outside the region of the mean plus or minus four standard deviations, where the mean and standard deviation are computed without the value suspected of being an outlier (20:279). The bases with efficiencies of approximately 40% met this criteria.

As can be seen from Figure 10, as the number of records increases, GOCESS ordering efficiency decreases.

Table 3 indicates that the average efficiency of GOCESS throughout the Air Force is 4.2%. This data indicates that materials ordered through Base Contracting are missing the RDD 95.8% of the time.

Results of Correlation Analysis

The purpose of the correlation analysis was to determine the relationship, if any, of independent variables such as the use of prepriced BPAs, collocated contracting buyers, or imprest funds to the variance and efficiencies of GOCESS logistics systems. The results of this analysis are shown in Table 5.

TABLE 5

RESULTS OF CORRELATION ANALYSIS
(r - VALUES)

Independent Variables	Dependent Variables			
	Eff	Tot-s	Co-s	Ven-s
Buyers	-0.3531	0.0612	-0.1804	0.1283
# Buyers	-0.2765	-0.0025	-0.1777	0.0887
CEMAS-BCAS	-0.0359	0.1415	-0.1321	0.2076
BPAs	-0.1525	-0.0021	-0.0046	-0.0174
BPA calls	0.3041	-0.241	-0.0508	-0.2283
Mult-item BPAs	-0.2863	0.2633	0.1205	0.1317
Type BPA	-0.3551	0.2227	0.1007	0.1427
Imprest Fund	0.1116	0.0494	0.0186	-0.0358
Form 44	0.0488	0.2958	-0.0195	0.2962
Credit Card	0.0993	0.0358	0.0074	0.0035
Years w/ CEMAS	0.0545	0.1467	-0.3552	0.339

The variables used in Table 5 are defined as follows:

1. Eff - Efficiency of GOCESS logistics systems.

2. Tot-s - Total performance cycle time standard deviation of GOCESS logistics systems.

3. Co-s - Base Contracting time standard deviation

4. Ven-s - Vendor response time standard deviation

5. Buyers - GOCESS system with or without collocated contracting buyers

6. # Buyers - Total number of collocated contracting buyers

7. CEMAS-BCAS - Indicates which computer system contracting uses to make purchases for CE

8. BPAs - GOCESS systems which use or do not use Blanket Purchase Agreements

9. BPA calls - Variable which indicates if CE or Base Contracting personnel makes calls against BPAs

10. Mult-item BPAs - Indicates if BPAs were being used to purchase multiple items such as a complete series of plumbing or electrical supplies

11. Type BPA - Indicates if prepriced or unpriced BPAs in use

12. Imprest Fund - Indicates if imprest fund in use

13. Form 44 - Indicates if Form 44 in use

14. Credit Card - Indicates if Credit Card in use to make emergency purchases

15. Years w/ CEMAS - Number of years CEMAS in use.

As stated in Chapter 3, a correlation coefficient r whose absolute value is greater than or equal to 0.8 and less than or equal to 1.0 indicates a strong relationship between two variables x and y. Table 5 illustrates that none of the r coefficients indicate a strong relationship between any of the variables tested.

Overall Evaluation

The goal of this data analysis was to determine if differences exist between the various types of GOCESS systems throughout the Air Force. This goal was accomplished. The analysis proved that differences do not exist between GOCESS systems. The ANOVA proved that differences do not exist between the total, contracting, and vendor average response times of the systems tested. The correlation analysis proved that the independent variables measured were not correlated to the variance or ordering efficiency of GOCESS systems.

In addition, this data analysis measured the overall responsiveness, variance, and ordering efficiency of Air Force GOCESS systems. Throughout the performance cycle, the standard deviations were near or greater than the mean. This indicates ordering systems which are difficult to control. The overall ordering efficiency was 4.2%. This indicates that materials obtained through Base Contracting are not obtained by the date required 95.8% of the time.

This analysis proved that there is no difference in the responsiveness or ordering efficiency of GOCESS systems with or without collocated contracting buyers. The efficiency of an entire CE Operations Branch hinges on responsiveness and efficiency of the Material Control Section. The Air Force wide GOCESS statistics prove that CE logistics is neither responsive nor efficient. Active CE management is required to improve this situation.

V. Expert Panel Process

The purpose of the expert panel was to develop a method to implement MRP concepts into CE logistics. This chapter describes the process development, results of the process, and the overall results.

Process Development

The process development consisted of two parts. First, a panel of experts was selected. And second, an initial MRP proposal was created and presented to the experts.

Panel of Experts. Table 6 lists experts that were selected to participate on the panel. The panel represents a mixture of CE logistics experience. Three of the experts have base supply experience. The other experts have CE operations experience.

Initial MRP Proposal Development. Initially, the author met with Major William Martin, Chief of Integrated Logistics, HQ AF Engineering and Services Center, to develop an MRP proposal. The goal of this meeting was to develop a method to accomplish the objectives listed in Chapter II. Those objectives were to solve the following problems:

(1) When should materials for a WO be available prior to the ESD?

(2) How should the lead time be forecasted?

(3) How do we manage funds in a CE MRP environment?

From this meeting, a set of nine discussion questions were developed to be presented to all experts. The questions and the results of the panel exercise to each question follow.

TABLE 6

PANEL OF EXPERTS

Name	Position and Level of Experience
Major William Martin	HQ AFESC Chief of Integrated Logistics 4 years experience in CE logistics 16 years SBSS experience
Mr Rick Childers	HQ TAC/DEMG Command Logistics Management 6 years in current position Retired Military with 27 years experience in Supply AFSC
Mr Tom Eikerenkotter	HQ AFLC/DEVE 2 years experience as base level CE Chief of Logistics Retired Air Force Civil Engineering Officer
Mr Bob Gagney	HQ SAC/DERIM Chief Management Systems Analysis Retired CE CMSgt 46 years total Federal Service
Mr John E. Simmons	HQ ATC/DEMG Command Logistics Management 8 years CE logistics experience (4 years at command level) Total 38 years SBSS experience
Mr Wil Wilson	HQ MAC/DEMG Industrial Engineering Technician 8 years experience in CE logistics Retired CE CMSgt

Results of Expert Panel Process

This section will discuss the overall iteration process and the panel results to each question.

Overall Process. The expert panel process consisted of two iterations. After the second iteration, it was apparent that a consensus could not be obtained. The initial proposal consisted of the discussion questions, a description of our current method of operation, and a brief explanation of the MRP philosophy and its benefits. The initial responses were accumulated, summarized, and returned to each expert.

One of the experts listed in Table 6 was unable to respond to the first iteration. However, he was able to respond to the second iteration and his comments are included.

Throughout the presentation of the data, the experts are referred to by numbers one through six. The numbers will not be associated with the names in Table 6. This preserves the anonymity of the Delphi method.

Panel Results. The complete expert panel data is contained in Appendix D. The final panel results to each question follow.

Question #1.

How soon before the RDD should all items be received in the WO/JO storage area?

Question one was designed to determine when all materials for a WO or JO should be assembled in the storage area. Five of the six experts agreed that 30 days was sufficient. Due to the one dissenting opinion, a consensus was not obtained.

Question #2.

Should we add to CEMAS a "Review Date" which is a date prior to the RDD that all items are to be received in the storage area? If not, what method would you recommend?

Question two suggested the establishment of a review date. All experts agreed that a review date was not necessary.

Question #3.

Should the timeframe between the "Review Date" and RDD be adjustable for high priority JO/WO's? If not, what method would you recommend to place emphasis on high priority JO/WO's?

Question three was suggested as a method to place emphasis on high priority WO/JOs. After the first iteration, expert one suggested a different automated method. In the final iteration, only three of the five experts agreed with the automated method. Therefore, a consensus was not obtained.

Question #4.

When should the items contained in the CEMAS store be transferred to WO/JO storage? If we transferred the CEMAS store items on the review date, would that be soon enough?

Question four was related to the transfer of materials from the CEMAS store to the holding area for WO/JOs. Five of the six experts agreed that the CEMAS store items could be transferred on the RDD. Expert five disagreed with the group. Therefore, a consensus does not exist.

Question #5.

Usually, the items contained in the CEMAS store can be procured locally. Do we need to reorder the CEMAS store items for the

JO/WO prior to the review date or can we just let the CEMAS reorder program do that after the items are pulled for the WO/JO?

Question five dealt with the method to be used to reorder materials for the CEMAS store that would be used for WO/JOs in the MRP system. Five of the six experts agreed with a compromise to program CEMAS to reorder material for the store a forecasted number of days prior to the RDD. Expert five disagreed with the compromise entirely. Therefore, a consensus was not obtained.

Question #6.

What if we receive status that indicates that some of the items with no buying history cannot be received by the RDD. Should the Chief of Logistics advise the Chief of Production Control and request a change to the RDD? If not, what procedure would you recommend to solve this problem?

Question six was asked to determine a method to deal with items that could not be obtained by the RDD. After the first iteration, expert one suggested changing the RDD to the Agreed Delivery Date (ADD) of the longest lead time item. Two of the six experts did not agree with the suggestion. Therefore, a consensus was not obtained.

Question #7.

If the RDD is changed by the Chief of Production Control, should the "Review Date" be changed as well?

Question seven dealt with relation of the Review Date with the RDD. The entire group agreed that the review date was not necessary. Therefore, this question is no longer relevant.

Question #8.

For the items with a buying history, how can we predict how long it will take to receive the item? Will a simple average be sufficient? Or, how about an average plus two standard deviations? A standard deviation is a measure of the variability of a process. For instance, normally an item may be received in 20 days. A variance analysis of the history indicates a standard deviation of 10 days. The average plus two standard deviation is equal to 40 days. This means that on the average the item is received in 20 days but sometimes it takes as long as 40 days to receive the item.

Question eight discussed the development of a forecasting method to be used in the MRP system. Experts two and five disagree with the final proposed solution. Expert four provided an entirely different method which may be feasible. A consensus was not obtained.

Question #9.

Previously, we committed funds for a given BOM all at once. Could we just leave the funds in memo-committed status until the items are ordered? This way, we could have the flexibility to recommit those funds to higher priority JO/WO's.

Question nine was asked to determine a method to deal with funds in an CE MRP environment. In the second iteration, two different proposal were suggested. Most experts agreed with the first proposal. However, each expert expressed different modifications. Therefore, a consensus was not obtained.

Evaluation of Results

The goal of the expert panel process was to derive a method to implement MRP into CE logistics. The process would have been successful if all the experts agreed on a single method. After the second iteration, it was apparent that several additional iterations would be required to obtain a consensus. A consensus was not obtained; however, the process was successful in introducing MRP to the logistics expert in each major command.

MRP is a complex concept. A face to face committee meeting with all of the experts may have been more successful. Throughout the data in Appendix C, it is apparent that one or two of the experts did not fully understand the ideas that were being presented. In a face to face committee meeting, these misconceptions may be clarified.

As mentioned before, the expert panel consisted of a mixture of individuals with supply and operations experience. Often, the opinions of these groups conflict on CE management issues. This conflict was evident throughout this Delphi process.

In an initial telephone interview with Expert #5, he disagreed immediately with the concept of MRP for CE logistics. However, he agreed to participate in the group process. Throughout the process, he routinely disagreed with the general consensus of the group. Also, Expert #2 disagreed initially with the implementation of MRP for CE logistics. Throughout the process, he stated that the concept should be tested for CE. However, during the second iteration, he failed to provide guidance with which to develop a method to test the concept.

Although a consensus was not obtained, it was evident from the panel data that a method to implement MRP may be developed through further deliberations with the command experts.

VI. Conclusion

> In fact, the battle is fought and decided by the quartermasters before the shooting begins.
>
> Erwin Rommel

Rommel's statement succinctly reiterates the importance of logistics to any military force. This chapter reviews the findings of this thesis and relates their importance to CE management. First, the results of the investigative questions will be summarized. Second, the importance of those results will be discussed. And third, recommendations for further research are provided.

Investigative Questions

Question 1.

Of the varied applications of GOCESS in the Air Force, which variation is most responsive, consistent, and efficient?

The statistical analysis measured total, Base Contracting, and local vendor responsiveness. In addition, the order cycle variance and order efficiency of each base system was measured. The statistical analysis proved that differences do not exist between GOCESS systems.

The results indicate that the average response time for GOCESS systems is 18.6 days with a standard deviation of 14.6 days. The high standard deviation in relation to the average response time indicates order systems which are difficult to control.

The overall logistics efficiency was 4.2%. This indicates that 95.8% of the materials ordered through Base Contracting are not received by the date required.

Question 2.

Can Material Requirements Planning (MRP) concepts be incorporated into CE logistics?

Annual warehousing holding costs to CE are approximately $15.5 million. MRP is a method that may reduce those warehousing costs.

For manufacturing, MRP consists of a complex system which links the planned production schedule with the bill of materials needed to make the product and examines the manufacturing inventory to see which parts and raw materials have to be ordered. For CE, MRP could be a method in which the CEMAS could automatically order materials a forecasted number of days prior to the RDD. This would avoid ordering short lead time materials in advance of the time they are actually needed.

The Delphi forecasting method was performed to determine if MRP concepts could be incorporated into CE logistics. The Delphi method is a panel of experts who are interrogated by a sequence of questionnaires in which the responses to one questionnaire are used to produce the next questionnaire. Any set of information available to some experts and not others is thus passed on to the others enabling all the experts to have access to all the information for forecasting. Normally, the results of a Delphi exercise are subject to greater acceptance on the part of the group than are the consensuses arrived at by more direct forms of interaction.

For this effort, the panel of experts consisted of a CE logistics expert from each major Air Force Command. The expert panel consisted of a mixture of "supply" type personnel and CE operations management personnel.

The goal of the expert panel process was to derive a method to implement MRP into CE logistics. The process would have been successful if all the experts agreed on a single method. After the second iteration, it was apparent that several additional iterations would be required to obtain a consensus. A consensus was not achieved; however, the process was successful in introducing MRP to a logistics expert in each major command.

Importance of Results

In regards to the results of this thesis, Lt Col James Holt, Director, Engineering Management Program, made the following statement:

> The results of this thesis illustrate the need for further research and active CE management involvement. The analysis indicates that local purchasing for CE by Base Contracting is miserably unresponsive and inefficient. An ordering efficiency of 4.2% is pathetic. What would happen on the flight line if 95.8% of the parts you ordered did not meet the required delivery date? (15)

The results of this thesis indicate a need for active CE management involvement in CE logistics. The effectiveness of the entire operations branch hinges on the responsiveness and efficiency of the local purchase process. CE management does not have control over the local purchase buying process. To deal with this lack of control and to ensure that materials are on hand when needed, CE orders materials several months in advance. This is poor management.

The warehousing of construction materials is expensive. Without a doubt, unresponsive and inefficient logistics systems have caused CE management over the years to require large WO/JO and residue storage areas to serve as safety stocks. However, CE now has the computer technology to gain control over the local purchase process and to implement MRP concepts which can reduce warehousing costs.

Recommendations for Further Research

The emphasis of MRP concepts for CE logistics is to devise a method to prevent materials from being ordered today that will be used three months to a year after the BOM is material complete. Successful MRP systems revolve around predictable ordering channels. The data from the statistical analysis portion of this thesis indicates that the local purchase ordering is difficult to control. However, the local purchase channel is predictable. Figure 9 illustrates that 97% of the requirements obtained through Air Force local purchase channels are obtained within the average response time plus two standard deviations. Only 3% of the total requirements are obtained after this timeframe.

The author recommends that the Engineering and Services Center continue to develop MRP concepts for CE logistics. He recommends that the results of this thesis be briefed at the November 1990 CEMAS steering group meeting. At this meeting, the MRP concepts can be clarified to all command experts, and a method to implement these concepts may be devised.

The responsiveness and efficiency of the CE local purchase channel needs improvement. The author recommends that the results of the statistical analysis portion of this thesis be briefed to the Contracting community. Usually, Base Contracting places primary emphasis on the MILSTRIP priority system with a secondary emphasis on the customer's RDD. Contracting emphasis should ensure that the agreed delivery date (ADD) with the local vendors is equal to or sooner than the RDD. Within CE, the RDD is the primary date on which Material Control personnel attempt to receive materials.

Chapter Summary

This chapter reported the final results of this thesis. The results of the investigative questions were summarized, the importance of those results were discussed, and recommendations for further research were provided.

Appendix A: GOCESS Classification Questionnaire

AFESC/DEM

Civil Engineering Supply Support Data

ALMAJCOM/DEM

1. We are collecting data to compare the different modes of CE supply support at base level. The purpose of gathering this data is not to compare bases or MAJCOMs, but to compare the different systems of support that we currently use (COCESS, GOCESS, LOGCES, Base Supply, etc.). We have asked for the base names only to provide a reference point in the event an answer needs clarification. We will use this data in an effort to improve Civil Engineering logistics.

2. We ask that each of your industrial engineering sections complete the attached questionnaire. Also, we ask that each WIMS office make a back-up copy of library MLOGDATA between 25 and 28 Feb 90.

3. Please have each of your bases complete the questionnaire, copy the CEMAS data, and forward both the questionnaire and the tape to this office by March 7, 1990. For further information, please contact CMSgt Hines, HQ /AFESC/DEMG, AUTOVON 523-6245.

HQ AFESC

MATERIAL ACQUISITION SUPPORT QUESTIONNAIRE

The purpose of this questionnaire and Civil engineering Material Acquisition System (CEMAS) data gathering is to determine ways to improve CE logistics support.

General Information

1. Please answer each question on the attached questionnaire.

2. Please copy onto a magnetic tape, a complete copy of the entire CEMAS data base no more than three days prior to End of Month (EOM) processing. The CEMAS data is located on the library MLOGDATA.

3. Please complete the questionnaire, copy the CEMAS data, and forward both the questionnaire and tape in a suitable container to AFESC/DEMG by 7 March 1990.

HQ AFESC

MATERIAL ACQUISITION SUPPORT QUESTIONNAIRE

1. Base:______________________________ Date:______________________

2. What type of CE Material Control operation do you have?

Check one: _____ LOGCES (Logistics Civil Engineering Support)

_____ COCESS (Contractor Operated Civil Engineering Supply Store)

_____ GOCESS (Government Operated Civil Engineering Supply Store)

_____ Other (please describe below)

____

____

____

____

3. Do you have contracting buyers physically located in Civil Engineering?

Yes: _____ No: _____

If yes, how many? ______________

4. Do the contacting buyers make CE requisitions while logged on the BCAS or CEMAS system?

Circle One BCAS CEMAS

5. Does your base use Blanket Purchase Agreements (BPAs) to purchase CE materials?

Yes: _____ No: _____

IF THE ANSWER TO QUESTION #5 IS "NO" SKIP TO QUESTION #9.

6. Do you use Blanket Purchase Agreements (BPAs) for MULTIPLE items such as all of your electrical or plumbing supplies?

Yes: _____ No: _____

7. Who makes the calls against the BPAs?

Contracting _____ CE _____

8. What type of BPAs are you using?

Prepriced _____ Unpriced _____

9. How long have you had CEMAS at your base? ________________________

10. Are there any unusual circumstances at your location that you believe would cause your material control operation to be more or less effective than the typical CE logistic system?

____

____

____

____

____

____

____

____

____

____

____

____

11. What procedures do you use for emergency (BCE pick-up requirements)?

Check one: _____Base Supply Emergency Walk-Thru

_____Standard Form 44

_____Imprest Fund

_____Credit Card

_____Other (please describe below)

12. If we have any addition questions concerning this questionnaire, who may we contact?

Name ______________________________

AV ______________________________

Appendix B: COBOL Computer Program Source Code

```
*****************************************************************
* This program calculates the total average response time,      *
* variance, and efficiency of a CE logistics system.  In        *
* addition, the program computes the response times and         *
* variances of base contracting and local vendors.              *
* The program uses the CEMAS file MPOF, MLOGDATA.               *
* LEGEND:                                                       *
*        I1 - INPUT FIELD FROM PRIMARY FILE                     *
*        Rn - REPORT HEADER PRINT LINE                          *
*        Dn - DETAIL PRINT LINE, OR TITLE                       *
*        An - ACCUMULATOR FIELD                                 *
*          WHERE n IS A NUMBER                                  *
*                                                               *
*        LINK,                                                  *
*        PUTPARM,                                               *
*        SCRATCH.                                               *
*****************************************************************
*
 IDENTIFICATION DIVISION.
 PROGRAM-ID.
     RESPTEST.
 AUTHOR.
     Robin Davis.
 DATE-WRITTEN.
     05/04/90.
/****************************************************************
*                                                               *
*                    ENVIRONMENT DIVISION                       *
*                                                               *
*****************************************************************
*
 ENVIRONMENT DIVISION.
 CONFIGURATION SECTION.
 SOURCE-COMPUTER.
     WANG-VS.
 OBJECT-COMPUTER.
     WANG-VS.
/****************************************************************
*                                                               *
*                    INPUT-OUTPUT SECTION                       *
*                                                               *
*****************************************************************
*
 INPUT-OUTPUT SECTION.
 FILE-CONTROL.
*
      SELECT PRINT
          ASSIGN TO "PRINT",   "PRINTER",
```

```
          ORGANIZATION    IS SEQUENTIAL
          ACCESS MODE     IS SEQUENTIAL
          FILE STATUS     IS FILSTAT.
*
      SELECT INPUT1
          ASSIGN TO "INPUT1",  "DISK",   NODISPLAY,
          ORGANIZATION    IS INDEXED
          ACCESS MODE     IS DYNAMIC
          RECORD KEY      IS I1-DOC
          ALTERNATE RECORD KEY 01 IS I1-CSL      WITH DUPLICATES
                               02 IS I1-PIINSUPP WITH DUPLICATES
                               03 IS I1-DTESERAL
                               04 IS I1-VEN-CODE WITH DUPLICATES
                               05 IS I1-WOJO     WITH DUPLICATES
                               06 IS I1-SOL-NBR  WITH DUPLICATES
                               07 IS I1-NSN      WITH DUPLICATES
          FILE STATUS     IS FILSTAT.
/****************************************************************
*                                                               *
*                 DATA DIVISION - FILE SECTION                  *
*                                                               *
*****************************************************************
*
 DATA DIVISION.
 FILE SECTION.
*
 FD  PRINT
     VALUE OF FILENAME IS FIL-FOR-PRINT
              LIBRARY  IS LIB-FOR-PRINT
              VOLUME   IS VOL-FOR-PRINT
     LABEL RECORDS ARE OMITTED.
 01  PRTREC                       PIC X(132).
*
 FD  INPUT1
     LABEL RECORDS ARE STANDARD
     VALUE OF FILENAME IS FIL-FOR-INPUT1
              LIBRARY  IS LIB-FOR-INPUT1
              VOLUME   IS VOL-FOR-INPUT1.
 01  MPOF-RECORD.
     05  I1-CSL                          PIC X(0006).
     05  I1-ITEMDESC                     PIC X(0050).
     05  I1-ITEMDESC-REDF-001 REDEFINES I1-ITEMDESC.
         10  I1-NOUN                     PIC X(0010).
         10  I1-ADJ1                     PIC X(0010).
         10  I1-ADJ2                     PIC X(0010).
         10  I1-ADJ3                     PIC X(0010).
         10  I1-ADJ4                     PIC X(0010).
     05  I1-UI                           PIC X(0002).
     05  I1-QTYPURCH                     PIC  9(05).
     05  I1-UNITCOST                     PIC  9(05)V9(4).
     05  I1-TOTCOST                      PIC  9(06)V9(2).
     05  I1-DELCOST                      PIC  9(04)V9(2).
     05  I1-VEN-CODE                     PIC X(0008).
```

```
05  I1-ORG-CODE                         PIC  9(03).
05  I1-SHOPCODE                         PIC X(0002).
05  I1-TYPE-REQ                         PIC  9(01).
05  I1-VAR                              PIC X(0001).
05  I1-DTERECEI                         PIC  9(04).
05  I1-TEMP-DTEREC REDEFINES I1-DTERECEI .
    07  I1-DTERECEI-YR                  PIC  9(01).
    07  I1-DTERECEI-SEQ                 PIC  9(03).
05  I1-QTYRECEI                         PIC  9(05).
05  I1-CONFNAME                         PIC X(0015).
05  I1-GEN-PROV                         PIC X(0006).
05  I1-GEN-PROV-REDF-001 REDEFINES I1-GEN-PROV.
    10  I1-GENPROV1                     PIC X(0002).
    10  I1-GENPROV2                     PIC X(0002).
    10  I1-GENPROV3                     PIC X(0002).
05  I1-COMPFLAG                         PIC X(0001).
05  I1-FOLL-CNT                         PIC  9(01).
05  I1-DTE-FOLL                         PIC X(0004).
05  I1-DTE-FOLL-REDF-001 REDEFINES I1-DTE-FOLL.
    10  I1-DTEFOLYR                     PIC  9(01).
    10  I1-DTEFOLDY                     PIC  9(03).
05  I1-LASTPRIC                         PIC  9(05)V9(2).
05  I1-INSTCODE                         PIC X(0004).
05  I1-CTL-CNTR                         PIC X(0001).
05  I1-SOL-NBR                          PIC X(0004).
05  I1-SOL-DTE                          PIC  9(04).
05  I1-SOLDELDT                         PIC  9(04).
05  I1-SOLDTEIN                         PIC  9(04).
05  I1-DTEASGBY                         PIC  9(04).
05  FILLER                              PIC X(0001).
05  I1-WOJO                             PIC X(0010).
05  I1-WOJO-REDF-001 REDEFINES I1-WOJO.
    10  I1-WO                           PIC  9(05).
    10  I1-JO                           PIC X(0005).
05  I1-PIINSUPP                         PIC X(0017).
05  I1-PIINSUPP-REDF-001 REDEFINES I1-PIINSUPP.
    10  I1-PIIN                         PIC X(0013).
    10  I1-PIIN-REDF-002 REDEFINES I1-PIIN.
        15  I1-PINCONST                 PIC X(0008).
        15  I1-PINLAST5                 PIC X(0005).
    10  I1-S-PIIN                       PIC  9(04).
05  I1-DTE-AWD                          PIC  9(04).
05  I1-DTE-AWD-REDF-001 REDEFINES I1-DTE-AWD.
    10  I1-DTAWDYR                      PIC  9(01).
    10  I1-DTEAWDDD                     PIC  9(03).
05  I1-DOC                              PIC X(0014).
05  I1-DOC-REDF-001 REDEFINES I1-DOC.
    10  I1-P-KEY                        PIC X(0014).
    10  I1-P-KEY-REDF-002 REDEFINES I1-P-KEY.
        15  I1-CONSTANT                 PIC X(0006).
        15  I1-DTESERAL                 PIC X(0008).
        15  I1-DTESERAL-REDF-003 REDEFINES I1-DTESERAL.
            20  I1-DATE                         PIC  9(04).
```

```
                    20  I1-SERIAL                    PIC X(0004).
        05  I1-TRAN-TYP                          PIC X(0001).
        05  I1-BUYER-ID                          PIC X(0001).
        05  I1-EDD                               PIC  9(04).
        05  I1-PROCAUTH                          PIC X(0002).
        05  I1-PROCTYPE                          PIC X(0001).
        05  I1-COMPCODE                          PIC  9(02).
        05  I1-COMMCODE                          PIC  9(04).
        05  I1-AMTAWARD                          PIC  9(06)V9(2).
        05  I1-CWM-D                             PIC  9(01).
        05  I1-RDD                               PIC  9(04).
        05  I1-RDD-REDF-001 REDEFINES I1-RDD.
            10  I1-RDD-YR                        PIC  9(01).
            10  I1-RDD-DAYS                      PIC  9(03).
        05  I1-ADD                               PIC  9(04).
        05  I1-PRIORITY                          PIC X(0001).
        05  I1-MFG-NAME                          PIC X(0030).
        05  I1-MFG-PART                          PIC X(0025).
        05  I1-FOB-IND                           PIC  9(01).
        05  I1-DISC-DAY                          PIC  9(02).
        05  I1-DISC-PC                           PIC  9(02)V9(2).
        05  I1-FUND-CIT                          PIC X(0050).
        05  I1-OA-NBR                            PIC  9(05).
        05  I1-DEMANDCD                          PIC X(0001).
        05  I1-FUNDCODE                          PIC X(0002).
        05  I1-NSN                               PIC X(0015).
        05  I1-COSSTICK                          PIC X(0005).
        05  I1-CO-PY                             PIC X(0001).
        05  I1-BCAS-STA                          PIC X(0002).
        05  I1-BCAS-DTE                          PIC  9(04).
        05  I1-BCAS-EDD                          PIC X(0004).
        05  I1-REQNAME                           PIC X(0020).
        05  I1-REQPHONE                          PIC  9(07).
        05  I1-CEBUY                             PIC X(0001).
        05  FILLER                               PIC X(0023).
*****************************************************************
*                                                               *
*                        WORKING STORAGE                        *
*                                                               *
*****************************************************************
*
 WORKING-STORAGE SECTION.
*****************************************************************
*                FILE CONTROL STATUS SWITCHES                   *
*****************************************************************
*
 01  FILSTAT.
     03  ERR-FLAG                    PIC X(01).
     03  PFK-BYTE                    PIC X(01).
 77  INPUT1-STATUS                   PIC X(01) VALUE "0".
     88 RECORD-FOUND-ON-INPUT1       VALUE "0".
     88 NO-MORE-INPUT1               VALUE "1".
 77  EDIT-STATUS                     PIC X(01) VALUE "0".
```

```
    88 RECORD-EDITED-OK              VALUE "1".
*****************************************************************
*                 EXTERNAL FILE LOCATION DEFINITIONS            *
*****************************************************************
*
 77  FIL-FOR-INPUT1                 PIC X(08) VALUE "MPOF".
 77  LIB-FOR-INPUT1                 PIC X(08) VALUE "MLOGDATA".
 77  VOL-FOR-INPUT1                 PIC X(06) VALUE "WRK001".
 77  FIL-FOR-PRINT                  PIC X(08) VALUE SPACES.
 77  LIB-FOR-PRINT                  PIC X(08) VALUE SPACES.
 77  VOL-FOR-PRINT                  PIC X(06) VALUE SPACES.
*****************************************************************
*       "DATE" SUBROUTINE PARAMETERS                            *
*****************************************************************
 77  DATE-FUNCTION                  PIC X(02) VALUE "J-".
 01  DATE-JUL1.
     03  DATE-JUL1-YR               PIC 9(01) VALUE ZERO.
     03  DATE-JUL1-REST             PIC 9(04) VALUE ZERO.
 01  DATE-JUL2.
     03  DATE-JUL2-YR               PIC 9(01) VALUE ZERO.
     03  DATE-JUL2-REST             PIC 9(04) VALUE ZERO.
 01  TEMP-DATE.
     03  TEMP-DATE-YR               PIC 9(01) VALUE ZERO.
     03  TEMP-DATE-REST             PIC 9(04) VALUE ZERO.
*
 01  VENRESP.
     03  FILLER       USAGE IS BINARY VALUE ZERO.
     03  VEN-DATA     USAGE IS BINARY VALUE ZERO.
 01  CORESP.
     03  FILLER       USAGE IS BINARY VALUE ZERO.
     03  CO-DATA USAGE IS BINARY VALUE ZERO.
 01  TOTRESP.
     03  FILLER       USAGE IS BINARY VALUE ZERO.
     03  TOT-DATA USAGE IS BINARY VALUE ZERO.
 01  RETURN-KODE.
     03  FILLER   USAGE IS BINARY VALUE ZERO.
     03  RETURNED USAGE IS BINARY VALUE ZERO.
/****************************************************************
*                                                               *
*                     PRINT LINE DEFINITIONS                    *
*                                                               *
*****************************************************************
*
 01  BL-LINE                        PIC X(001) VALUE SPACE.
*****************************************************************
*                     DETAIL PRINT LINE(S)                      *
*****************************************************************
*
*01  D1-LINE.
*    03  D1-INSTCODE                PIC XXXX.
*    03  FILLER                     PIC X(004) VALUE SPACES.
*    03  D1-VENSUM                  PIC 9(10).
*    03  FILLER                     PIC X(004) VALUE SPACES.
```

```
*      03  D1-VENMEAN                    PIC 9(04).9(02).
*      03  FILLER                        PIC X(004) VALUE SPACES.
*      03  D1-VENVAR                     PIC 9(04).9(02).
*      03  FILLER                        PIC X(004) VALUE SPACES.
*      03  D1-VENMEAN                    PIC 9(04).9(02).
*      03  D1-CORESP                     PIC 9999.
*      03  FILLER                        PIC X(004) VALUE SPACES.
*      03  D1-CORESP                     PIC 9999.
*      03  FILLER                        PIC X(004) VALUE SPACES.
*      03  D1-DTERECEI                   PIC 9999.
*      03  FILLER                        PIC X(004) VALUE SPACES.
*      03  D1-DTE-AWD                    PIC 9999.
*      03  FILLER                        PIC X(004) VALUE SPACES.
*      03  D1-DATE                       PIC 9999.
*      03  FILLER                        PIC X(004) VALUE SPACES.
*      03  D1-N                          PIC 9999.
*      03  FILLER                        PIC X(004) VALUE SPACES.
*      03  D1-TOT-SQUARED-SUM           PIC S9(07).
*      03  FILLER                        PIC X(004) VALUE SPACES.
*      03  D1-TERM1                      PIC S9(10).
*      03  FILLER                        PIC X(004) VALUE SPACES.
*      03  D1-TERM2                      PIC 9999.
*      03  FILLER                        PIC X(004) VALUE SPACES.
*      03  D1-TERM3                      PIC S9(10).
*      03  FILLER                        PIC X(004) VALUE SPACES.
*      03  D1-TERM4                      PIC S9(10).
*      03  FILLER                        PIC X(004) VALUE SPACES.
*      03  D1-TERM5                      PIC 9(05).9(03).
*      03. FILLER                        PIC X(004) VALUE SPACES.
*
 01  D1-TITLE.
       03  FILLER                        PIC X(004) VALUE "INST".
       03  FILLER                        PIC X(004) VALUE SPACES.
       03  FILLER                        PIC X(008) VALUE "RECORDS".
       03  FILLER                        PIC X(004) VALUE SPACES.
       03  FILLER                        PIC X(008) VALUE "TOT-MEAN".
       03  FILLER                        PIC X(004) VALUE SPACES.
       03  FILLER                        PIC X(008) VALUE "TOT-VAR".
       03  FILLER                        PIC X(004) VALUE SPACES.
       03  FILLER                        PIC X(008) VALUE "VEN-MEAN".
       03  FILLER                        PIC X(004) VALUE SPACES.
       03  FILLER                        PIC X(008) VALUE "VEN-VAR".
       03  FILLER                        PIC X(004) VALUE SPACES.
       03  FILLER                        PIC X(008) VALUE "CO-MEAN".
       03  FILLER                        PIC X(004) VALUE SPACES.
       03  FILLER                        PIC X(008) VALUE "CO-VAR".
       03  FILLER                        PIC X(004) VALUE SPACES.
       03  FILLER                        PIC X(008) VALUE "LOG-EFF".
*
 01  D1-RESULTS.
       03  D1-INSTCODE                   PIC X(004).
       03  FILLER                        PIC X(004) VALUE SPACES.
       03  D1-N                          PIC 9999.
```

```
    03  FILLER                          PIC X(008) VALUE SPACES.
    03  D1-TOT-MEAN                     PIC 9999.99.
    03  FILLER                          PIC X(004) VALUE SPACES.
    03  D1-TOT-VAR                      PIC 9(05).9(03).
    03  FILLER                          PIC X(004) VALUE SPACES.
    03  D1-VEN-MEAN                     PIC 9999.99.
    03  FILLER                          PIC X(004) VALUE SPACES.
    03  D1-VEN-VAR                      PIC 9(05).9(03).
    03  FILLER                          PIC X(004) VALUE SPACES.
    03  D1-CO-MEAN                      PIC 9999.99.
    03  FILLER                          PIC X(004) VALUE SPACES.
    03  D1-CO-VAR                       PIC 9(05).9(03).
    03  FILLER                          PIC X(004) VALUE SPACES.
    03  D1-LOG-EFF                      PIC 9.999.
/*****************************************************************
*                                                                *
*                  ACCUMULATOR AND SAVE AREA                     *
*                                                                *
******************************************************************
*
 01  LINE-COUNT                         BINARY     VALUE ZERO.
 01  PAGE-COUNT                         BINARY     VALUE ZERO.
 01  RECORDS-SELECTED                   PIC S9(07) COMP VALUE ZERO.
 01  N                                  PIC S9(07) COMP VALUE ZERO.
 01  X                                  PIC S9(07) COMP VALUE ZERO.
 01  X-SQUARED                      PIC S9(07)V9(03) COMP VALUE ZERO.
 01  DEN                                PIC S9(07) COMP VALUE ZERO.
 01  TOT-SQUARED-SUM                  PIC S9(07) COMP VALUE ZERO.
 01  TOT-SUM                          PIC S9(07) COMP VALUE ZERO.
 01  TOT-MEAN                   PIC S9(05)V9(02) COMP VALUE ZERO.
 01  TOT-VAR                    PIC S9(05)V9(03) COMP VALUE ZERO.
 01  VEN-SQUARED-SUM            PIC S9(07) COMP VALUE ZERO.
 01  VEN-SUM                    PIC S9(07) COMP VALUE ZERO.
 01  VEN-MEAN                   PIC S9(05)V9(02) COMP VALUE ZERO.
 01  VEN-VAR                    PIC S9(05)V9(03) COMP VALUE ZERO.
 01  CO-SQUARED-SUM             PIC S9(07) COMP VALUE ZERO.
 01  CO-SUM                     PIC S9(07) COMP VALUE ZERO.
 01  CO-MEAN                    PIC S9(05)V9(02) COMP VALUE ZERO.
 01  CO-VAR                     PIC S9(05)V9(03) COMP VALUE ZERO.
 01  EFF-SUM                    PIC S9(02)V9(03) COMP VALUE ZERO.
 01  LOG-EFF                    PIC S9(02)V9(03) COMP VALUE ZERO.
/*****************************************************************
*                                                                *
*                       PUTPARM DEFINTIONS                       *
*                                                                *
******************************************************************
*
******************************************************************
*            DEFINITIONS FOR PUTPARM 01 (INPUT   )               *
******************************************************************
 01  PUTPARM01-TYPE                     PIC X(01) VALUE "E".
 01  PUTPARM01-PRNAME                   PIC X(08) VALUE "INPUT   ".
 01  PUTPARM01-KEYCOUNT.
```

```
     03  FILLER                       BINARY    VALUE ZERO.
     03  FILLER                       BINARY    VALUE 04.
 01  PUTPARM01-AID                    PIC X(01) VALUE "@".
 01  PUTPARM-LABEL                    PIC X(08) VALUE SPACES.
 01  PUTPARM-REF-LABEL                PIC X(08) VALUE SPACES.
 01  PUTPARM01-KEYWORD01              PIC X(08) VALUE "FILE".
 01  PUTPARM01-VAL-LEN01.
     03  FILLER                       BINARY    VALUE ZERO.
     03  FILLER                       BINARY    VALUE  08.
 01  PUTPARM01-KEYWORD02              PIC X(08) VALUE "LIBRARY".
 01  PUTPARM01-VAL-LEN02.
     03  FILLER                       BINARY    VALUE ZERO.
     03  FILLER                       BINARY    VALUE  08.
 01  PUTPARM01-KEYWORD03              PIC X(08) VALUE "VOLUME".
 01  PUTPARM01-VAL-LEN03.
     03  FILLER                       BINARY    VALUE ZERO.
     03  FILLER                       BINARY    VALUE  06.
 01  PUTPARM01-KEYWORD04              PIC X(08) VALUE "ACCESS  ".
 01  PUTPARM01-VALUE04                PIC X(05) VALUE "PRINT".
 01  PUTPARM01-VAL-LEN04.
     03  FILLER                       BINARY    VALUE ZERO.
     03  FILLER                       BINARY    VALUE  05.
 01  PUTPARM-RTN-CODE.
     03  FILLER                       BINARY    VALUE ZERO.
     03  PUTPARM-RETURN-CODE          BINARY    VALUE ZERO.
*****************************************************************
*             DEFINITIONS FOR PUTPARM 02 (EOJ      )            *
*****************************************************************
 01  PUTPARM02-TYPE                   PIC X(01) VALUE "E".
 01  PUTPARM02-PRNAME                 PIC X(08) VALUE "EOJ".
 01  PUTPARM02-KEYCOUNT.
     03  FILLER                       BINARY    VALUE ZERO.
     03  FILLER                       BINARY    VALUE 00.
 01  PUTPARM02-AID                    PIC X(01) VALUE "P".
/*****************************************************************
*                                                               *
*                DEFINITIONS FOR LINK TO DISPLAY                *
*                                                               *
*****************************************************************
*
 77  LINK-TO-NAME                     PIC X(08) VALUE "DISPLAY".
 77  LINK-TYPE                        PIC X(01) VALUE "S".
 77  LINK-LIBRARY                     PIC X(08) VALUE SPACES.
 77  LINK-VOLUME                      PIC X(06) VALUE SPACES.
 01  LINK-PCOUNT.
     03  FILLER                       BINARY    VALUE ZERO.
     03  FILLER                       BINARY    VALUE ZERO.
 77  LINK-CEXIT-FLAG                  PIC X(01) VALUE "N".
 77  LINK-CEXIT-MSG                   PIC X(27) VALUE SPACES.
 01  LINK-CEXIT-MSG-LEN.
     03  FILLER                       BINARY    VALUE ZERO.
     03  FILLER                       BINARY    VALUE 27.
 77  LINK-HELP-FLAG                   PIC X(1)  VALUE "H".
```

```
 77  LINK-PFKEY-MASK                PIC X(02) VALUE LOW-VALUES.
 77  LINK-CANCEL-RCVR               PIC X(001) VALUE SPACES.
 01  LINK-CANCEL-RCVR-LEN.
     03  FILLER                     BINARY     VALUE ZERO.
     03  FILLER                     BINARY     VALUE 001.
 01  LINK-CODE.
     03  FILLER                     BINARY     VALUE ZERO.
     03  LINK-CODE-VAL              BINARY     VALUE ZERO.
 01  LINK-RETURN-CODE.
     03  FILLER                     BINARY     VALUE ZERO.
     03  LINK-RTN-CODE-VAL          BINARY     VALUE ZERO.
******************************************************************
*                     DEFINTIONS FOR SCRATCH                     *
******************************************************************
 77  SCR-TYPE                       PIC X(1) VALUE "F".
 77  EXP-FLAG                       PIC X(1) VALUE "B".
 77  LIM-FLAG                       PIC X(1) VALUE " ".
 01  SCRATCH-RTN-CODE.
     03  FILLER                     BINARY     VALUE ZERO.
     03  FILLER                     BINARY     VALUE ZERO.
/*****************************************************************
*                                                                *
*                      PROCEDURE DIVISION                        *
*                                                                *
******************************************************************
*
 PROCEDURE DIVISION.
 START-PROGRAM.
     PERFORM INITIALIZATION.
     PERFORM MAIN-PROCESS
       UNTIL NO-MORE-INPUT1.
     PERFORM MEANS-DEVIATIONS.
     PERFORM PRINT-OUTPUT.
     PERFORM TERMINATION.
 EXIT-PROGRAM.
     STOP RUN.


******************************************************************
*                             MAIN PROCESS                       *
******************************************************************
*
 MAIN-PROCESS.
     PERFORM GET-A-REC-FROM-INPUT1.
     IF RECORD-FOUND-ON-INPUT1 AND RECORD-EDITED-OK
        PERFORM PRINT-A-DETAIL-LINE.
/*****************************************************************
*                                                                *
*                       INPUT OUTPUT ROUTINES                    *
*                                                                *
******************************************************************


*
```

```
*******************************************************************
*                      GET A REC FROM INPUT1                      *
*******************************************************************
*
 GET-A-REC-FROM-INPUT1.
     READ INPUT1
       NEXT
       AT END
         MOVE "1" TO INPUT1-STATUS.
     IF RECORD-FOUND-ON-INPUT1
        PERFORM EDIT-INPUT-RECORD.
*******************************************************************
*                       EDIT INPUT RECORD                         *
*******************************************************************
*
 EDIT-INPUT-RECORD.
*
     IF  (I1-DTERECEI       IS > 0
                       AND NOT > 365)
     AND (I1-DTE-AWD        IS > 0
                       AND NOT > 365)
     AND (I1-DATE           IS > 0
                       AND NOT > 365)
     AND (I1-PIIN          NOT = "SBSS")
*        THEN ACCEPT THE RECORD - TURN ON EDIT STATUS SWITCH
         MOVE "1" TO EDIT-STATUS
      ELSE
*        REJECT THE RECORD - TURN OFF EDIT STATUS SWITCH
         MOVE "0" TO EDIT-STATUS.
*******************************************************************
*                      PRINT A DETAIL LINE                        *
*******************************************************************
*
 PRINT-A-DETAIL-LINE.
     ADD 1 TO RECORDS-SELECTED.
     PERFORM DATE-DIFFERENCE .
     PERFORM INTERATION-CALCULATIONS.
*    MOVE I1-INSTCODE      TO D1-INSTCODE.
*    MOVE I1-DTERECEI      TO D1-DTERECEI.
*    MOVE I1-DTE-AWD       TO D1-DTE-AWD.
*    MOVE I1-DATE          TO D1-DATE.
*    MOVE VEN-SUM          TO D1-VENSUM.
*    MOVE VEN-MEAN         TO D1-VENMEAN.
*    MOVE VEN-VAR          TO D1-VENVAR.
*    MOVE CO-DATA          TO D1-CORESP.
     ADD 1 TO LINE-COUNT.
     IF LINE-COUNT IS >  55
        ADD 1 TO LINE-COUNT.
*    WRITE PRTREC FROM D1-LINE  AFTER ADVANCING 1 LINE.
```

```
*****************************************************************
*                  DATE-DIFFERENCE CALCULATIONS                 *
*****************************************************************
*
 DATE-DIFFERENCE.
     MOVE ZEROES      TO DATE-JUL1 DATE-JUL2.
     MOVE I1-DTERECEI TO DATE-JUL1-REST.
     MOVE I1-DTE-AWD  TO DATE-JUL2-REST.
     IF I1-DTERECEI-YR = 0
        MOVE 9           TO DATE-JUL1-YR
      ELSE
        MOVE 8           TO DATE-JUL1-YR .
     IF I1-DTAWDYR = 0
        MOVE 9           TO DATE-JUL2-YR
      ELSE
        MOVE 8           TO DATE-JUL2-YR .
     CALL "DATE" USING DATE-FUNCTION, DATE-JUL1, DATE-JUL2,
           VENRESP, RETURN-KODE.
     MOVE ZEROES      TO DATE-JUL1 DATE-JUL2.
     MOVE I1-DTE-AWD  TO DATE-JUL1-REST.
     MOVE I1-DATE     TO DATE-JUL2-REST.
     MOVE I1-DATE     TO TEMP-DATE.
     IF I1-DTAWDYR = 0
        MOVE 9           TO DATE-JUL1-YR
      ELSE
        MOVE 8           TO DATE-JUL1-YR.
     IF TEMP-DATE-YR = 0
         MOVE 9          TO DATE-JUL2-YR
      ELSE
         MOVE 8          TO DATE-JUL2-YR.
     CALL "DATE" USING DATE-FUNCTION, DATE-JUL1, DATE-JUL2,
           CORESP, RETURN-KODE.
     MOVE ZEROES      TO DATE-JUL1 DATE-JUL2.
     MOVE I1-DTERECEI  TO DATE-JUL1-REST.
     MOVE I1-DATE     TO DATE-JUL2-REST.
     MOVE I1-DATE     TO TEMP-DATE.
     IF I1-DTAWDYR = 0
        MOVE 9           TO DATE-JUL1-YR
      ELSE
        MOVE 8           TO DATE-JUL1-YR.
     IF TEMP-DATE-YR = 0
         MOVE 9          TO DATE-JUL2-YR
      ELSE
         MOVE 8          TO DATE-JUL2-YR.
     CALL "DATE" USING DATE-FUNCTION, DATE-JUL1, DATE-JUL2,
           TOTRESP, RETURN-KODE.
```

```
*******************************************************************
*                                                                 *
*                  INTERATION CALCULATIONS                        *
*                                                                 *
*******************************************************************
 INTERATION-CALCULATIONS.
        MOVE RECORDS-SELECTED TO N.
* TOTAL RESPONSE INTERATIONS *
        ADD TOT-DATA TO TOT-SUM.
        MOVE ZEROES   TO X.
        MOVE ZEROES   TO X-SQUARED.
        MOVE TOT-DATA TO X.
        MULTIPLY X BY X GIVING X-SQUARED ROUNDED.
        ADD X-SQUARED TO TOT-SQUARED-SUM.
* VENDOR RESPONSE INTERATIONS *
        ADD VEN-DATA TO VEN-SUM.
        MOVE ZEROES   TO X.
        MOVE ZEROES   TO X-SQUARED.
        MOVE VEN-DATA TO X.
        MULTIPLY X BY X GIVING X-SQUARED ROUNDED.
        ADD X-SQUARED TO VEN-SQUARED-SUM.
* CONTRACTING RESPONSE INTERATIONS *
        ADD CO-DATA TO CO-SUM.
        MOVE ZEROES   TO X.
        MOVE ZEROES   TO X-SQUARED.
        MOVE CO-DATA TO X.
        MULTIPLY X BY X GIVING X-SQUARED ROUNDED.
        ADD X-SQUARED TO CO-SQUARED-SUM.
* EFFICIENCY INTERATIONS *
    MOVE ZEROES       TO DATE-JUL1 DATE-JUL2.
    MOVE I1-DTERECEI  TO DATE-JUL1-REST.
    MOVE I1-RDD       TO DATE-JUL2-REST.
    IF I1-DTERECEI-YR = 0
       MOVE 9            TO DATE-JUL1-YR
     ELSE
       MOVE 8            TO DATE-JUL1-YR .
    IF I1-RDD-YR = 0
       MOVE 9            TO DATE-JUL2-YR
     ELSE
       MOVE 8            TO DATE-JUL2-YR .
    IF (DATE-JUL1    NOT > DATE-JUL2)
        THEN ADD 1 TO EFF-SUM.
/******************************************************************
*                                                                 *
*           MEANS, SAMPLE VARIANCES, AND EFFICIENCY               *
*                                                                 *
*******************************************************************
 MEANS-DEVIATIONS.
* TOTAL SAMPLE VARIANCE *
        COMPUTE DEN = N * (N - 1).
        DIVIDE TOT-SUM BY N GIVING TOT-MEAN ROUNDED.
        COMPUTE TOT-VAR ROUNDED = ((N * TOT-SQUARED-SUM) -
         (TOT-SUM ** 2)) / DEN.
```

```
* VENDOR SAMPLE VARIANCE *
         DIVIDE VEN-SUM BY N GIVING VEN-MEAN ROUNDED.
         COMPUTE VEN-VAR ROUNDED = ((N * VEN-SQUARED-SUM) -
          (VEN-SUM ** 2)) / DEN.
* CONTRACTING SAMPLE VARIANCE *
         DIVIDE CO-SUM BY N GIVING CO-MEAN ROUNDED.
         COMPUTE CO-VAR ROUNDED = ((N * CO-SQUARED-SUM) -
          (CO-SUM ** 2)) / DEN.
* EFFICIENCY CALCULATION *
         DIVIDE EFF-SUM BY N GIVING LOG-EFF ROUNDED.
/*****************************************************************
*                                                                *
*                         PRINT OUTPUT                           *
*                                                                *
******************************************************************
 PRINT-OUTPUT.
     MOVE N                  TO D1-N.
     MOVE TOT-MEAN           TO D1-TOT-MEAN.
     MOVE TOT-VAR            TO D1-TOT-VAR.
     MOVE VEN-MEAN           TO D1-VEN-MEAN.
     MOVE VEN-VAR            TO D1-VEN-VAR.
     MOVE CO-MEAN            TO D1-CO-MEAN.
     MOVE CO-VAR             TO D1-CO-VAR.
     MOVE I1-INSTCODE        TO D1-INSTCODE.
     MOVE LOG-EFF            TO D1-LOG-EFF.
     WRITE PRTREC FROM D1-TITLE AFTER ADVANCING 2 LINES.
     WRITE PRTREC FROM D1-RESULTS AFTER ADVANCING 1 LINE.
/*****************************************************************
*                                                                *
*                          INITIALIZATION                        *
*                                                                *
******************************************************************
*
 INITIALIZATION.
     OPEN INPUT INPUT1.
     OPEN OUTPUT PRINT.
* PROCESS FIRST RECORD
     PERFORM GET-A-REC-FROM-INPUT1
       UNTIL RECORD-EDITED-OK, OR NO-MORE-INPUT1.
     IF RECORD-FOUND-ON-INPUT1
        PERFORM PRINT-A-DETAIL-LINE.
/*****************************************************************
*                                                                *
*                          TERMINATION                           *
*                                                                *
******************************************************************
*
 TERMINATION.
     CLOSE INPUT1.
     CLOSE PRINT.
     PERFORM PUTPARM-AND-LINK-TO-DISPLAY.
```

```
/*****************************************************************
*                                                                *
*                 PUTPARM AND LINK TO DISPLAY                    *
*                                                                *
******************************************************************
*
 PUTPARM-AND-LINK-TO-DISPLAY.
* CALL PUTPARM FOR "INPUT"
     CALL "PUTPARM" USING  PUTPARM01-TYPE,
                           PUTPARM01-PRNAME,
                           PUTPARM01-KEYCOUNT,
                           PUTPARM01-KEYWORD01,
                           FIL-FOR-PRINT,
                           PUTPARM01-VAL-LEN01,
                           PUTPARM01-KEYWORD02,
                           LIB-FOR-PRINT,
                           PUTPARM01-VAL-LEN02,
                           PUTPARM01-KEYWORD03,
                           VOL-FOR-PRINT,
                           PUTPARM01-VAL-LEN03,
                           PUTPARM01-KEYWORD04,
                           PUTPARM01-VALUE04,
                           PUTPARM01-VAL-LEN04,
                           PUTPARM01-AID,
                           PUTPARM-LABEL,
                           PUTPARM-REF-LABEL,
                           PUTPARM-RTN-CODE.
* CALL PUTPARM FOR EOJ
     CALL "PUTPARM" USING  PUTPARM02-TYPE,
                           PUTPARM02-PRNAME,
                           PUTPARM02-KEYCOUNT,
                           PUTPARM02-AID,
                           PUTPARM-LABEL,
                           PUTPARM-REF-LABEL,
                           PUTPARM-RTN-CODE.
* LINK TO DISPLAY
     CALL "LINK" USING LINK-TO-NAME,
                       LINK-TYPE, LINK-LIBRARY, LINK-VOLUME,
                       LINK-PCOUNT,
                       LINK-CEXIT-FLAG,
                       LINK-CEXIT-MSG, LINK-CEXIT-MSG-LEN,
                       LINK-HELP-FLAG, LINK-PFKEY-MASK,
                       LINK-CANCEL-RCVR, LINK-CANCEL-RCVR-LEN,
                       LINK-CODE, LINK-RETURN-CODE.
* CALL TO SCRATCH THE PRINT FILE
      CALL "SCRATCH" USING SCR-TYPE,
                           FIL-FOR-PRINT,
                           LIB-FOR-PRINT,
                           VOL-FOR-PRINT,
                           EXP-FLAG, LIM-FLAG, SCRATCH-RTN-CODE.
```

Appendix C: GOCESS Data Used in ANOVA and Correlation Analysis

The variables used in this appendix are defined as follows:

INST - Base Installation Code

TOT-X - Total order cycle response time

TOT-S - Total order cycle standard deviation

CO-X - Base contracting response time

CO-X - Base contracting standard deviation

VEN-X - Vendor average response time

VEN-X - Vendor standard deviation

EFF - Order cycle efficiency

Part I - Data for GOCESS Systems Without Collocated Contracting Buyers

INST	TOT-X	TOT-S	CO-X	CO-S	VEN-X	VEN-S	EFF
DDPF	022.48	020.17	011.50	011.60	010.98	016.52	0.0140
DJDB	019.26	014.97	006.24	006.47	013.02	012.42	0.0620
EEPZ	013.23	007.88	006.18	005.37	007.05	006.76	0.0740
GAMH	012.47	012.33	005.48	004.94	006.99	010.04	0.0260
GJKZ	022.61	019.60	005.87	004.36	016.74	018.14	0.0200
MAHG	018.06	012.61	004.56	005.14	013.49	011.37	0.0130
MPLS	021.50	120.10	005.81	050.16	015.69	106.60	0.0060
MXDP	027.30	015.60	019.01	012.32	008.29	012.14	0.4230
NRCH	028.98	017.77	008.97	007.40	020.00	015.40	0.0270
NTMU	020.78	013.76	010.78	009.41	010.00	010.83	0.0390
PLXL	019.11	016.66	008.06	005.38	011.06	009.92	0.4340
SXHT	028.58	016.77	013.28	010.79	015.30	010.97	0.1730
TYMX	019.12	012.92	007.11	006.61	012.01	011.65	0.0230
UBNY	013.44	010.32	006.42	007.00	007.02	007.81	0.0730
UHHZ	016.15	011.29	005.87	005.03	010.28	010.80	0.0890
VNVP	015.90	011.86	007.43	008.05	008.48	009.56	0.1170
YZJU	022.76	015.46	011.13	010.81	011.64	012.33	0.1420
ZHTV	024.21	014.18	005.60	004.28	018.61	013.19	0.0330

Part II - Data for GOCESS Systems With Collocated Contracting Buyers

INST	TOT-X	TOT-S	CO-X	CO-S	VEN-X	VEN-S	EFF
ASPR	014.09	013.32	001.89	003.52	012.20	012.41	0.0250
BJHZ	009.74	010.24	002.49	002.94	007.25	009.66	0.0590
BXUR	020.20	015.57	006.61	007.76	013.59	012.15	0.0660
CNBC	021.90	012.55	012.45	006.49	009.44	009.69	0.0010
CZQZ	016.25	012.40	004.43	005.09	011.82	010.70	0.0240
DKFX	024.21	017.82	015.67	013.35	008.54	009.38	0.0290
FBNV	020.21	013.56	009.17	009.12	011.03	009.95	0.0180
FJXT	012.78	011.61	002.69	003.51	010.10	011.00	0.0170
FNWZ	017.51	038.51	002.95	008.06	014.57	036.63	0.0030
HUUA	017.56	014.39	005.24	005.65	012.32	012.66	0.0390
JCGU	017.39	010.43	007.17	006.39	010.22	006.99	0.1230
JFSD	011.97	024.00	001.72	004.18	010.26	023.50	0.0190
KNMD	020.97	015.14	008.66	009.33	012.31	013.30	0.0440
KRSM	021.66	013.35	009.50	006.02	012.17	012.67	0.0300
KWRD	024.73	015.23	013.15	010.43	011.58	011.03	0.0210
KYJL	011.58	011.66	002.81	003.33	008.77	010.32	0.0520
MBPB	027.52	016.57	012.93	009.84	014.59	015.57	0.0400
MUHJ	018.88	014.11	009.87	009.78	009.01	009.65	0.0210
NKAK	017.19	013.89	006.35	005.36	010.83	011.69	0.0170
NUEX	013.34	011.85	001.58	002.02	011.76	011.52	0.0030
PTFL	027.92	018.01	015.70	014.78	012.22	009.67	0.0060
QYZH	013.77	011.77	002.48	002.14	011.28	011.39	0.0600
SCEY	012.03	010.04	003.87	002.84	008.16	009.16	0.0560
TDKA	011.29	008.69	004.58	003.70	006.71	007.21	0.0560
TMKH	016.22	013.25	004.73	003.42	011.49	012.08	0.0050
VDYD	015.06	011.71	003.45	003.97	011.61	010.65	0.0080
VKAG	018.91	012.70	005.23	006.21	013.68	012.49	0.0340
VLSB	012.56	014.47	006.10	007.17	014.46	013.10	0.0410

Appendix D: Expert Panel Data

The expert panel process consisted of two iterations. Each iterations consisted of a cover letter, preliminary information, and discussion questions. The discussion questions, expert responses, and mediator summations are combined so that the group progression can be examined. This appendix is organized in three sections. First, the cover letters for each iteration are listed. Second, the preliminary information to each proposal is provided. And third, the discussion questions, expert responses, and mediator summations are listed.

Cover Letters

First Expert Panel Proposal Cover Letter.

AFIT/LSG

Expert Panel to Evaluate Material Requirements Planning Concepts for Implementation into the Civil Engineering Material Acquisition System

HQ Command XYZ
Attn: Command Logistics Expert

1. We've asked you to participate on a panel of experts to evaluate Material Requirements Planning (MRP) concepts for implementation into the Civil Engineering Material Acquisition System (CEMAS) because you are a recognized expert in the field of Civil Engineering (CE) logistics. In our research effort to improve CE logistics, we have uncovered several areas which need improvement such as base contracting responsiveness to CE. However, for this panel exercise we are concentrating only on the implementation of MRP. By obtaining your opinions and incorporating your ideas, these concepts can be effectively tested.

2. To determine the feasibility of MRP, we are using the Delphi interviewing method. The Delphi method consists of a panel of experts who are interrogated by a sequence of questionnaires in which the responses to one questionnaire are used to produce the next questionnaire. Any information available to some experts and

not others is thus passed on enabling all the experts to have access to all the information for evaluation. Each expert's response remains anonymous throughout the entire process. This technique eliminates the bandwagon effect of majority opinion. The results of Delphi exercises generally achieve greater acceptance by group members than are other forms of interaction.

3. On the attached proposal, we've described the scope of material holding costs, our current method of operation, introduced basic MRP concepts, proposed a method to implement these concepts, and asked a few questions to fine tune the method. Please answer the questions and feel free to question or dispute anything throughout the entire text. We've double spaced the entire document so that you can easily comment throughout. Also, feel free to discuss the proposal with any of your colleagues. Please return the reviewed proposal in the enclosed envelope by 27 Jun 90. If you have any questions, contact Captain Robin Davis at AV 255-8989. Thanks for your support.

Second Expert Panel Proposal Cover Letter.

AFIT/LSG

Experts' Responses to the First Proposal of the Implementation of Material Requirements Planning into the Civil Engineering Material Acquisition System

HQ Command XYZ
Attn: Command Logistics Expert

1. Thanks for your quick response to the first iteration of the implementation of Material Requirements Planning (MRP) into the Civil Engineering Material Acquisition System (CEMAS). We have consolidated all the responses to the first iteration from the experts. At the end of each question on the attached second iteration, we have reported the opinions of the experts and restated each question based on these opinions.

2. After viewing the responses of the other experts, we ask that you agree with the group summation or provide further recommendations if you disagree. Please return the reviewed proposal in the enclosed envelope by 16 July 90. If you have any questions, contact Captain Robin Davis at AV 255-8989. The goal of this exercise is to identify a method to improve the way we order materials through our logistics systems that will be acceptable to all commands in the Air Force. Thanks for your support.

Preliminary Information

First Proposal.

IMPLEMENTATION OF MATERIAL REQUIREMENTS PLANNING CONCEPTS
INTO THE
CIVIL ENGINEERING MATERIAL ACQUISITION SYSTEM

Scope of Material Holding Costs

From November 1988 through January 1989, the Air Force Audit Agency performed an evaluation of the management of Civil Engineering materials. They reviewed 14 bases representing six major commands. In their review, they found that the total value of material in the work/job order storage areas of these bases was approximately $6.9 million, averaging nearly $500,000 per installation.

According to Chief Hines, HQ AF Engineering and Services Center, the approximate holding cost rate for CE logistics material is 33%. There are roughly 100 major Air Force installations in the world. The following is the approximate annual cost of work/job order holding costs to Air Force CE:

Annual Holding Cost =

$$100 \text{ installations} \times \frac{\$469{,}366}{\text{Base}} \times .33 = \$15{,}489{,}078$$

Consider for example, if the amount of materials in work/job order storage areas could be reduced throughout the AF by 50 %. AF CE could save approximately $7.7 million in inventory holding costs per year.

Current Method

Currently, all material requirements for CE routine work/job orders are ordered and stored well in advance of the time they are actually needed. After a Bill of Materials (BOM) is received into Material Control for either a work order (WO) or job order (JO) and the research has been completed, all items are simultaneously either placed on order with the Standard Base Supply System (SBSS) or base contracting or transferred from the holding area or CEMAS store to the WO/JO storage area. Meanwhile, those items that were available for day to day use in the CEMAS store have been transferred to the holding area and must be reordered for the CEMAS store. If the items that were ordered through SBSS or base contracting are received within a few days, they must be warehoused until the work begins. In addition, all the funds that were memo-committed for the JO/WO are committed. The term "memo-committed" implies that we have "earmarked" funds within CEMAS. The term "committed" implies that we have transferred funds to SBSS or Base Contracting for the purchase of materials.

The amount of materials in the work/job order storage areas may be reduced by incorporating modern logistics concepts such as Material Requirements Planning (MRP).

Material Requirements Planning (MRP)

The MRP concept uses computer capabilities to time phase procurement and/or production of materials used in a manufacturing system. The emphasis was to minimize on-hand inventory by arranging for the time-phased delivery of materials or subassemblies from vendors as required by the manufacturing process. Essentially, MRP emphasizes timing the arrival of manufacturing requirements so as to minimize on-hand stock of material (and thus minimizing inventory investment). If the on-hand stocks are thought of as water in a river covering a bed of boulders, where the boulders represent problems, it is logical that lowering the water level (inventory) exposes the boulders (problems), making them easier to find and remove. By likening the river bed to our JO/WO storage areas, the analogy conveys a powerful message: The way to detect what is holding back production is to reduce stock levels enough to expose operating inefficiencies that are normally masked by buffers of stockpiled materials.

MRP was conceived to support a manufacturing environment. CE is a Job Shop environment which means that each "product" is produced only after receiving a customer's order. The job-shop nature of our work means that production orders may: 1) come from different customers, 2) be for different quantities and designs, and 3), the time allowed for production may vary as a result of CE's delivery promises. Nonetheless, while CE is a job shop versus a manufacturing environment, the basic MRP concepts may be incorporated to a degree and thereby reduce CE operating costs.

Proposed Method of Implementation

Consider an example of a BOM just received into Material Control from the Production Control Center (PCC). The BOM has been assigned a Required Delivery Date (RDD). The establishment of the RDD memo-committed funds equal to the estimated materials. The following is a breakdown of our BOM:

25 Items	- CEMAS store items
10 Items	- No buying history
15 Items	- Buying history exists in the Noun Dictionary
50 Items Total	

For the CEMAS store items, perhaps we could make a change to the CEMAS software so that logistics personnel will be automatically notified to transfer these items at some date prior to the RDD.

For the items with no buying history or items which have never been ordered, perhaps we should order these items right away.

For the items which are not on hand which, we've ordered them in the past, and have a lead time history in the noun dictionary, perhaps we could develop a forecasting technique that will predict how long it will take to receive each item. CEMAS could be changed to automatically order these items at the predicted lead time prior to the RDD.

Second Proposal Preliminary Information

EXPERTS' RESPONSES TO THE FIRST PROPOSAL OF THE IMPLEMENTATION OF MATERIALS REQUIREMENTS PLANNING TO THE CIVIL ENGINEERING MATERIAL ACQUISITION SYSTEM

Basic Concepts

The underlying concepts for the techniques collected and unified under the name material requirements planning (MRP) have been known for many years, but they could not be exploited fully without the data-processing power of modern computers. Record-keeping time and costs were formerly prohibitive because MRP combines inventory control with production planning; the time required manually to modify production schedules, as unpredictable demands and delays occurred, was so long that adequate inventory adjustments could not be made fast enough to satisfy the material requirements of manufacturing.

Civil Engineering is not a manufacturing environment. MRP for manufacturing consists of a complex system which links the planned production schedule with the bill of materials needed to make the product and examines the manufacturing inventory to see which parts and raw materials have to be ordered. For CE, MRP will simply be a method in which the CEMAS will automatically order materials a forecasted number of days prior to the Required Delivery Date (RDD). Currently, for long lead time Work Orders (WOs), all materials for the WO are ordered several months in advance of the time they are actually needed. MRP systems are built around the variability of the logistics systems. After our initial MRP proposal to you, we have performed a CEMAS data analysis on all the bases that responded to the Engineering and Services Center's request for CEMAS data. The attached histogram illustrates the variability of an average AFB Material Control System. This chart answers the question, "How long does it take to get a requirement filled through our logistics system?"

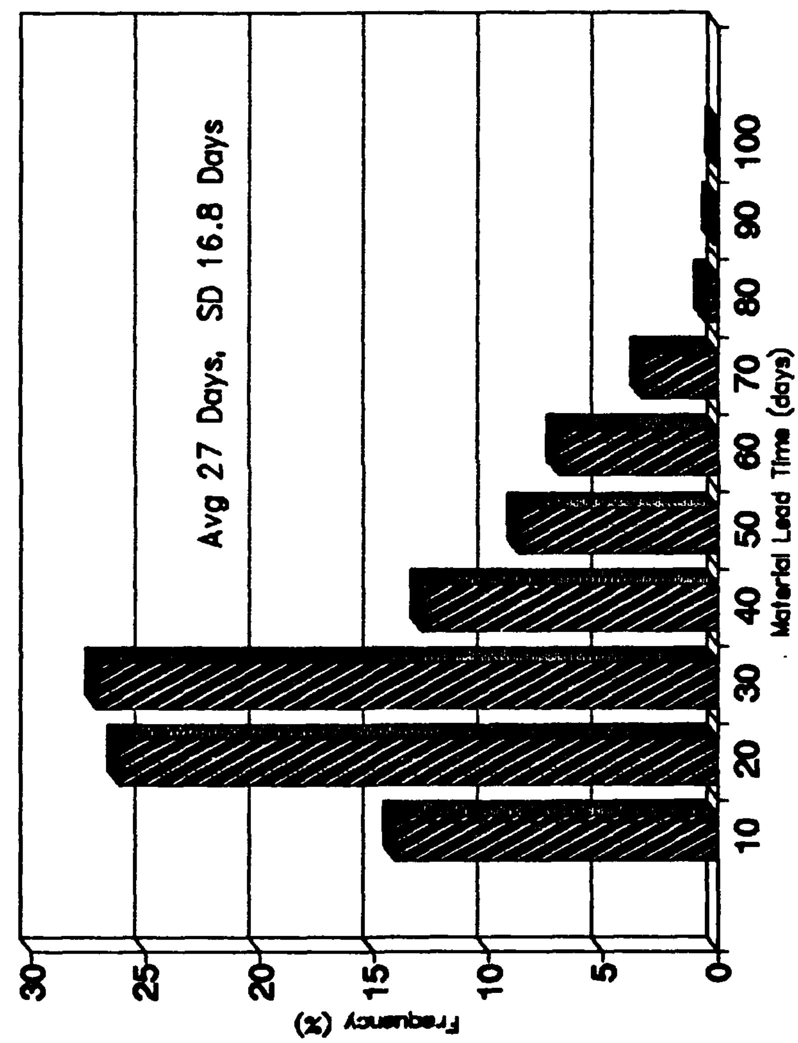

Figure 11. Histogram: "How Long to Get Materials"

The histogram was computed from the actual buying history of all the requirements completed during the first part of FY 90 for one of the bases in the analysis. ALL the bases analyzed have the same type distribution. For this base, the average time to get a requirement filled was 27 days with a standard deviation of 16.8 days. What this means is that most requirements are filled within 27 days while some requirements take as long as 27 days plus two standard deviations or 60 days. This base illustrates a normal buying distribution as compared to all the other bases tested.

Upon request, each expert may obtain the same chart for any one of your bases that submitted a CEMAS data base tape.

To design an MRP system for CE, we must solve the following problems:

(1) When should all materials for a WO be available prior to the ESD?

(2) How should the lead time be forecasted?

(3) How do we manage funds in a CE MRP environment?

Discussion Questions, Expert Responses, and Mediator Summations

Question #1.

How soon before the RDD should all items be received in the WO/JO storage area?

1st Iteration Responses.

Expert #1 - "1 Week."

Expert #2 -

> I believe that five working days is reasonable. As a matter of fact, our COCESS contracts are written so as to allow refusal of materials received by the contractor prior to five days before the RDD.

Expert #3 -

Assuming the RDD is equal to the desired job start date -then 30 days. On my routine job, 30 days gives sufficient time to schedule job. On priority jobs the time must be much less.

Expert #4 -

The RDD is the date assigned by Production Control that the material is required by. Work Orders are programmed (forecasted) to be scheduled for work 30-45 days after the RDD. When the BOM is material complete within several work days, Planners are to inventory to ensure the materials are what is needed (right items and quantities to do job). Job Orders are programmed as soon as possible after the RDD.

When materials are not received by the RDD, work requirements must be reforecast and reprogrammed for future accomplishment, after all materials are received.

Expert #5 - "Normally 30 days permits material verification by the planner/foreman and provides a pad-factor of materials complete jobs for the scheduler.

1st Mediator Summation. Initially, we did not remind everyone that AFR 85-2 states that the timeframe between the RDD to the Estimated Start Date (ESD) is approximately 45 days. There seems to be a consensus among the experts that 30 days will be a sufficient timeframe before the ESD to allow for material verification.

Therefore, will you agree, based on the opinion of the other experts, that 30 days will allow sufficient time for material verification between the RDD and the ESD? And also, the RDD will be the date that all materials will be required in the WO/JO storage area. If you do not agree, what adjustments would you recommend?

2nd Iteration Responses.

Expert #1 - "Agree."

Expert #2 -

> Disagree. My original comments were dictated by AFR 85-2 guidance, namely, the RDD should be 45 days prior to the ESD. The five workdays I referred to was for the RDD not the ESD.Another concern deals with bringing work orders and job orders together. They are like comparing apples and oranges.
> a) Work orders are individually scheduled - job orders are not normally scheduled; hours are reserved.
> b) Job order priority is often more critical than the work order priority e.g., emergency job orders.
> c) RDD's are often governed by terms of COCESS contract
> d) Even the same type of a job order may require a different RDD. For example, a routine job order might need a shorter lead time if the work is in an upcoming zone versus a recently completed zone.

Expert #3 - "Agree."

Expert #4 - "Agree!"

Expert #5 - "Agree."

Expert #6 - "Agree with the opinion of the other experts."

Final Mediator Summation. Five of six experts agree that 30 days will allow sufficient time between the RDD and the ESD for material verification. Due to the one descending opinion, a consensus does not exist.

Question #2.

Should we add to CEMAS a "Review Date" which is a date prior to the RDD that all items are to be received in the storage area? If not, what method would you recommend?

1st Iteration Responses.

Expert #1 -

> Use a review date: That date should be a time for verification that material is coming in on schedule.

It should also be a time when the planner and shop foreman, again, discuss the scope of the work. This review date could be a base variable to allow the base a chance to decide how much time is normally needed to work requirements with bad status.

Expert #2 -

Production Management is currently provided a listing of those material requirements where the Work/Job Order is incomplete, complete, and not on order yet. There are also other management tools, reports, and listings within CEMAS and WIMS that provide more than sufficient data necessary for technicians to perform their day to day operations.

Expert #3 - "May be a good idea. We did it automatically at base XYZ (Base names remain anonymous) by reviewing a special program built on the RDD."

Expert #4 -

A review date is not necessary. The RDD is the date contracting tries to get material by. They agree to a date with the vendor that material can be provided by which is called an ADD (Agreed Delivery Date). The RDD and ADD should agree in most cases. To follow up on items prior to the RDD is a waste of time. When the RDD expires and all material is not received by that date, a listing is provided daily of all items with expired RDD's. The listing is given to contracting each day to follow up on these items.

Expert #5 - "Not sure this is necessary since the system produces reports when all BOM items are available."

<u>1st Mediator Summation</u>. On our initial brainstorm of a method to implement MRP into CEMAS, we envisioned the Review Date as a time prior to the RDD in which CEMAS would automatically kick out a report concerning the status on items for a BOM. The date would be established by the Chief of Logistics and CEMAS would automatically kick out the report. No human interaction would be

necessary other than reviewing the report to ensure that all items have good status and that the items should be received by the RDD.

From above, three of the five experts believe that a "Review Date" will not be necessary. Based on the opinions of the experts and this further information, do you agree that a "Review Date" will not be necessary? If not, what would you recommend?

<u>2nd Iteration Responses</u>.

Expert #1 - "Agree - - Review Date is not necessary - - if we allow 30 days between RDD and ESD.

Expert #2 -

> Existing tools are available in WIMS and CEMAS to monitor status. There are insufficient personnel resources available now to perform all needed work. Don't build in another 19, auditor or other oversight activity item to write our people up unnecessarily. Bottom line - Sufficient management tools are currently available, if used, to provide status.

Expert #3 - "Agree"

Expert #4 -

> The review date is not necessary. <u>RDD</u> is the <u>key</u>. If material is not available by the RDD a list of all expired RDD's will print out at end of day. Follow up should be made on these items to contracting buyers, COCESS contractor, or SBSS. When the last item is received on a BOM, at EOD a list of all BOMs that became material complete for that day is printed out. A copy is sent to Production Control, also the BOM is tracked back to PCC after it becomes material complete.

Expert #5 - Agree, "review date" is unnecessary."

Expert #6 -

> Do not agree with a "Review Date". Production Control is provided a report when a BOM is complete. Logistics cannot schedule work for Production Control and should not even try without knowing the overall workload at the shops.

Final Mediator Summation. All experts agree that a Review Date is not necessary. Therefore, a review date will be used.

Question #3.

Should the timeframe between the "Review Date" and RDD be adjustable for high priority JO/WO's? If not, what method would you recommend to place emphasis on high priority JO/WO's?

1st Iteration Responses.

Expert #1 -

> Do not need to make the time frame adjustable -- but probably need to gear the review date to the agreed delivery date and not the RDD. Probably need to highlight ADDs when greater than RDD - -could use flashing screen method. We could also designate a field in WIMS Work Order/Job Order program to show commander interest - - then run reports on those with commanders' interest.

Expert #2 -

> The BOM workload package along with existing reports and listing already provides Production Management with quality information needed to make decisions on priority upgrades and requirements.

Expert #3 - "Yes. Your time on a priority JO would logically be zero."

Expert #4 -

> The RDD determines the requestor's priority. Emphasis on high priority JO/WO is now and should continue to be determined by the RDD assigned by Production Control. Logistics in turn assigns the priority E - 2 days or less, U - 3-5 days or R - 6 days to whatever. CE wants material on hand by the RDD. Contracting tries to get material in by the RDD. Can't see what good a "Review Date" will do.

Expert #5 -

> If used, yes. However, application would probably be limited to routine requirements. Emergency and urgent

requirements are normally scheduled as soon as materials become available. The method should be periodic computer-produced reports until all materials are received.

1st Mediator Summation. In our initial MRP method brainstorm, the adjustable timeframe between the RDD and "Review Date" was thought to be a method to place emphasis on high priority WO/JOs. Three of the five experts do not agree with the adjustable timeframe between the RDD and "Review Date". Expert #1 has suggested an automated method to place emphasis on high priority WO/JOs. This automated method will relieve manual searching of reports and listing.

Do you agree with Expert #1's suggestion. If not, what method would you recommend?

2nd Iteration Responses.

Expert #1 - "Agree"

Expert #2 -

Looks like your not reading the tea leaves. You're trying to force a decision to do something that the consensus says wasn't needed. My original reply to this question stands.

Expert #3 -

Agree. These are the jobs that get the BCE in most trouble. Working on the agreed delivery date will be beneficial to all concerned. This data should also be highlighted in reports as it will give a better idea of potential job start date.

Expert #4 -

In COCESS the ADD is agreed to by Logistics QAE and contractor. In GOCESS the ADD is assigned by Contracting Buyers. The BCAS priority system does not equate to CEMAS, i.e. in CEMAS a routine is anything over 5 days. In BCAS a routine allows for 15 days to buy the item and 30 days to get it in. The RDD is the date CE requires the material by. I feel the review process we presently have, if the management reports/listings are being used properly, is sufficient.

Expert #5 -

Do not agree. The RDD is the method used to identify (i.e. emphasize) priority work requirements. Logistics responds accordingly by comparing it (RDD) to the current date. Then they code the requirement appropriately (E.g., E, U, or R) when the BOM is firmed.

Expert #6 - "Agree with Expert #1's recommendation."

Final Mediator Summation

Expert #1 suggested an automated method to place emphasis on high priority WO/JOs. Three of the six experts agree with the automated method. A consensus does not exist.

Question #4.

When should the items contained in the CEMAS store be transferred to WO/JO storage? If we transferred the CEMAS store items on the review date, would that be soon enough?

1st Iteration Responses.

Expert #1 - "On the Review Date"

Expert #2 -

Items should be transferred when Production Management places a required date on the material. Whether the transfer of material is made now or at a later date is inconsequential. If I need the material for a higher priority I simply transfer it to my highest requirement and order against my lowest if no property is available. By transferring it right away I am allowing myself sufficient amount of time to get restocked for future requirements.

Expert #3 -

Store items can even wait or be pulled when a job is scheduled. This would preclude double handling. Problem is inventory must be high enough to cover the requirement. Possibly a file in CEMAS to list what unpulled requirements are for store items that will add to demand and adjust reorder level to keep enough on hand. At Base XYZ (Base name anonymous), we used a method of bulky high use items of keeping store inventories high and not pulling until scheduled - saved manpower and warehouse space.

Expert #4 -

All material for WO's should be on hand in WO/JO storage 20 - 30 days prior to scheduling the WO/JO (By RDD). This allows planners/shops to check items to ensure they have the right item in the right quantities. If additional items or quantities are needed, which happens frequently, when the shop reviews the items, this gives them the 20-30 days to order the material.

Expert #5 -

In my opinion, CEMAS store items should be transferred when BOM is firmed. These aren't normally high cost items and it's poor economics to obtain major items and delay the job for lack of a common inexpensive item. (e.g., At one time, we delayed pulling bench stock until after other items were available. CE credibility is destroyed when the Wing Commander waits 6 months for materials to support his project and then must be told project is further delayed by lack of a common bench stock item).

<u>1st Mediator Summation</u>. Basically, three of five experts agree that the items contained in the CEMAS store can be transferred on or about the RDD. Two experts are concerned that the items may not be available in the CEMAS store when needed for the BOM. Perhaps the following compromise will be acceptable to all experts:

For all the items on the BOM that are contained in the CEMAS store, we will program CEMAS to reorder these items for the store a forecasted number of days prior to the RDD. The "forecasted number of days" will be calculated from the method that we agree on in question 8 below. The items contained in the store for the BOM will be transferred on the RDD.

Do you agree with this method? If not, what modifications would you recommend?

2nd Iteration Responses.

Expert #1 - "Agree"

Expert #2 - "Agree with transferring on the RDD if we all agree that RDD is 45 days prior to work start"

Expert #3 - "Agree"

Expert #4 - "Agree - Also see comments atch on four classifications of materials where I am basically saying the same thing"

Expert #5 -

> Agree with immediate transfer of material from store to BOM. The reorder procedure is not feasible in a "real world" environment. Because of fund shortages, few XXX bases (command name remains anonymous) are able to fully fund store requirements. Some have been forced to by-pass the reorder program completely (i.e., zero funds for store stock replenishment) and use line item requisitions for individual item replenishment.

Expert #6 - "Agree"

Final Mediator Summation. Five of six experts agree that the CEMAS store items can be transferred on the RDD. Expert #5 disagrees with this solution. Therefore, a consensus does not exist.

Question #5.

Usually, the items contained in the CEMAS store can be procured locally. Do we need to reorder the CEMAS store items for the JO/WO prior to the review date or can we just let the CEMAS reorder program do that after the items are pulled for the WO/JO?

1st Iteration Responses.

Expert #1 - "Let the CEMAS reorder program handle the store."

Expert #2 - "Don't re-invent the wheel for the sake of invention. Fix the one that's broken first."

Expert #3 -

> Depends on store level. What if the level won't support the WO/JO level. Must be some method to order for the store to fill WO/JO future needs. Ideally why pull and rewarehouse an item?

Expert #4 - "No review date is necessary when prior to RDD as previously stated."

Expert #5 -

> No action is required. System currently works fine. The system will order if BOM requirements equal more than half the on-hand quantity. Then the reorder program replenishes stock.

1st Mediator Summation. Four of five experts agree that the store reorder program may replenish the store. The main concern is if the store can not handle the BOM requirements on the RDD. Therefore, the compromise as proposed in question 4 may satisfy this concern. The compromise is restated as follows:

> For all the items on the BOM that are contained in the CEMAS store, we will program CEMAS to reorder these items for the store a forecasted number of days prior to the RDD. The "forecasted number of days" will be calculated from the method that we agree on in question 8 below. The items contained in the store for the BOM will be transferred on the RDD.

Do you agree with this method? If not, what modifications would you recommend?

2nd Iteration Responses.

Expert #1 - "Agree"

Expert #2 - "Seems like our consensus was that the CEMAS reorder program was adequate as is - "

Expert #3 - "Agree with the revision"

Expert #4 - "See comments atch!"

Expert #5 -

> Do not agree. Micro-managing funds is flusterating (sic) enough without having to override another computer program. Materials should be transferred at the time BOM is firmed if quantity can supported. They are still available to support higher priority work any time before the BOM is issued.

Expert #6 - "Agree"

Final Mediator Summation. Five of the six experts agree with the compromise to program CEMAS to reorder material for the store a forecasted number of days prior to the RDD. Expert #5 disagrees with the compromise entirely. Therefore, a consensus does not exist.

Question #6.

What if we receive status that indicates that some of the items with no buying history cannot be received by the RDD. Should the Chief of Logistics advise the Chief of Production Control and request a change to the RDD? If not, what procedure would you recommend to solve this problem?

1st Iteration Responses.

Expert #1 - "T'.is is where the ADD Agreed Delivery Date comes in. I think we should update the RDD to the ADD."

Expert #2 -

> The status of a Work/Job order is available upon demand. If the RDD cannot be met Logistics should

make every effort to improve it, if not, then notify Production Management.

Expert #3 -

Why adjust RDD. That should never change. If you are saying an RDD can change because something can not be delivered, then the RDD was erroneous in the first place. I'd suggest another field reflecting an adjusted date - adjusted delivery date (ADD).

Expert #4 -

The Chief of Logistics should notify PCC who may elect to increase the requisition priority depending on the work priority. For example, paying premium shipping rates could get the material by the RDD. PCC may elect to change the RDD to agree with the ADD or leave the RDD as it is. The requisition priority is determined by PCC."

Expert #5 -

If the initial RDD isn't supported, follow-on estimates are seldom reliable. Dates provided by SBSS are normally unreliable. SBSS and vendors don't purposely mislead us. They have problems obtaining good data. As mentioned earlier, we are buying commercial items and when vendors, suppliers, and manufacturers misread the market, we must wait for the pipeline to be refilled.

1st Mediator Summation. In our initial brainstorm, our purpose in this question was to develop a method, in our MRP system, to deal with an item that simply cannot be received by the RDD. For instance, an air handler unit or other non-typical unit that must be manufactured. Expert #1 suggests changing the RDD to the ADD of the longest lead time item. In our MRP system, all the other items on the BOM will be ordered those forecasted number of days prior to the adjusted RDD. This will prevent us from having to warehouse those routine items from the original RDD to the time that the item with the longest lead time is received. We will program CEMAS such that a "single" change to the RDD of the WO will automatically adjust the ordering times of all BOM items. No human intervention will be necessary and the requests for all BOM items will be automatically sent to base contracting to be ordered.

Do you agree that Expert #1's solution to this problem is acceptable? If not, what method would you recommend to deal with this problem?

<u>2nd Iteration Responses</u>.

Expert #1 - "Agree - - Although you wouldn't have to adjust the RDD. You could just adjust the date the system's going to order - - based on the longest lead time."

Expert #2 -

> The question was , "Should the Chief of Logistics advise the Chief of Production Control and request a change to the RDD?" Answer to question is yes, Logistics should advise Production Control. If expert #1 is saying the ADD is the date Production Control agrees to, then I concur with expert #1.

Expert #3 -

> Agree - The only factor that then can not be solved is the item that does not get delivered by the agreed delivery date. Unfortunately, this happens more than we would like.
>
> There is one other point. A check that should probably be put in is a listing to kick out when a agreed delivery date is not against a requisition. Such a list needs to be generated x number of days prior to the RDD to review items to ensure proper requisitioning is underway.

Expert #4 - "Agree with 2, 3, 4, and 5 above. The RDD should never be changed to the ADD unless PCC agrees to it. Again, see comments atch."

Expert #5 -

> Do not agree. Automatic adjustment of all RDDs related to the BOM is not an acceptable solution. In most cases, related items will already be ordered before you before you learn the long-lead-time isn't available. Furthermore, the purposed feature would prohibit accomplishment of job phases unaffected by the delayed item.

Expert #6 -

> Do not agree with Expert #1. Don't change the RDD, this record is used to collect data such as how the source's are meeting the RDD's for BCE. The ADD can be used for sitting the review day if it is used, which I don't think is necessary.

Final Mediator Summation. Two experts do not agree with purposed solution. Therefore, a consensus does not exist.

Question #7.

If the RDD is changed by the Chief of Production Control, should the "Review Date" be changed as well?

1st Iteration Responses.

Expert #1 - "Yes, as well as the movement date for the store items."

Expert #2 -

> No, however, if we have a Agreed Delivery Date (ADD) with a local contractor or the COCESS operation we are required by Federal Acquisition Regulations to honor it. Whether they agree to change or not to change it is matter of courtesy.

Expert #3 - "Change review date to go along with ADD column."

Expert #4 - "Again, can't see what review date will accomplish."

Expert #5 - "No. (See comment 5c)" Comment 5c:

1st Mediator Summation. Please reconsider this question based on the information from questions two and three.

2nd Iteration Responses.

Expert #1 - "Based on question 2 - RDD will be review date and far enough out to allow work on problem items."

Expert #2 - "Consensus was that we don't need a review date"

Expert #3 - "Adjust the review data to the agreed delivery date as suggested in question #3."

Expert #4 - "No review date necessary!"

Expert #5 - "No longer a factor if the review data is omitted per question #2"

Expert #6 - "Do not agree. We do not need a "Review Date" therefore no change to agree with any other date."

Final Mediator Summation. The issue of the review date is no longer relevant.

Question #8.

For the items with a buying history, how can we predict how long it will take to receive the item? Will a simple average be sufficient? Or, how about an average plus two standard deviations? A standard deviation is a measure of the variability of a process. For instance, normally an item may be received in 20 days. A variance analysis of the history indicates a standard deviation of 10 days. The average plus two standard deviation is equal to 40 days. This means that on the average the item is received in 20 days but sometimes it takes as long as 40 days to receive the item.

1st Iteration Responses.

Expert #1 -

In most cases a simple average would be adequate. For instance, if normally can get the item in a short time, (under 20 days) then when we take extra effort to get the item we ought to be able to do it faster. However for long lead time items with a wide variation, we may need to look at incorporating variability. I would state that if the standard deviation is under 5 days use the average, if over 5 days use the average plus one standard deviation.

Expert #2 -

The receipt of an item for store replacement is normally within 48 hours. If it is for backordered requirement then it should be whatever the RDD is.

Expert #3 -

I'd say go with the buying history date. Have found that unless contracting goes to a completely different vendor for an item the date doesn't change that much. What causes a change to occur is dumping a big workload on contracting when funds are available and the buyers can not get to items. With routine items (often CEMAS store or items with the buying history) they get pushed down the list and delivery times grow. Object - keep the flow of work to contracting constant - even during periods of low funding. Don't dump on them when there is money, then not send anything for days on end.

Expert #4 - "Using an average plus two standard deviations seems to be more practical."

Expert #5 - "Verify a standard deviation of 10 days if the mean is 20 days. This would indicate erratic distribution and limit the use of the mean as a planning factor."

1st Mediator Summation. Expert #4 stated that the average plus two standard deviations seems practical. Examine the histogram chart from the average base provided at the beginning of this proposal. Based on this information, consider the follow solution:

> In our MRP system, we will program CEMAS to base its ordering lead time for each BOM item on the item's lead time history. The program will compute a mean and standard deviation calculation for each item. The program will then automatically order those items the mean plus two standard deviations prior to the RDD. For the average base, whose data we used to produce the histogram chart at the beginning of this proposal, CEMAS would automatically order most BOM items 60 days prior to the RDD. For bases which have lethargic base contracting offices or local vendors located several miles away, the CEMAS will automatically compute longer lead times. Items with no buying history will be ordered when the BOM is firmed.

Do you agree with this solution? If not, what method would you recommend?

2nd Iteration Responses.

Expert #1 - "I agree, but I think by ordering an item 60 days in advance when it normally comes in 16 is getting away from MRP."

Expert #2 -

> Do not agree. Piecemeal ordering of material for different jobs will result in numerous partially filled work/job orders when funds become short and a hold is put on ordering the balance of the materials based on your MRP. I still disagree with the concept but the only way to disapprove its value is to test.

Expert #3 - "Agree"

Expert #4 -

> Recommend you talk to Mr Arnold (See atch) on this. I feel breaking items into the four categories (See atch) using order and ship historical data would be the best method.

Expert #5 -

> Do not agree. The erratic distribution and validity of the mean as a planning factor has not been addressed. Neither is the basic cause (i.e., poor programming and management of the workload) being considered. Our concern is that the underlying cause has been misidentified.

Expert #6 - "Agree"

Final Mediator Summation. Experts #2 and #5 disagree with the purposed solution. Expert #2 disagrees with MRP concepts in general. In the general comments, Expert #4 provided an alternative method of lead time ordering. A consensus does not exist.

Question #9.

Previously, we committed funds for a given BOM all at once. Could we just leave the funds in memo-committed status until the items are ordered? This way, we could have the flexibility to recommit those funds to higher priority JO/WO's.

1st Iteration Responses.

Expert #1 -

> That is the way it works now! We don't commit the funds until ordered. Once funds are committed - - if we cancel, we don't automatically get the funds back. This would give us the option of cancelling later because funds wouldn't be committed."

Expert #2 - "This option exits now. Production Management is responsible for the assignment of RDD's based upon known workload."

Expert #3 - "Good idea but what is going to keep track of the jobs $ that have been pulled from, then what will that do for the RDD on the jobs material has been ordered?"

Expert #5 - "Funds must remain in memo-committed status. A partially funded BOM serves no useful purpose."

<u>1st Mediator Summation.</u> The purpose of this question is to determine how to manage funds in a CE MRP system. For a WO with an ESD several months down the road, we need not commit those funds now and warehouse the majority of the materials until the ESD. However, Material Control must order some items with long lead times immediately. For instance, the air handler unit which must be manufactured. The question is rephrased as follows:

Which method would you recommend to deal with funds in a CE MRP environment?

A. Leave funds for a BOM in memo-committed status. When funds are needed to order those items on the BOM (a forecasted number of days prior to the RDD), the CEMAS will use the funds which have been earmarked for that BOM.

B. Do not memo-commit funds for any WO when the BOM is firmed. The BOM will be sent to Material Control. All items on the BOM will be ordered at different times prior to the RDD. When an item is at X lead time days prior to the RDD (as calculated from our forecasting program), the CEMAS will automatically pull funds from the central CE fund. If funds are not available, CEMAS will signal both the Chiefs of Production and Logistics that funds are not available for WO WXYZ.

Do you agree with option A or B? If not, what method would you recommend to deal with funds in a CE MRP environment?

<u>2nd Iteration Responses</u>.

Expert #1 - "Option A"

Expert #2 - "Same concern as on previous question. However, only a test will prove/disapprove my concern"

Expert #3 -

Yes, commit the funds when BOM goes to Logistics. In these days of short dollars, I can see a portion of a BOM being ordered then no money being available to order the rest. You would then defeat the purpose of this effort to reduce warehouse inventories.

Expert #4 -

Option A. However during critical funding times or EOY you should have the option to print a list of what is to automatically order for the next day and be able to override the automatic requisition action. Especially necessary 7 - 14 days prior to EOY cutoff.

Expert #5 -

Question #9: If choices are limited to options A and B, then A is our selection. However, tampering with the current methodology will create more problems than it solves. Now funds remain in "memo-committed" or "committed" status for only a short period of time and any difference between estimated and actual costs are resolved quickly. Options provided either fail to commit or commit for long periods of time. Consider the disruptive influence when additional funds are required to cover the award and none are available."

Expert #6 -

Do not agree with A or B. Logistics, should not be involved with controlling funds. When the WO/JO is firmed and forwarded to Logistics they should order the materials as they do today. Leave the funds control as it is today.

Final Mediator Final Summation. A consensus does not exist regarding how to deal with funds in a CE MRP environment.

1st Iteration General Comments.

Expert #2 -

a. Scope of Material Holding Costs: The assumption that $7.7 million dollars might be saved from an inventory is unrealistic. Property in the holding area is for funded known requirements that have been logically prioritized base upon each base's work load and purchased for known requirements. Management has made a decision prior to ordering materials that funds are available, the work has been programmed, a customer commitment has been made, and the work needs to be accomplished.
b. Just in time material ordering is impractical at overseas locations using the SBSS as source of supply. Long pipelines and routine missed delivery dates are not uncommon given the FAD and UJC normally assigned to civil engineering routine work. Attempting to use MRP should result in as large or larger holding accounts of partially completed work/job order bills of material.
c. There is also some question as to the value of MRP in a GOCESS environment. Purchases for the GOCESS are made based on consumption of specific items. Delaying purchases for MRP could result in lost volume purchase discounts and end up costing more in the long run. Since CEMAS also provides the research capability for like items and allows management to use these asset if needed, we wonder what really is gained with MRP.
d. Finally, materials on completed work/job orders in the holding area provide civil engineering with the needed flexibility in programming/scheduling work. It allows site work force to remain productive when delays are encountered that include weather, site access, craft availability and equipment requirements.

Despite the above concerns, I believe it is reasonable to conduct a test of this concept."

Expert #4 -

The key to this whole process is PCC programming and scheduling more realistically rather than hap hazzard (sic). Depending on the work priority of a BOM and volume of work already scheduled, the RDD they assign should be realistic and should allow for the type of materials being requested.

Property shouldn't be ordered now that is used 3 months to a year after the BOM is material complete. This happens frequently.

Most CE materials are purchased Local Purchase - approximately 90-93 % under a GOCESS. Most materials are available within a 200 mile radius. The problem that comes up with contracting is that base BCO's interpretation of the FAR. Some bases buy from big business, others absolutely refuse to. Therefore, some bases can get materials a lot faster than others."

Expert #5 -

1. a. Verify 33 percent cost-to-hold.

(1) Cost is related to type, size, and perishability of materials.

(2) IE magazine article a few years ago determined 20 percent or less per year.

b. We agree on the problem, but disagree on cause. We believe the primary cause of the condition described is improper management and programming (e.g., work is approved and placed in the system without consideration of available resources. Also, materials are received but more recently identified work is scheduled). Bases with larger volumes of holding area material routinely have bills-of-material (BOM) that have been complete and ready for scheduling for extended periods of time.

2. Current Method. Funds are memo-committed in CEMAS when Production Control assigns the RDD. This feature was purposely incorporated into CEMAS to preclude passing of requirements when funds are not available.

3. MRP. Time-phased procurement can be applied to an assembly line operation (i.e., like items obtained from the same vendors on a recurring basis). The same concept applied to non-recurring demands is questionable. The cost-to-hold access materials is far less than the cost of an idle work force. Another factor is limited manpower. At most of our bases, buyers and logistics personnel have been reduced to point that additional transactions associated with time-phased procurement can't be supported.

4. Proposed Method of Implementation.

a. Lead time history is affected by extraneous factors (i.e., CE requirements are largely commercial items and surge requirements in the local area impact availability).

2nd Iteration General Comments.

Expert #4 provided the following general comment in regards to Expert #2's comment concerning the impracticality of Just-in-Time material ordering at overseas locations using the SBSS as source of supply:

> Could be a big problem for overseas bases with long lead time and using Base Supply for majority of support. However, the time to get materials would be increased for overseas bases.

Expert #4 provided the following ideas:

Something to Think About

> CE materials can be classified into four basic categories. The time in advance to order this material can be broken down as indicated. Although store stock in most cases should be immediately available and common items available within five days after the order is placed, sufficient time should be allowed for zero balances in store stock, insufficient funds to order material, backlog, order and ship time, etc.
>
> A. Store Stock Items - Order 14 days prior to RDD.
>
> B. Common Items (not store stock) - Order 30 days prior
>
> C. Specialty Items - Order 90 days prior
>
> D. Hard to get item (Misc) Order at least 120 days (Includes New Items, Never ordered)
>
> Depending on the category an item falls into and the order and ship time to obtain the item, CEMAS could be programmed to order each item individually to meet the RDD.

Expert #5 -

> Does the histogram include all items received since the first of the year? Normally, the lead time for some items exceeds 100 days. The average lead time in MAC for the period 1 Jan through 30 May 90 was 40 days for job order and 71 days for work orders. Individual bases reported average lead time of well over 100 days.

Bibliography

1. Air Force Audit Agency. Management of Civil Engineering Materials. Report of Audit; Project 9175211. Norton AFB CA: Directorate of Financial and Support Audits, August 1989.

2. Air Force Institute of Technology. Logistics Management for Civil Engineering. Mgt-435 Course Book. School of Civil Engineering and Services.

3. Bowersox, Donald J. and others. Logistics Management. New York: Macmillan Publishing Company, 1986.

4. Dalkey, Norman C. The Delphi Method: An Experimental Study of Group Opinion, June 1969. Contract No. F44620-67-C-0045. Santa Monica CA: Rand Corporation (AD-690 498).

5. Dean, 1Lt Willie P. Cost Effectiveness An analysis of the Proposed Civil Engineering Materials Acquisition System (CEMAS). MS thesis, AFIT/GEM/LSSR 73-83. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1983 (AD-A134995).

6. Department of the Air Force. Civil Engineering Combat Support Doctrine. AFM 2-XY. Washington: HQ USAF, 8 August 1989.

7. -----. Civil Engineering General: OPERATIONS MANAGEMENT. AFR 85-2. Washington: HQ USAF, 7 October 1988.

8. -----. Civil Engineering Supply Support Procedures. AFM 67-1, Volume II, Part Two. Washington: HQ USAF, 1 October 1989.

9. -----. Establishing, Accounting, and Reporting Real Property. AFR 87-5, Attachment 1. Washington:HQ USAF, 15 March 1985.

10. -----. Real Property Building Manager Responsibilities. WPAFB Regulation 91-1. HQ Wright Patterson AFB OH, 30 May 1989.

11. Department of Defense. Federal Acquisition Regulation. General Services Administration, National Aeronautics and Space Administration, 1 June 1987.

12. Devore, Jay L. Probability and Statistics for Engineering and the Sciences. California: Brooks/Cole Publishing Company, 1987.

13. General Accounting Office. Military Contractor-Operated Stores' Contracts Are Unmanageable and Vulnerable to Abuse. Report Series MASAD-81-27, 8 July 1981.

14. Hines, CMSgt Curt, Chief Integrated Logistics Manager. Telephone interview. HQ AF Engineering and Services Center, Tyndall AFB FL, 24 July 1990.

15. Holt, Lt Col James R., Director, Engineering Management Program. Personal interview. Department of Logistics Management, Air Force Institute of Technology, Wright Patterson AFB OH, 10 August 1990.

16. Kachigan, Sam Koch. Statistical Analysis. New York: Radius Press, 1986.

17. Martin, Maj William, Chief of Integrated Logistics. Telephone interview. HQ AF Engineering and Services Center, Tyndall AFB FL, 30 November 1989.

18. Riggs, James L. Production Systems: Planning, Analysis, and Control. New York: John Wiley and Sons, 1987.

19. Rose, W. M., "Base Contracting: It's Definitely Not Vanilla!", Contract Management, 27: 12-15 (December 1987).

20. Sachs, Lothar. Applied Statistics. New York: Springer-Verlay, 1982.

21. Walters, David. "The Cost of a Stock-Out," International Journal of Physical Distribution, 5:39 (1974/1975).

22. Wentz, Walter B. Marketing Research. New York: Harper & Row, 1979.

23. Wilson, Ed E., Deputy Director, Operations and Maintenance. Bankcard Procedures. Report to all Air Force commands. HQ AFESC/DEMG, Tyndall AFB FL, 9 February 1989.

Vita

Captain Robin Davis was born on 7 May 1955 in Gadsden AL. He graduated from Emma Sansom High School in 1974. In 1975 he entered the Air Force as a heavy equipment mechanic and was stationed at Langley AFB VA and Taegu AB Korea. In 1977, he returned from Korea to attend Gadsden State Junior College and Auburn University. He graduated with a Bachelor of Science in Mechanical Engineering in May 1983. After graduation, he attended the Air Force Officer Training School. After graduation from Officer Training School, he served his first tour of duty at Barksdale AFB LA as a Mechanical Design Engineer, Programmer, and Readiness Officer. In 1986, he was transferred to Eielson AFB AK where he served as the Chief of the Work Information Management System and the Chief of Logistics. At Eielson AFB, he was responsible for the installation and operation of the Work Information Management System and the Civil Engineering Material Acquisition System. In May 1989 he entered the School of Systems and Logistics, Air Force Institute of Technology.

Permanent Address: Captain Robin Davis
610 Noccalula Dr
Gadsden AL 35901

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
September 1990

3. REPORT TYPE AND DATES COVERED
Masters Thesis

4. TITLE AND SUBTITLE
AN ANALYSIS OF THE AIR FORCE GOVERNMENT OPERATED CIVIL ENGINEERING SUPPLY STORE LOGISTIC SYSTEM: HOW CAN IT BE IMPROVED?

5. FUNDING NUMBERS

6. AUTHOR(S)
Robin Davis, Captain, USAF

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Air Force Institute of Technology, WPAFB OH 45433-6583

8. PERFORMING ORGANIZATION REPORT NUMBER
AFIT/GEM/LSM/90S-6

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

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

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

This thesis researched ways to improve the timeliness and consistency of CE logistics and methods to reduce inventory holding costs. The study focused on the Base Contracting local purchase channels used by the Government Operated Civil Engineering Supply Store (GOCESS) logistics systems throughout the Air Force. The results indicate that the average response time for GOCESS systems is 18.6 days with a standard deviation of 14.6 days. The high standard deviation in relation to the average response time indicates local purchase channels are difficult to control. The overall logistics efficiency was 4.2%. This indicates that materials ordered through Base Contracting are not received by the date required 95.8% of the time.

Annual warehousing holding costs to CE are approximately $15.5 million. Material Requirements Planning (MRP) is a method that may reduce those warehousing costs. The emphasis of MRP is to minimize inventory by arranging for the delivery of the exact amounts of materials from vendors as required in manufacturing. An expert panel was formed with experts from each major command to derive a method to implement MRP into CE logistics. No consensus was achieved. However, the process introduced MRP to the logistics experts in each major command.

14. SUBJECT TERMS
Logistics, Logistics Management, Logistics Planning, Logistics Support. (KR)

15. NUMBER OF PAGES
125

16. PRICE CODE

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