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A Method for FMS Countries to Maximize CLSSA Service Levels while Minimizing Costs through Optimal Requisitioning Patterns

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THESIS

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Robert A. Wasik

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Abstract

The Cooperative Logistics Supply Support Arrangement (CLSSA) is a program designed to provide follow-on supply support for weapon systems procured by foreign military sales (FMS) countries from the United States. CLSSA calculates a Stock Level Quantity (SLQ) for each item based on demand history, item lead-time, and requisitioning patterns. Item SLQs affects program cost and service levels to FMS customers; a high SLQ level improves service levels, but also creates higher costs. The author created a model to replicate the CLSSA formulation used to calculate SLQs, using different combinations of demand levels and item lead-times to determine the impact that different ordering patterns have on SLQ levels. The results provide optimal ordering patterns for the various combinations used in this study to ensure maximum service levels while minimizing customer program costs. Although each different combination of demand level and lead-time produced a specific optimal ordering frequency, in general, items with lead-times of 24 months or greater, 12 months, and 7 months or less, had optimal requisitioning frequencies of annually, semiannually, and quarterly respectively. The complete results can be used by FMS countries to tailor their CLSSA requisitioning strategy to meet their needs of service levels and cost.

A METHOD FOR FMS COUNTRIES TO MAXIMIZE

CLSSA SERVICE LEVELS WHILE MINIMIZING COSTS

THROUGH OPTIMAL REQUISITIONING PATTERNS

I. Introduction

General Issue

National defense is a singularly important goal of the United States (US), and security assistance programs are one means of attaining this goal (7:5). Foreign Military Sales (FMS) are one of the chief security assistance programs the US uses to promote global stability, through the sale of US equipment and technology to allied and other friendly countries. FMS is authorized by the *Foreign Assistance Act of 1961* and the *Arms Export Control Act of 1976* (8:5).

An added benefit of FMS is that with the reduction of US military force strength, the additional FMS customers purchasing military systems through the US allow the Department of Defense (DOD) to increase the size of contract purchases, and because of the additional economies of scale, reduce the overall price of DOD procured systems. For example, it was estimated that over $342 million were saved on the DOD purchase of the Hellfire and Advanced Medium Range Air-to-Air Missiles, Black Hawk Helicopter, High Mobility Multipurpose Wheeled Vehicle, and the Aegis Weapon System because the additional FMS sales reduced the per unit cost of each item (17:2).

The Air Force Security Assistance Center (AFSAC) is the lead organization for the Air Force (AF) to manage all FMS sales, both in the initial sales as well as the follow-on logistical support to those sales. The Cooperative Logistics Supply Support Arrangement (CLSSA) program is managed by AFSAC, and is designed to provide FMS customers with follow-on logistics support to previously procured items, or as part of a new procurement. Each of the services has an established CLSSA program, although since the management details can vary among them, this research primarily will examine the USAF CLSSA program. Figure 1 presents the percentage of FMS requisitions in relationship with the rest of the USAF, to provide a perspective of the magnitude of the total FMS sales.

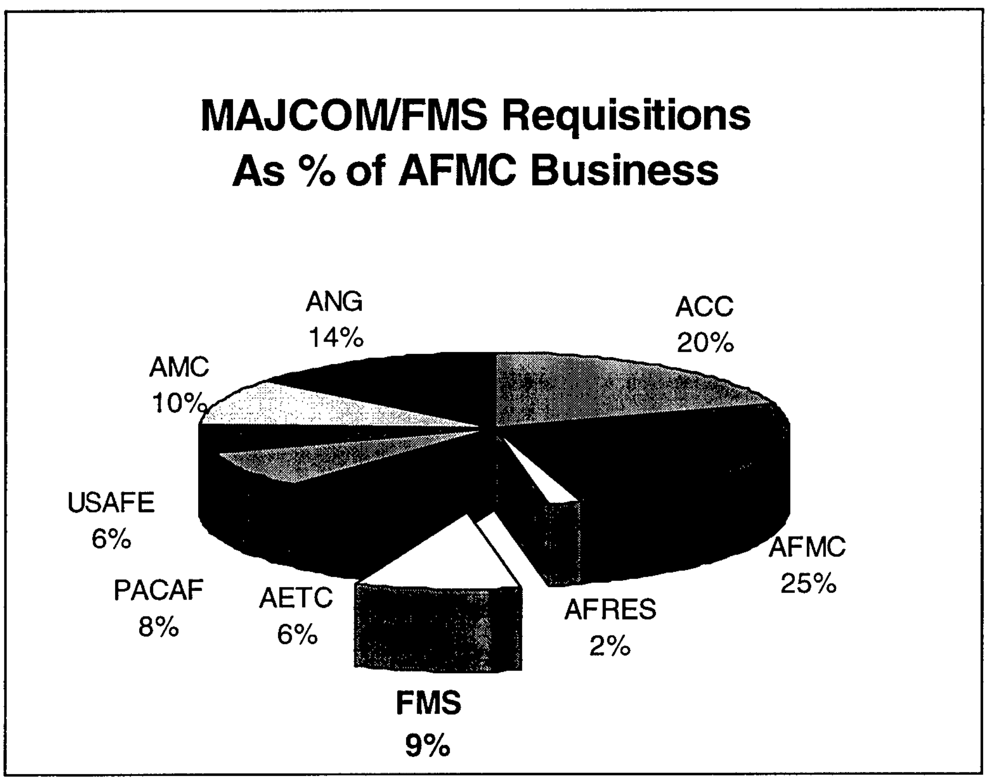


Figure 1. FMS Requisitions (4:19)

Through a CLSSA, the FMS country becomes a partner in the USAF and Defense Logistics Agency (DLA) supply systems, and benefits from established processes and procedures in the DOD, precluding the need for the FMS country to establish an entire supply chain infrastructure (7:34). For example in 1999, Taiwan established a $150 million CLSSA for follow-on supplies, supporting their F-5E/F, C-130H, and F-16A/B upgrades to these systems (11:1), rather than procure those supplies in other manners.

Although historically most FMS customers participate in CLSSA, it is not a mandatory program. The FMS country might choose to procure items directly from the manufacturer, institute an internal maintenance facility for repair and replace items, or engage USAF contractor support on an as-needed basis (16:1). While traditional practice has been for FMS customers to establish follow-on supply arrangements through the CLSSA program, with the ever increasing popularity of outsourcing logistics both in the military and civilian sectors, it becomes more critical then ever that the CLSSA remains an effective logistics system for FMS customers, to ensure their continued involvement. Even though on the surface AFSAC is acting as a third party logistics partner for FMS customers, other truly private third party logistics firms are on the rise throughout the world (14:83), which adds another competitor to AFSAC.

Two primary concerns of any inventory system are cost and performance, and CLSSA as an inventory system is not immune from these concerns. Tighter controls on cash flow for military spending is not limited to the United States. FMS countries also need to feel confident that monies spent through the CLSSA program are being efficiently spent. In addition, current FMS customer complaints about program inefficiencies, lack of comparative information, and the shrinking defense industry in the US all point to the need to evaluate FMS programs (23:1). Therefore, continued research in this area is not only justified, but also particularly warranted in these economic times—this research will focus on the CLSSA program, both from the perspective of cost and performance.

Background

The specific details of the processes and procedures required by FMS countries under the CLSSA program are discussed more thoroughly in Chapter II; however, an understanding of some of the basic principles are necessary in order to appreciate the problem questions of this thesis. When participating in CLSSA, the FMS customer in essence is treated like another AF base, where their requisitions are handled contingent on their supply requisition priority, the Force Activity Designator (FAD) code assigned to their country, and their Urgency of Need Designator (UND), all of which are stated in the Letter of Offer and Acceptance (LOA) (7:28). An agreement between an FMS country and the US is called a "case," which is a contractual agreement documented by the LOA, and provides a tracking and management tool for each sales offer (6:17-2).

In the CLSSA program, the two cases used are Foreign Military Sales Order I (FMSO I) and the Foreign Military Sales Order II (FMSO II), both of which are also known as "K" cases (7:34). CLSSA is part of the FMS supply chain for follow-on supply support, and supply chains in general can be considered as either a "push" or "pull" based system, where items in a push system are automatically (based on forecasts) entered into the supply chain, while items in a pull system are requisitioned based on actual customer demand (24:118). With this perspective in mind, FMSO I cases (as a push-type system) and FMSO II cases (as a pull-type system) will be further discussed.

The FMSO I case determines the requirements of the follow-on support for the FMS country, and gives the USAF and DLA the legal authority to procure and/or store the items listed within the FMSO I case (9:66). There are four methods for establishing FMSO I cases: initial, major add, manual adjustment, and recurring (6:2-3). An initial case is established for brand new CLSSA FMS customers without any demand history, and the USAF System Manager, working in conjunction with the customer, establishes the initial follow-on supply requirements. A major add is when a customer has a on-going FMSO I case; however, a new requirement that is significantly different from the current case is needed, and since there is no demand data for the items in the new case, procedures similar to originating an initial case are used for a major add. A manual adjustment case is made by the FMS customer when they identify to AFSAC specific needs for increased or decreased future demands, such as a major change in their training program significantly increasing their sortie rates for a particular system. Recurring demand is the final way to modify FMSO I cases, and will be the focus of this research.

The establishment of FMSO I cases for recurring demands is examined closely in this thesis, because while the first three methods forecast demand through other means (either by USAF System Manager for initial and major adds, or by the FMS country for manual adjustments), recurring demands establish an FMSO I case through an automated forecasting system (26:1). Prior to 1994, it was the responsibility of the FMS customers (similar to a manual adjustment) to provide AFSAC with forecasts of every item, which would then become recurring FMSO I cases; however, in 1994 an automated system was developed for recurring requirements.

Whereas the FMSO I case is how the *requirements* are established, the actual *requisition* of items by the FMS customer is made through the establishment of an FMSO II case. FMSO II cases are either programmed or nonprogrammed orders. Programmed cases are those requisitions where there is an established FMSO I case for that item, and in general, nonprogrammed cases are where there is no pre-established FMSO I case. Both programmed and nonprogrammed FMSO II cases are orders paid for by the FMS customer based on the cost of materiel shipped, a 3% administrative charge, and other applicable charges (6:6-4).

The key difference between programmed and nonprogrammed FMSO II cases is that requisitions which are programmed are authorized to be filled by on-hand or on-order stocks, similar to other USAF stock orders of similar priority. Nonprogrammed FMSO II requisitions are only filled from on-hand or on-order stock if there is excess inventory for the particular item; otherwise, the nonprogrammed requisition's timetable to be filled will be the lead-time away from the order. Lead-time includes both administrative and procurement lead-time (6:6-6). Hence, it is to the FMS customer's advantage to establish recurring requirements through an FMSO I case, since programmed FMSO II orders will normally provide quicker response times. In addition to the timesavings, items purchased from off-the-shelf can be less expensive, since by the end of the total lead-time (at which point the customer will finally pay for the item), the item price can be higher because of inflation or other factors.

Although FMS countries are treated similar to USAF bases, unlike USAF bases, when an FMS customer places a requirement on the DOD supply system, they are responsible for an initial payment of 5/17 of the value of the FMSO I case, and are held liable for the entire value of the case—whether they eventually place an FMSO II requisition or not. The purpose of the 5/17 up-front payment is to provide "seed money" for the initial purchases by the USAF or DLA for the items in the FMSO I case, which is paid to the actual firm making the items. CLSSA works like a revolving account, where at any given time approximately 5/17 of the case are on order, and by the time that order arrives an FMSO II case requisition actually purchases the items at their full price, and the 5/17 remains with the USAF to make the next order, and the cycle continues.

The reasoning behind this revolving account is that the entire FMSO I case requirement is not purchased it its entirety from the manufacture in one lump sum, since the actual usage pattern is not normally in such large quantities. Additionally, when the US government places an order with the firm producing the item, the government is required to have the funds available to pay for the order, and the 5/17 from the FMS country prevents the need for the US government to subsidize the FMS customer (16:1). This means that the larger the FMSO I case requirement, the higher up-front costs there are to the FMS customer, thus making the accuracy of the FMSO I forecast for recurring demands even more critical.

Another cost issue is the total FMSO I case value, which is above and beyond the 5/17 up front payment. Since FMS customers are financially responsible for the entire FMSO I case, capital that is tied up on items with zero demands cannot be used for high demand items. Therefore, high case value in relationship to actual requisition values, in conjunction with high number of FMSO I items with zero or few demands, is an indication of inaccurate forecasting techniques (26:1).

As stated previously, recurring demand is one of the ways to establish or change FMSO I cases. Basically, recurring demand occurs from the FMSO II requisitions and creates an FMSO I stock level quantity (SLQ) through a formulation described in detail in Chapter II; however, for the purpose of understanding the research objectives and questions, the key is that the SLQ is automatically created based on FMS customer requisitions. When a new CLSSA account is established for a particular item without any demand history from the FMS customer, information from the item manager is used to initially set an SLQ, which is then modified as the customer begins placing orders (26:1).

One important fact is that although FMSO II requisitions are considered programmed if there is an established FMSO I case, requisition quantities in FMSO II cases should be less than the SLQ (6:3-3) to ensure programmed versus nonprogrammed support. So for example, if the FMSO I case SLQ was 20 for a particular item and the FMSO II requisition was 34, then 20 items would be considered a programmed order, while the other 14 nonprogrammed. This ensures that FMS customers' FMSO II requisitions accurately reflect the FMSO I case requirements, and protects the USAF financially because of the 5/17 charge to the FMS country being applied based on the SLQ in the FMSO I case.

Research Objectives and Questions

A high customer service level at the lowest cost is one way of gauging the effectiveness of the CLSSA program. In general, programmed requisitions can be expected to generate higher customer service levels, since they are eligible to be filled directly from off the shelf stocks. With regards to the SLQ, the higher the SLQ the more likely FMSO II requisitions will be coded programmed. So an inventory policy that maximizes SLQs might seem optimal for FMS countries. However, since FMS customers are required to pay 5/17 of the FMSO I case up-front, higher SLQs equate to higher FMSO I cases, which mean higher cost to the FMS customer. With only CLSSA program cost in mind, minimizing SLQs would be optimal.

Unlike FMSO I cases which are "pushed" upon the FMS customer based in part, on a forecasting formulation, the FMSO II case requisitions are independent of any USAF interference. An FMS country can place an FMSO II requisition for basically any item at any time. If for example, a country requests 500 wing spars for an F-16, the USAF does not care (for the purposes of inventory management) whether that country has an established FMSO I case, or even if during the past quarter they just ordered 1000 similar wing spars. The frequency of FMSO II requisitions are strictly under the control of the FMS country, albeit with the advice of AFSAC personnel if they so choose. The first research objective is to determine how the FMSO II requisitioning policies of FMS customers directly impacts both the costs they incur (through the 5/17 charge), and the customer service levels they receive (through the orders being coded either programmed or nonprogrammed).

As stated previously, the CLSSA program allows FMS countries to participate at the same level as USAF bases with the same FAD code, for requisitions of equal priority. However, USAF bases have the advantage of automated requisitions through the Standard Base Supply System (SBSS), while each FMS country has the responsibility of establishing a requisitioning policy individually. So while FMS customers are considered "partners" in the DOD supply systems, they do not have access to the full resources of the DOD, such as SBSS for requisitioning based on usage. The second research objective is to create a heuristic or model for establishing an effective FMSO II requisitioning policy that FMS countries can use to maximize customer service levels and minimize cost, given the constraints of the CLSSA program.

Based on the previously described issues, specific investigative questions are provided to meet the research objectives. The following research questions are:

1. How are FMS customer service levels impacted by programmed versus nonprogrammed FMSO II requisitions, following the advent of the new CLSSA automation features implemented in 1994?

2. Given that customer service levels are impacted by whether FMSO II cases are coded programmed or nonprogrammed, how do the requisitioning policies of FMS countries affect SLQ levels, which in part determine whether FMSO II cases are in fact coded programmed or nonprogrammed?

3. How do the requisitioning policies of FMS countries affect overall CLSSA cost through the 5/17 charge of the SLQ level being paid for by the FMS country?

4. Based on the method CLSSA uses to compute SLQs, what requisitioning strategy, or tool, can be used by FMS countries to optimize the SLQ level, so that it is high enough to ensure programmed requisition support, yet no higher then it needs to be, so as to remain fiscally efficient.

Methodology Overview

The methods for answering the previously stated research questions will be to first compare the fill rates of programmed versus nonprogrammed requisitions since 1994 to determine the actual benefits to orders being coded programmed. Next the actual CLSSA FMSO I SLQ computation will be analyzed to determine the effect that different requisitioning strategies have on the SLQ, relating to both cost through the 5/17 charge, and performance through the coding of orders programmed or nonprogrammed. Finally, a model will be developed to maximize programmed orders while at the same time minimizing the 5/17 charge for a variety of item demand levels, item lead-times, and ordering patterns, since the SLQ computation is based on these three factors.

Assumptions

One of the basic assumptions is that improved fill rates and lower CLSSA charges are in fact an important goal to FMS countries, and that the time involved analyzing each of the individual items' requisitioning patterns is worth the time and effort to do so. Several assumptions are based on the methods the CLSSA SLQ model uses to calculate the SLQ levels, specifically that the item lead-time is assumed to be an accurate portrayal of the total time it takes to procure the item and process the requisition. Additionally it is assumed that this SLQ model, which has been used since 1994, will continue to be the method for determining SLQ levels for recurring demands. Since it is virtually impossible to model every possible combination of demand level, lead-time, and ordering pattern, certain categories of each will be used to provide a broad range of possibilities. Other assumptions will be explained within this document as they arise—assumptions that without the necessary context would be not understandable.

Limitations

The purpose of this study is to develop an optimal requisitioning policy with respect to the CLSSA SLQ computational formula to ensure the best fill rates while keeping the 5/17 charge as low as possible. Obviously FMS countries will have other criteria by which to evaluate an overall inventory policy, but this research is limited to the above stated goal. CLSSA is designed for peacetime operating stocks; therefore, this research is not designed for contingency or wartime logistics. Although fill rates can be affected on whether the requisition was coded programmed or nonprogrammed, USAF parts shortages, manufacturing delays, inaccurate procurement lead-times, and other factors can affect fill rates as well; this research is limited strictly to the reported differences between programmed and nonprogrammed requisitions only.

Organization

This research is organized into five chapters: Chapter I Introduction, Chapter II Literature Review, Chapter III Methodology, Chapter IV Analysis and Results, and Chapter V Conclusion and Recommendations. There are also three supplements: Appendix A – Fill Rates, Appendix B – SLQ Model Examples, and Appendix C – SLQ Model Analysis. Generally, Appendix A provides the complete tables, graphs, and data used in Chapter II, Appendix B for Chapter III, and Appendix C for Chapter IV.

The purpose of Chapter I was to provide the reader with the overall background of security assistance programs, FMS, and CLSSA in particular. Additionally, the basis for this research, the problem areas, details of the specific research objectives, and specific research questions have also been provided. A brief description of the methodology, limitations, and assumptions were also provided, all of which will be discussed in further detail in the subsequent chapters.

Chapter II Literature Review lays the groundwork for the rest of this research. First an examination of inventory management and forecasting are described, followed by an explanation of the relevant terms relating to CLSSA. Next, the CLSSA process will be described in detail, examining all of the nuances of the SLQ formulation. CLSSA service levels will then be investigated to determine the actual advantages and disadvantages to programmed and nonprogrammed requisitions for various types of supply items. Finally, previous research in the area of FMS and CLSSA will be expounded upon as a further foundation for this current research effort. Throughout this chapter are references as to the need and impact of FMS, as well as the relationships that exist between FMS countries and the DOD.

Chapter III Methodology provides the specific details on the data analysis techniques used for answering the research questions. It describes the methods used by AFSAC's CLSSA program to formulate the recurring FMSO I case requirements based on the FMS customer's FMSO II requisitions. The model that was created by the author to analyze different combinations of requisitioning patterns will be discussed, along with various model assumptions. Finally, the specific types and categories of data that will be used in the analysis will be examined.

Chapter IV Analysis and Results extracts information from the model, based on the criteria and parameters as described in Chapter III. Each of the main factors, demand, lead-time, and orders-per-period, are segregated as constants so the influence of the remaining factors can be more closely scrutinized. Finally, a summary of an ideal requisitioning policy based on the present CLSSA SLQ computation method, and with the two-pronged goal of high customer service and the low customer cost will be thoroughly discussed.

Chapter V Conclusion and Recommendations is the final chapter where a summary of the total research is effort is examined one last time. The original research questions are reviewed, and concise answers based on the results attained in Chapter IV are provided. Several recommendations are made for potential follow-on research to this thesis. This thesis will culminate in a few final closing thoughts.

II. Literature Review

Introduction

This chapter will provide a body of literature to complete an understanding of the background of this research effort. Since the CLSSA program is part of a larger inventory management and demand forecasting environment, an overview of these areas will be first examined to put the CLSSA processes in perspective within the wider supply chain management framework. As stated previously, cooperative logistic arrangements in general are strongly encouraged between the US and friendly countries (3:7), and the CLSSA program is one such arrangement in the supply chain process. Next in this chapter, unique terms relevant to CLSSA will be defined, followed by the details on the actual SLQ computational formulation for FMSO I recurring cases. CLSSA service levels will be then studied with regards to the differences between programmed and nonprogrammed support. Finally, previous CLSSA research will be discussed to provide other essential information surrounding this thesis.

Inventory Management

The CLSSA is a program designed to provide FMS customers with an effective, efficient, and reliably source of supply for systems previously acquired from the US; therefore, a brief review of the importance of inventory management is necessary, since it sets the foundation for CLSSA and the bulk of this research. For an FMS country, inventory management begins with the original purchase of DOD procured system and/or equipment. The significance of follow-on logistics support and supply chain management costs have become an increasingly critical factor in the decision making process for acquiring a new system—this focus on long term costs, rather than simply on the initial acquisition cost, makes programs such as CLSSA even more critical to DOD acquisition strategy (22:416).

The USAF, and DOD in general, have much in common with private sector inventory management principles. Excessive inventory and inaccurate demand forecasting are two of the main problems that plague any inventory system (21:102). Unlike the private sector, the DOD is more restricted in its capability of accessing funds that private industry can use to compensate for forecasting errors. A US General Accounting Office (GAO) report in 1999 indicated that inefficient inventory management policies of the USAF resulted in needless inventory expenditures for items with excess stock levels, which in turn reduced funds available for purchasing items where there were critical stock shortages (25:6). It is issues like these that potentially worry FMS customers, who when deciding upon purchasing USAF systems and equipment, realize that programs such as CLSSA are only as effective as the overall USAF supply system.

While excessive inventory primarily influences cost, lack of inventory more often impacts customer service levels, which can directly affect mission effectiveness for all DOD customers, including FMS countries. Although the focus of this research is dedicated to USAF FMS customers, all services have similar inventory management problems. The US Army, for example, considers long-term inventory management a major issue, both in terms of total acquisition costs, as well as because of specific spare parts shortages (1:7). Yet even though all branches of the armed services manage their own security assistance programs, it is the USAF that manages the bulk of the programs throughout DOD (see Figure 2 below).

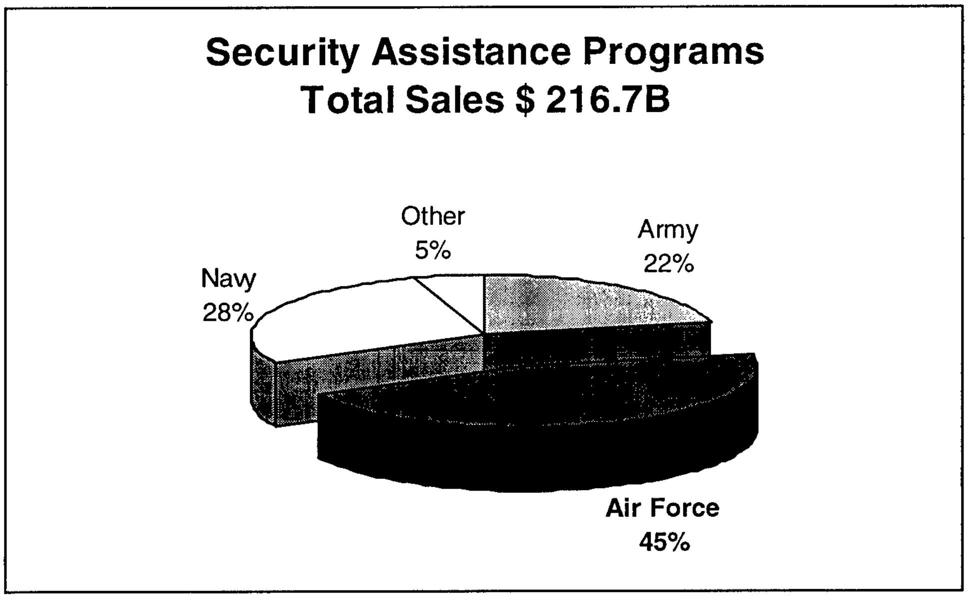


Figure 2. Security Assistance Programs (4:20)

In light of the significance of USAF involvement in security assistance programs as shown above, a recent report to the Secretary of Defense indicating problems with USAF controls over FMS programs is yet another impetus for this current research (18:1). So inventory management is a critical issue for DOD and FMS countries, and CLSSA is one of those critical logistic support programs.

Forecasting

Demand forecasting is one of the keys to an effective supply management program. Three primary methods to forecasting include judgmental estimates, causal models, and historical methods (22:341). Of these three, CLSSA currently uses a historical method, with additional manual FMSO I adjustments incorporating judgmental estimates. Although CLSSA primarily uses an automatic forecasting method as part of the FMSO I case, this is different from an automatic *replenishment* program, which is becoming more popular in the private sector, and involves a firm receiving stock automatically from their supplier—potentially leading to improved firm performance (2:63). FMSO II case replenishments or requisitions from FMS customers continues to remain a manual process.

The purpose of demand forecasting is determining the need for an item well before the entire lead-time through effective and efficient planning (19:2). The time from when an FMS country determines there is a need for a particular item, to when the manufacturer can produce and deliver the part is the lead-time for the item. This lead-time can be very long, not only because of the manufacturing time, but also because of the administrative time required to process the request. Total lead-time is defined as the sum of the administrative time involved to process a requisition, and procurement time or the time it takes for the private firm to manufacture the item.

There are several other general forecasting guidelines: increasing lead-time increases the importance of forecasting, even automated forecasting systems need periodic human intervention and review, and more complex forecasting does not equate to increased accuracy when it comes to forecasting in large-scale inventory systems (20:2010). With these basic concepts of inventory management and forecasting in mind, the more detailed FMS and CLSSA processes can be examined.

Relevant Terms

Before looking at specific aspects of FMS and the CLSSA program, it is important to understand the language, terms, definitions, and concepts that are outlined in the CLSSA Country Brochure, which draws information from a number of different sources, all relating to CLSSA processes (6:17-1 to 17-8).

Letter of Offer and Acceptance (LOA). A US government offer to a foreign government listing items or services, estimated costs, and terms of sales. The foreign government's signature obligates them to the LOA.

SAMIS. The Security Assistance Management Information System (SAMIS) is the computer system used by AFSAC for FMS management.

Investment Item. Any item that can be repaired and reused, having an ERRC code of C for XD1 or T for XD2.

H-Coded. A SAMIS identifier for investment item requisitions upon return of an unserviceable carcass.

Non-H. A SAMIS identifier for investment item requisitions other than H-Coded.

Expense items. Items that are not repairable, and are coded N for XB3 and P for XF3, also known as consumable items.

Stock Level Quantity (SLQ). The quantity calculated based on customer demand and total lead-time of the item; used for both investment and expense items.

Control Level. Computed stock level used by Inventory Managers and the D035 (Air Logistics Center asset management system) to determine allowability of filling nonprogrammed requisitions. Support and critical support levels are levels below the control level as cut-off points for filling particular requisition priorities.

CLSSA Management

There are three methods for FMS customers to order materiel: defined order cases with specific stock numbers identified, blanket order cases with only a category of items identified, and CLSSA arrangements for follow-on support (9:7). Follow-on support is defined as support that begins with the operation of a weapon system, and requirements for CLSSA participants are forecasted in advance of the actual need (6:1-1). The first two cases are one-time order scenarios, whereas CLSSA is a continuing program, which is the type of case being discussed throughout this research. As stated in Chapter I, cases are either FMSO I or FMSO II, as shown in Figure 3 below:

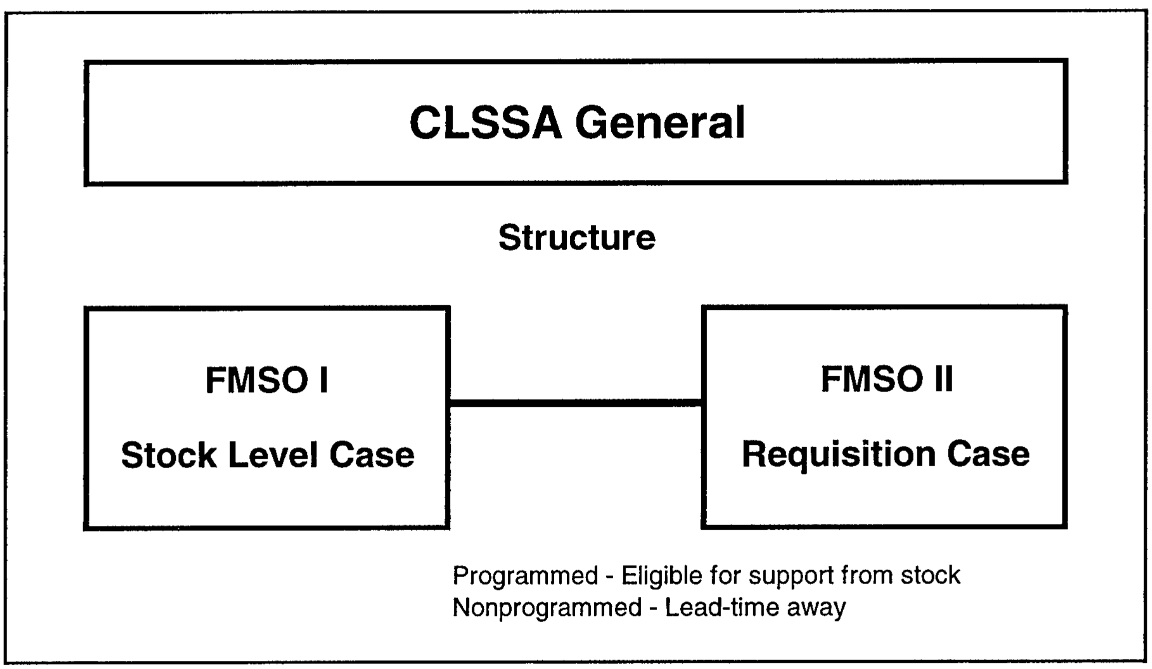


Figure 3. CLSSA Structure (4:5)

FMSO I case is the forecasted requirement, and FMSO II is the actual requisition, which can be either programmed (with an existing FMSO I case and the quantity ordered is below the SLQ) or nonprogrammed (without a defined FMSO I case or the quantity ordered is above the SLQ). As shown in Figure 3, programmed requisitions can be filled directly from stored or on-order stock, while there is not any guaranteed schedule for nonprogrammed requisitions, other than it should be approximately the total lead-time (administrative and procurement) away from the requisition date.

Even FMSO II programmed requisitions are not *guaranteed* 100% off-the-shelf support, but as shown in Figure 4 below, it is based on the request priority, and with the case of nonprogrammed requisitions, off-the-shelf support is authorized only if there is excessive stock above the control level.

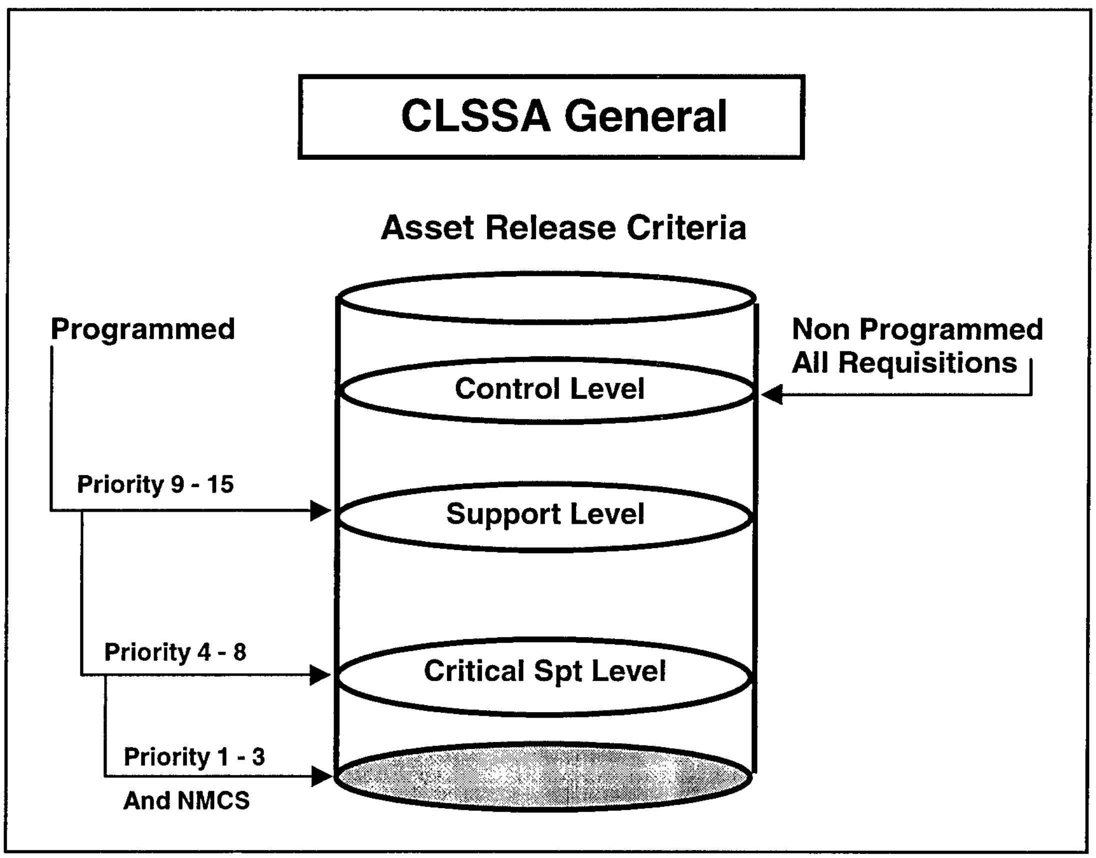


Figure 4. CLSSA Asset Release Criteria (4:6)

FMSO I cases can contain only Service Code A (USAF investment items), B (USAF expense items), or C (DLA expense items) (9:66). Investment items are usually the most expensive, as well as the items which cause the most problems because of delays and/or excess inventory. For the purpose of examining research question one, only the differences between programmed and nonprogrammed customer service levels for investment items will be analyzed, not expense items. All expense items have been coded programmed since 1994, so for these items research question one is of no significance.

The FMSO I case items are further grouped into specific categories for AFSAC management purposes. Procurement investment items (AA items) are those where the FMS country simply replaces the item (the subsequent requisition is coded Non-H). Repair investment items (AB items) are similar to AA items, except the FMS country returns a carcass to the US (the subsequent requisition is marked H-Coded). USAF expense items are coded "BB," and DLA expense items coded "CC."

Two special item groupings are liability and termination file items, both of which are used to manage excess inventory. Items in the liability file (LI items) are identified as excess, however, there is still demand for the item; however, because of changes in the SLQ or demand pattern, excess inventory is building up. Basically items are tagged LI to flag them for management attention. Termination file items (TR items) are similar to LI items except there has been *no* demand in the past four years for the item. Although all FMS countries are technically financially liable for all of their FMSO I cases, negotiations usually take place to attempt to eliminate this liability through drawdown requisitions (where Item Managers absorb the excess items), and items can spend years as TR items (6:2-2) in this limbo state.

While the liability and termination files are designed to manage excess inventory, the normal, or active, stock level file is the primary file for managing current assets. As stated earlier, FMSO I stock level files can again be established in four manners: initial, major add, manual adjustment, and recurring. The recurring method for establishing active stock level files is done automatically by the SAMIS system through an FMSO II case requisition. Since H-Coded orders are for repair and replace items, the purpose of the H-Coded order is not to trigger additional *procurement* of the item, but to "augment AFMC stocks to cover the repair pipeline" (6:2-3). In these requisitions, the lead-time becomes the repair lead-time, but the SLQ computation policy remains basically the same as for procurement items.

The automated forecasting method used by SAMIS to determine the FMSO I SLQ level is a weighted moving average, based on the previous 16 quarter's demand as identified through the FMS customer's FMSO II requisitions, with weights higher on the most recent quarter. FMS customers place requisitions on a quarterly basis, where the 16 quarter SLQ period equal 4 years. Previous research in 1994 (when the CLSSA system was transferred to an automated forecasting methodology) indicated that this method performed better than double exponential smoothing, adaptive response, and classical decomposition methods, when using the mean squared error (MSE) as an indicator of forecasting accuracy (15:65).

The process for determining recurring FMSO I stock levels is based on two factors—the average FMSO II case recurring monthly demand, and the lead-time for the item. The average monthly demand is calculated by using a weighted moving average of the previous quarter's demand over the past four years. The weighting factor begins with one, or 100%, and is reduced by 6.25% if there is a quantity of zero requisitioned for that quarter. The 6.25% figure is derived by dividing 100% by the 16 quarters, under the principle that the more recent requisitions will have a greater impact on the future requisitions than will the ones further back—a standard principle in the weighted moving average forecasting method. Table 1 provides an example of the SLQ weighted moving average formulation.

Table 1. SAMIS Weighting Factor Example (6:3-5)

QUARTER	REQUISITION QUANTITY	WEIGHTING FACTOR	WEIGHTED REQ. QUANTITY
1	2	100.00	2.0000
2	1	100.00	1.0000
3	0	93.75	0.0000
4	0	87.50	0.0000
5	2	87.50	1.7500
6	2	87.50	1.7500
7	1	87.50	0.8750
8	1	87.50	0.8750
9	0	81.25	0.0000
10	0	75.00	0.0000
11	0	68.75	0.0000
12	1	68.75	0.6875
13	0	62.50	0.0000
14	0	56.25	0.0000
15	0	50.00	0.0000
16	1	50.00	0.5000
TOTAL	**11**		**9.4375**
SLQ = (9.4375/48months) x 24months lead-time = 4.7 = 5			

SAMIS would take the total weighted requisition quantity (9.4375) and divide it by 48 months to arrive at the average weighted monthly average (0.1966). The procurement SLQ would then be calculated by multiplying the average weighted monthly average by the procurement lead-time. For repair and replace items, the repair SLQ would be calculated in the same manner as the procurement SLQ, except that SAMIS uses an average weighted *daily* average instead of *months*, because the repair lead-time is calculated in days (6:3-5).

In general, the procurement lead-time will range from 1 to 60 months, and the repair lead-time approximately 7 months (6:3-1). Finally, the resulting SLQ would be rounded to the whole number with values of 0.5 and above being rounded up, except any SLQ less than one would always equal one. In the example shown in Table 1, with a lead-time of 24 months, the SLQ would equal 5 (0.1966 x 24 = 4.7 = 5).

So the SLQ can change quarterly based on the actual requisitions for an item. In our Table 1 example, if a this item has no demands placed on it this quarter, then the next quarter the SLQ would decrease because there would be a zero in the requisition quantity for Quarter 1, which would result in the weighting factor starting with 93.75% instead of 100%. Additionally, all of the subsequent values would drop down one quarter and the previous requisition quantity of "1" for Quarter 16 would drop off from the SLQ calculation altogether. Table 2 shows how the SLQ would change from 5 the previous quarter down to 4 based on these changes.

Table 2. SAMIS Weighting Factor Example—The Next Quarter

QUARTER	REQUISITION QUANTITY	WEIGHTING FACTOR	WEIGHTED REQ. QUANTITY
1	0	93.75	0.0000
2	2	93.75	1.8750
3	1	93.75	0.9375
4	0	87.50	0.0000
5	0	81.25	0.0000
6	2	81.25	1.6250
7	2	81.25	1.6250
8	1	81.25	0.8125
9	1	81.25	0.8125
10	0	75.00	0.0000
11	0	68.75	0.0000
12	0	62.50	0.0000
13	1	62.50	0.6250
14	0	56.25	0.0000
15	0	50.00	0.0000
16	0	43.75	0.0000
TOTAL	**10**		**8.3125**
SLQ = (8.3125/48months) x 24months lead-time = 4.2 = 4			

Again, the principle is that the quantities maintained in the DOD supply system are based on each of the countries SLQs that are established in the FMSO I case. Not only is this a mechanism to allow SAMIS to manage the entirety of the FMS customers inventory, but provides an incentive for FMS customers to judicially monitor their FMSO II requisitions. As seen in Tables 1 and 2, the SLQ changes quarterly. So in the Table 1 example, the FMS customer could place an order for 5 items and have them all coded programmed because the SLQ was 5; however, if they ordered nothing this quarter and waited until the next quarter, the SLQ would fall to only 4 as shown in Table 2. This would result in only 4 items being ordered programmed, while the other 1 item would be ordered nonprogrammed, if the FMS country still choose to place an order for 5 items.

Up to now the focus has been too look at inventory levels with respect to quantity, forecasting methods, and ordering process. Now the CLSSA process will be examined using a cost approach, since cost can be a limiting factor when managing inventory, and is especially important when discussing excessive inventory. The FMSO I case is divided up into part A (5/17) and part B (12/17), with the theory being that part A is the USAF on-hand portion already paid for by the FMS customer, and the part B is in the administrative and/or procurement/repair pipeline (5:123). Although the up front payment by the FMS country will occur much earlier then the actual date of delivery, SAMIS computes FMSO I total valuations based on the Latest Acquisition Cost (LAC), not the cost at the time of the original 5/17 payment.

Furthermore, when an FMSO II requisition case is processed, the LAC (plus surcharges) is used to determine the purchase cost to the FMS customer. Because the FMSO I case value can vary because of changes in demand, lead-times, and case value, an LOA modification can be used to amend the 5/17 contribution to ensure the correct ratio remains in effect. The 5/17 is based on the average annual SLQ, since the SLQ changes each quarter. So for example if the average SLQ is increased over last year, then the 5/17 charge will increase, however, since this only on an item basis, SLQs for some items may go up while others go down, so adjustments through an LOA modification are based on this aggregate change, if at all.

This is accomplished annually with refunds going back to the FMS customer in the case where it is determined that the customer has paid more than the required 5/17, or additional payments by the FMS country to AFSAC if they underpaid. Since the 1994

CLSSA change, most FMS customer's FMSO I case requirements have held excess SLQs and they have been working to reduce the levels, which has resulted in the FMS customers most often being owed, rather than owing, additional funds; however, the FMS country normally allows AFSAC to retain this amount for future use rather than request annual refunds (26:1). This is only a temporary phenomenon and currently excessive FMSO I cases have been reduced to more normal levels (26:1). It should also be noted that manual adjustments in the SLQ are not authorized for the sole purpose of manipulating FMSO I case values in an attempt to preclude the need for the FMS customer to provide more funds into their FMSO I case (6:5-1).

CLSSA Service Levels

As stated in the previous section, one of the benefits to increasing the number of programmed requisitions is to improve customer service levels. The first research question of this thesis was to determine if customer service levels are in fact different between the programmed and nonprogrammed requisitions. It is important to determine that now, because the following chapters are dedicated to showing how FMS customer requisition policies determine whether items are ordered programmed or nonprogrammed, so it is necessary to establish a justification for examining those differences.

Aggregate fill rates are the standard unit AFSAC uses to measure customer service levels. The fill rate "clock" begins when AFSAC receives an FMSO II requisition, and ends when the item is shipped to the FMS customer. Fill rates are given both in terms of days and percentages. The category of fill days used are for items shipped within 15, 30, 60, 90, and 180 days, with an appropriate fill rate percentage assigned.

So for example, a 40% fill rate for the "ship in 15 days" category means that 40% of all items were shipped within 15 days of the FMSO II requisition. An 80% fill rate for the "ship in 180 days" category means that 80% of all items were shipped within 180 days of the order, or 20% of all items were shipped over 180 days. This does not mean that it took 180 days to ship 80% of the items, only that 80% of all items were shipped *within* 180 days. In this method of calculation, with only information on 180 day fill rates, it could be that 80% of the items were filled in 10 days, 20 days, or anytime prior to the 180 day period, but if only 180 day fill rates were provided, it would be impossible to determine more exact rates.

Since this is the way the categories and fill rates are construed by SAMIS, certain ground rules must be established in the discussion and analysis of fill rates as a means of determining customer services levels in the following tables and graphs. First is that the categories of "shipped within 15, 30, 60, etc. days" will be shortened to strictly the days only. So the category "shipped within 60 days" is the same as the 60 day fill rate. The second rule is that although the categories are "within" the simpler usage will indicate "in." So when comparing a 60 day fill rate for programmed to a 60 day fill rate for nonprogrammed items, although the language may indicate items were shipped "in" 60 days, it really means "within."

Which brings up the final rule and that is unless otherwise indicated, the fill rates will be for a range of days. For example, the 60 day fill rate means that the items were filled between 31 and 60 days. The 30 day fill rate means items were filled between 16 and 30 days. And so on. Obviously the 15 day fill rates are the same for both cumulative and noncumulative, since that is the first category. Additionally, the "over 180" day fill rate category will always be 100% on cumulative tables and graphs. If a table or graph is cumulative, it will be indicated as such. In cumulative graphs, a 90 day fill rate for instance, indicates that the items was filled in 90 or less days.

Fill rate data provided by SAMIS covers the calendar years of 1994 to 1999, for both H-Coded and Non-H investment items. First the H-Coded fill rates as shown in Table 3 will be analyzed, and then a similar examination for the Non-H items will be conducted. Over the past six years it can be seen that fill rates for programmed requisitions consistently outperformed nonprogrammed requisitions. The mean for the 15 day fill rates for programmed was 42.3% and only 27.9% for the programmed, a difference of 14.4%. Another way of looking at it is that the 15 day fill rates for programmed requisition was approximately 50% higher relatively speaking than for nonprogrammed requisitions. Similarly, while on average 25.6% of nonprogrammed requisitions took over 180 days to be filled, only 16.8% of the programmed orders took over 180 days to be filled. So to summarize on these averages, twice as many programmed requisitions get filled in 15 days compared to nonprogrammed, while about twice as many nonprogrammed requisitions take more than 180 days to be filled. A

Table 3. H-Coded Fill Rates

H-Coded

Programmed

Shipped by Day "X"	94	95	96	97	98	99	Mean
15	43.1	42.4	40.2	36.8	41.2	49.8	42.3
30	8.9	7.7	8.0	8.6	11.5	10.5	9.2
60	9.9	11.0	11.0	12.2	13.0	10.6	11.3
90	7.2	5.9	7.0	8.1	8.6	6.2	7.2
180	12.7	13.6	14.0	15.9	13.2	10.4	13.3
>180	18.2	19.4	19.8	18.4	12.5	12.5	16.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	

Non-Programmed

Shipped by Day "X"	94	95	96	97	98	99	Mean
15	30.7	25.7	25.2	27.4	28.6	29.6	27.9
30	11.4	8.3	7.5	8.0	7.7	9.6	8.8
60	11.7	11.4	8.0	11.0	12.8	11.8	11.1
90	8.1	9.2	8.1	8.9	9.7	6.9	8.5
180	17.1	19.6	16.7	18.2	21.9	15.8	18.2
>180	21.0	25.8	34.5	26.5	19.3	26.3	25.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	

Cumulative Data

Programmed

Shipped by Day "X"	94	95	96	97	98	99	Mean
15	43.1	42.4	40.2	36.8	41.2	49.8	42.3
30	52.0	50.1	48.2	45.4	52.7	60.3	51.5
60	61.9	61.1	59.2	57.6	65.7	70.9	62.7
90	69.1	67.0	66.2	65.7	74.3	77.1	69.9
180	81.8	80.6	80.2	81.6	87.5	87.5	83.2
>180	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Non-Programmed

Shipped by Day "X"	94	95	96	97	98	99	Mean
15	30.7	25.7	25.2	27.4	28.6	29.6	27.9
30	42.1	34.0	32.7	35.4	36.3	39.2	36.6
60	53.8	45.4	40.7	46.4	49.1	51.0	47.7
90	61.9	54.6	48.8	55.3	58.8	57.9	56.2
180	79.0	74.2	65.5	73.5	80.7	73.7	74.4
>180	100.0	100.0	100.0	100.0	100.0	100.0	100.0

similar analysis on the cumulative 30 and 60 day fill rates shows that the fill rates are approximately 40% and 30% better for the programmed requisitions on average.

Comparing averages only tells half of the story, though, since fill rates have been generally improving since 1994. Figure 5 includes four graphic depictions of the fill rates over time to highlight some of the changes. A complete set of graphs and tables can be found in Appendix A for all material relating to fill rates in this chapter.

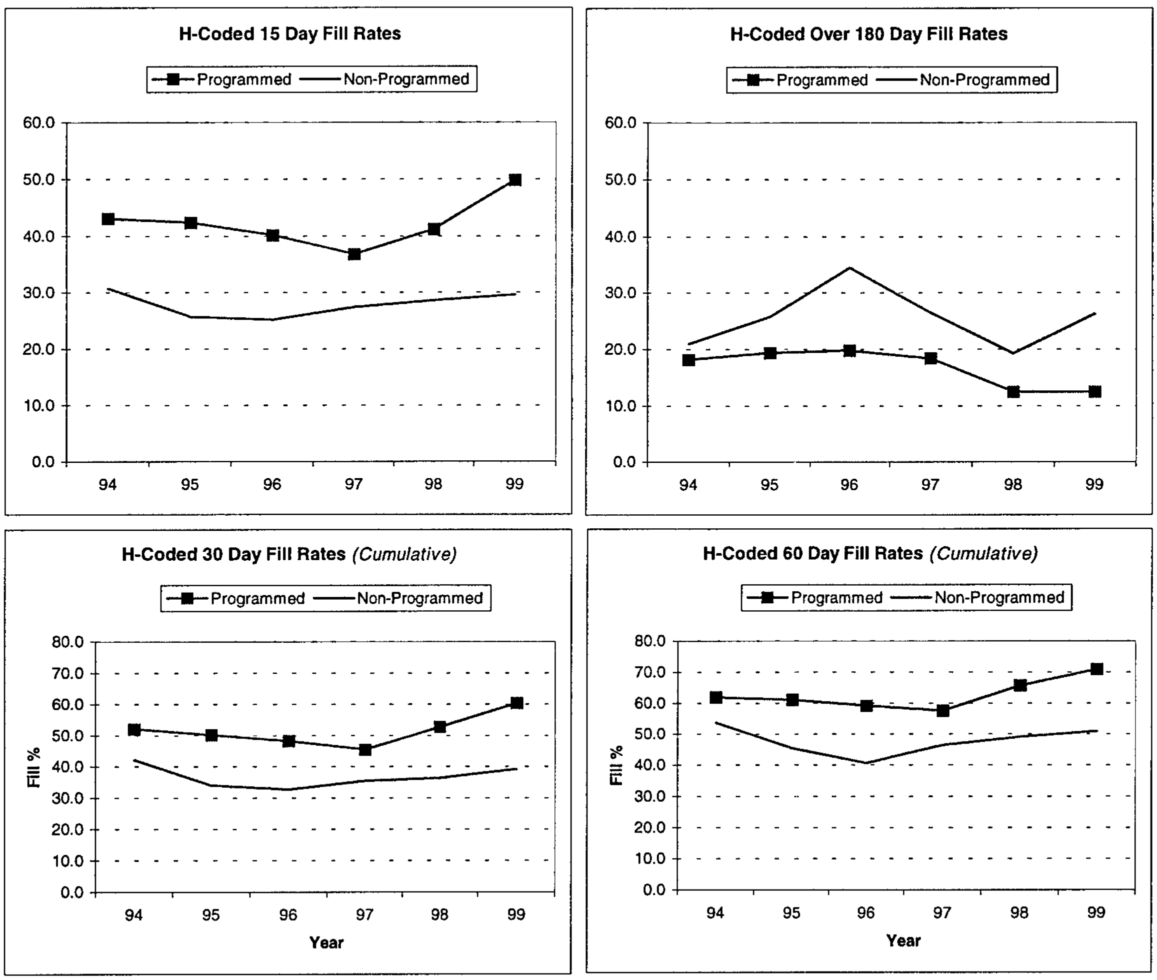


Figure 5. H-Coded Fill Rate Percentages

The 15 day fill rates show an increasing upward trend over the past couple of years for the programmed requisitions, with an upward trend in general over the past six years; however, nonprogrammed fill rates have remain basically constant over the same time period. So while the 15 day average for programmed fill rates was approximately 50% better over the past six years, because of the increasing trend, current programmed fill rates are closer to 70% better than nonprogrammed 15 day fill rates. The 180 day fill rate also shows an improved fill rate trend for programmed orders, and a worsening trend for nonprogrammed ones. Nonprogrammed requisitions have seen a 25% increase in fill rates over 180 days, while at the same time programmed requisitions have seen a 30% decrease in fill rates over 180 days. Similarly, the 30 and 60 day cumulative fill rate graphs also indicate that programmed orders are also improving over time, while the nonprogrammed fill rates are at best remaining constant.

Rather than provide the tables and graphs for the Non-H item fill rates within the body of this text, they are listed in Appendix A, following the H-Coded fill rates. Basically, the differences and trends between programmed and nonprogrammed requisitions that the H-Coded items presented are the same for the Non-H investment items. In general it can be said that because of the differences in programmed versus nonprogrammed fill rates for all investment items, it is important to have coded as many items programmed as possible. As described in previous sections, this is done by FMSO II requisition quantities being at or below SLQ levels as set in the FMSO I case.

The purpose of this section was to determine *what* the differences were between programmed and nonprogrammed coded requisitions, not to discover *why* fill rates were different, nor *why* there appears to be an upward trend. Those questions would be an entirely separate research topic, since variations in fill rates could be caused by numerous factors: USAF fill rates, manufacturing problems, procurement lead-time inaccuracies, FMS investment levels, excessive inventory levels, etc. The goal was simply to establish a preference for programmed over nonprogrammed requisitions.

Based on the fill rate data discussed in this section, it seems apparent that it is a justifiable inventory management goal to achieve programmed requisitions whenever possible. Not only is there a clear difference in fill rates between programmed and nonprogrammed requisitions, but the improvements in fill rates over the past six years have tended to favor programmed orders. This satisfies research question one, which was to determine how programmed and nonprogrammed requisitions affect customer service levels. It also provides further incentive for FMS countries to establish a requisitioning policy that includes a method to maximize programmed orders.

Previous Research

Now that the CLSSA processes and basic relationships between FMSO I cases, FMSO II cases, SLQ calculations, and the 5/17 charge are more fully understood, some previous research conducted on the CLSSA program will be discussed. Because of the nature of the changes to the CLSSA program following the 1994 conversion to automated forecasting and SLQ calculations, studies prior to 1994 will not be examined in this thesis.

One exception will be a 1988 article in the Defense Institute of Security Assistance Management (DISAM) Journal, which discussed more of the philosophy behind CLSSA, rather than the mechanical operations. A key point in this article was that CLSSA is a "wholesale-to-wholesale support system" rather than a method to satisfy direct flightline supply needs (13:70). Although CLSSA is often described as a cooperative relationship where FMS customers receive support on par with other bases with the same FAD and requisition priority, USAF bases are not necessarily "mini-depots" being supported by either DLA or USAF depots. Although the relationship between USAF bases to DLA and USAF depots may change in the future, currently a USAF base making a requisition through SBSS is not of the same magnitude as an FMS country making a FMSO II requisition through CLSSA. Additionally, CLSSA was not designed as the sole inventory replenishment method for FMS countries to receive all of their supplies, since ammunition items, non-standard items, replacement end items, and other items are excluded from CLSSA support. Finally, CLSSA was designed for peacetime operations, not wartime surge requests (13:70).

A main emphasis of this thesis is to analyze how FMS countries *themselves* can affect CLSSA support levels and overall cost to the FMS customer through their FMSO II requisitions, and the subsequent changes to the SLQ. FMS countries can also influence CLSSA effectiveness in other ways, as discussed in other studies. Since CLSSA is a wholesale-to-wholesale system, FMS countries need to maintain adequate stocks, normally achieved through the initial support package, where-by CLSSA is only being used for normal replenishment of the country's stock; defined order or blanket order cases should be used to augment stocks (10:5). Another way FMS influence CLSSA effectiveness is through ordering policy; FMS countries should requisitions items on a regular basis, rather than through infrequent but large orders (10:6). This is a critical point to research question four of this thesis, which is to determine an optimal requisitioning strategy to promote high levels of programmed orders, without excessive SLQs to pay for through the 5/17 charge. Whether or not regular small orders are *always* more beneficial to the FMS customer, compared to large infrequent orders will be analyzed more closely in Chapter IV.

A 1997 study was conducted to investigate lead-time and cost differences between CLSSA, PROS procurement system, and a simulated third party logistics firm for follow-on supply support. The PROS system is also managed through AFSAC, but is primarily used for non-standard items not readily available through the normal DLA or USAF depot system, which is where CLSSA items originate. Results of this study indicated that while there was no significant difference in lead-times between CLSSA and PROS, the third party logistics method did reduce lead-time, but at a higher total cost (12:67). This study was limited to a single FMS country.

As described in the forecasting section of this chapter, research was also conducted at the time of the 1994 conversion to the automated forecasting method to compare the proposed AFSAC forecasting method (weighted moving average) with double exponential smoothing, adaptive response, and classical decomposition methods. Although the AFSAC model performed better than the other methods, the difference was slight; however, the AFSAC model did do better than the pre-1994 system of forecasting, which was solely based on FMS country discretion (15:68).

Summary

The purpose of this chapter was to provide the necessary background information by which a thorough analysis can be intelligently studied and discussed. CLSSA is just one option FMS countries can choose to manage their follow-on logistics supply chain. Inventory management and demand forecasting are two critical components to reducing lead-time and cost, both in the military and private sectors. Because the military is more fiscally restricted and unable to easily expend additional funds to offset an inefficient logistics support system, the area of inventory management and demand forecasting becomes even more critical.

The CLSSA process was discussed in detail, with particular emphasis dedicated to the forecasting methodologies and SLQ calculations used by the SAMIS inventory management system. CLSSA service levels were then examined in detail to highlight the importance of FMSO II requisitions to be ordered programmed rather than nonprogrammed whenever possible, to take advantage of the improved fill rates. This leads directly into the next two chapters, which demonstrate how FMS customers themselves can affect their own fill rates and program costs through their requisitioning policy.

Throughout this chapter, references were made to the importance of FMS and follow-on logistics specifically (to both FMS countries as well as DOD), and to the need for continued research in this area because of high level concern over these issues. Previous research was finally discussed as prelude for this sustaining research. Chapter

III will now discuss the methodology used for the subsequent analysis of the SLQ computational model.

III. Methodology

Introduction

Research questions two and three asked how requisitioning policies of FMS countries affect their customer service levels and cost, through changing SLQs based upon FMSO II requisitions. Research question four asked how a strategy could be developed to provide the highest service levels at the lowest cost, through the establishment of an ordering policy that optimized SLQs. A model has been created to answer all three of these questions, the results of which will be discussed in Chapter IV Analysis and Results. The purpose of this chapter is to provide the rationale and methodology for creating this model, or heuristic.

The details of how the AFSAC SAMIS computer system calculates the SLQ will be examined first, by using an author-created Microsoft® Excel 97 software model for examining variations in requisitioning frequencies, which will be used throughout the rest of this thesis. Assumptions necessary for the creation and use of this model will be discussed next, followed by the specific methods and criteria for the data analysis that will occur in Chapter IV.

Basic Principles of SAMIS SLQ Computation

The overall premise is that low SLQs can increase nonprogrammed orders yet lower costs, since requisitions above the SLQ level will be ordered nonprogrammed and countries are required to pay 5/17 of the SLQ up front; conversely, high SLQs reduce nonprogrammed orders, but increase costs. Therefore the various ways an FMS country places FMSO II requisitions will be examined to show how it impacts the SLQ, and ultimately service levels and cost. However, first an understanding of some of the common principles behind the SAMIS SLQ computation needs to be understood. Figure 6 will be used as an example to go over these basic principles.

The mechanical computations for arriving at an SLQ are identical to those describing Tables 1 and 2 in Chapter II, although the format of the tables may differ somewhat. Numerical examples will be used throughout this discussion to better instill the mathematical principles. Unless otherwise indicated, the particular numbers used in these examples were selected for their illustrative value, rather than as actual demand and lead-time figures of for specific items.

As will be shown in Figure 6 for this example, the demand is 32, lead-time is 24 months, and an order-per-period of 8 is the requisitioning policy for this item. Recall that the lead-time is both the procurement and administrative lead-time, and the demand is over the previous 16 quarters. FMSO II requisitions and SLQs are calculated on a quarterly basis; therefore, where-ever a "demand" is indicated, this is the total FMSO II requisitions over the previous 16 quarters. Also, to simplify the verbiage, rather than stating 16 quarters, 48 months, 4 years, or demand history, the phrase "SLQ period" will be used, since it most accurately portrays what this time period actually is. The SLQ period is the previous four years of demand history that SAMIS uses to calculate the SLQ.

Even though the SLQ period is the *previous* 16 quarters, when using the model and comparing different possible combinations of demand, lead-time and orders-per-period, the resulting SLQs will be for the *next* 16 quarters, and "what if?" questions will be asked. In reality it is the same thing. That is, the model can be examined so as to determine what would the SLQ be if during the *previous* four years the FMS customer's ordering policy was a certain way based on previous actual demand, lead-time, and varying orders-per-period; or, the model can be examined so as to determine what will be the SLQ over the *next* four years given future projected demand, lead-time, and varying orders-per period. The first method uses the model to determine any differences between actual requisitioning policy to other possible orders-per-period scenarios, while the later examination method uses the model to determine optimal requisitioning policies for the future.

The only differences is that actual versus projected values for demand and lead-time would be used, but the actual model functions exactly the same under either scenario. For the purposes of this research, the emphasis will be on how varying orders-per-period will affect the next SLQ period, based a forecasted demand and item lead-time. Yet as stated previously, this model can be used just as effectively to evaluate past requisitioning policies if an FMS country chooses to do so.

So it is assumed that the FMS country can provide an approximate forecast for what their demand will be over the next SLQ period for a particular item. The purpose of this model is not to forecast demand, but rather provide a tool for FMS customers to better manage their requisitions. So with all of the various "what if?" scenarios, the assumption will be made that the FMS customer can provide an approximate demand level over the SLQ period. Another assumption is that the lead-time is known and relatively constant over the SLQ period. As will be shown, however, the model is robust enough to allow for changes in either of these two assumptions. One of the simplest ways for dealing with large changes in demand and/or lead-time would be to recompute the optimal requisitioning policy from that point forward.

In Figure 6, the "Quarter" column represents the previous quarters, so Quarter 1 is last quarter, Quarter 2 the one before that, and so on, with Quarter 16 being the quarter 4 years ago. The weighting factor subtracts 6.25% at every quarter where zero orders were placed for that item. So in this example, since the ordering policy is to order 4 items every other quarter (8 orders-per-period), when the current order is placed, there will be a

8 Orders for 4

8 Orders Per 16 Quarters

Average SLQ **12.5**

Items Ordered Over SLQ **-64**

CHANGING CELLS
4 Year Forecasted Demand = **32**
Item Lead Time in Months = **24**

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty	Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000	1	4	100.0%	4.000
2	4	93.75%	3.750	2	0	93.75%	0.000
3	0	87.50%	0.000	3	4	93.75%	3.750
4	4	87.50%	3.500	4	0	87.50%	0.000
5	0	81.25%	0.000	5	4	87.50%	3.500
6	4	81.25%	3.250	6	0	81.25%	0.000
7	0	75.00%	0.000	7	4	81.25%	3.250
8	4	75.00%	3.000	8	0	75.00%	0.000
9	0	68.75%	0.000	9	4	75.00%	3.000
10	4	68.75%	2.750	10	0	68.75%	0.000
11	0	62.50%	0.000	11	4	68.75%	2.750
12	4	62.50%	2.500	12	0	62.50%	0.000
13	0	56.25%	0.000	13	4	62.50%	2.500
14	4	56.25%	2.250	14	0	56.25%	0.000
15	0	50.00%	0.000	15	4	56.25%	2.250
16	4	50.00%	2.000	16	0	50.00%	0.000
SUM	32		23	SUM	32		25

	4 Year Demand =	32	4 Year Demand =	32
Weighted Req'd Quantity divided by 48 Months =	Avg. Mon. Dmd =	0.4792	Avg. Mon. Demand =	0.5208
Average Monthly Demand x Lead Time =	SLQ =	11.500	SLQ =	12.500
Rounded SLQ (1.0 if less than 1.0) =	**SLQ =**	**12**	**SLQ =**	**13**

Figure 6. SLQ Example (Demand 32, Lead Time 24 Months, 8 Orders/Period)

zero in the requisition quantity for Quarter 1, since no orders were placed last quarter, and the previous 16 quarters will appear as shown in Figure 6. Since the SLQ is 12 at the time of the order, all 4 of the items in the order would be coded programmed, because the requisition of 4 is less than the SLQ of 12.

As stated in Chapter 2, the SLQ is calculated by multiplying the quantity requisitioned by the weighting factor each quarter, summing up the weighted requisitioned quantities, dividing that by 48 months to arrive at an average monthly demand, which is then multiplied by the lead-time, and then rounded to determine the current SLQ. So the first table in Figure 6 represents the present state, with the specified requisitioning history, and an order being placed in this current quarter using the current SLQ.

The table to the right in Figure 6 represents the next quarter in the future using the continuing ordering policy of 8 requisitions per SLQ period. Therefore, no requisitions will be made that quarter, however an SLQ will be calculated, since SLQs are always updated on a quarterly basis. The SLQ shows a rise from the previous SLQ and that is because there is now an order in Quarter 1 (this is because we placed an order as discussed previously, moved ahead one quarter into the future, so that order now becomes an order placed last quarter, or at Quarter 1), and through the weighting factors and other calculations there is a different SLQ.

Since the ordering policy is 8 orders per SLQ period, the requisitioning history will continuously cycle between the two tables shown in Figure 6, and the table on the left will always represent the ordering history at the time when an order is placed. So for a requisition policy of 8 orders-per-period, only two tables will be needed to represent all of the possible combinations of orders at any given quarter throughout the entire SLQ period in this example.

The two key SLQ measurements shown in Figure 6 are the average SLQ and the actual SLQ when an order is placed. The FMS customer is charged 5/17 on the SLQ, but only annually do the FMS countries either pay additional money to AFSAC or does AFSAC provide refunds to the FMS countries. Since during some quarters the SLQ goes up and others it goes down, there may not necessarily be any aggregate change. The key is that it is the *average* SLQ that determines the cost bases for the 5/17 charge to the FMS customer, not the specific SLQ at the end of the calendar year, since FMS countries could simply place orders during the first two quarters and order nothing the next two quarters, there-by artificially reducing the SLQ at calendar's year end.

Therefore from a cost perspective, it is this average SLQ which should be as low as possible. For the purpose of this model, the average SLQ is the average over the entire four year SLQ period, rather than on an annual basis. This is because with certain ordering-per-period policies, the annual average SLQ may change from year to year, however, the average SLQ over the entire 4 year SLQ period will remain constant with all of the different order-per-period variations, and therefore comparisons in average SLQ can be accurately compared.

The SLQ average, however, is not a factor in determining whether or not the FMSO II requisitions are coded programmed or nonprogrammed. The SLQ that is important is the actual SLQ at the time of the order. In the Figure 6 example, the SLQ during the quarter at which the order was placed was 12, and the alternate quarter had an SLQ of 13, but again this is an example of a demand of 32, lead-time 24 months, and an 8 per period ordering policy. The calculation in Figure 6 "Items Ordered Over SLQ" indicates the number of items ordered throughout the entire SLQ period that were over the SLQ at the time of the requisition. In other words, how many items were nonprogrammed requisitions. In this example the number was –64 because at each of the 8 orders of quantity 4, there were –8 items ordered above the SLQ level of 12.

The negative number indicates that every requisition was below the SLQ. Although the model could have been designed to convert all negative numbers to zero, or only count positive numbers, the negative numbers were left in the model to provide an indication of the magnitude of the slack. So in the previous case, since each order was at a quantity of eight under the SLQ, if there were known demand flucuations for instance, the FMS customer would know that during each of the quarters where they placed an order they could have increased the quantity ordered by up to eight items and still remained at or below the SLQ. So leaving the negative numbers in the model output provides customers additional information for creating an effective inventory strategy; however, SAMIS only considers positive numbers in coding orders programmed or nonprogrammed.

If on the other hand the SLQ at the time of the requisition was 1 instead of 12 for example, then at each of the 8 orders, 3 items would be ordered above the SLQ, equating to 24 total items being ordered above the SLQ during the entire SLQ period, meaning that 24 items were ordered nonprogrammed and 12 ordered programmed for the total demand of 32 items. In this case, the "Items Ordered Over SLQ" would equal 24 instead of –64 as shown in Figure 6.

Since the common advice AFSAC provides to FMS customers is to order small quantities on a regular basis, let us now examine the same example of a demand of 32 items per SLQ period with a lead-time of 24 months, except instead of an 8 order-per-period policy, a policy of 16 orders-per-period will be used, or basically ordering every quarter instead of ordering every other quarter as was the scenario in Figure 6. Figure 7 shows this example of an item with a demand of 32, lead-time of 24 month, and a 16 orders-per-period requisitioning policy.

16 Orders Per 16 Quarters

Average SLQ: 16

Items Ordered Over SLQ: -224

CHANGING CELLS

4 Year Forecasted Demand = 32

Item Lead Time in Months = 24

16 Orders for 2

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	2	100.0%	2.000
2	2	100.0%	2.000
3	2	100.0%	2.000
4	2	100.0%	2.000
5	2	100.0%	2.000
6	2	100.0%	2.000
7	2	100.0%	2.000
8	2	100.0%	2.000
9	2	100.0%	2.000
10	2	100.0%	2.000
11	2	100.0%	2.000
12	2	100.0%	2.000
13	2	100.0%	2.000
14	2	100.0%	2.000
15	2	100.0%	2.000
16	2	100.0%	2.000
SUM	32		32

4 Year Demand = 32

Weighted Req'd Quantity divided by 48 Months = Avg. Mon. Dmd = 0.6667

Average Monthly Demand x Lead Time =.................. SLQ = 16.000

Rounded SLQ (1.0 if less than 1.0) =.................. **SLQ = 16**

Figure 7. SLQ Example (Demand 32, Lead Time 24 Months, 16 Orders/Period)

By comparing Figure 6 to Figure 7, one of the principle relationships can be seen, that is, with all else being equal (i.e. demand and lead-time), as the number of orders increase over an SLQ period, the greater the SLQ average will be. This is particularly true when ordering every quarter, as in Figure 7. The average SLQ went from 12.5 to 16, or increased by about 33%, by increasing the orders-per-period from 8 to 16. With this increase in SLQ and reduction in quantities ordered during each order, the number of items (if any) ordered above the SLQ level will decrease. In the previous examples, there were not any nonprogrammed requisitions, since the "Items Ordered Over SLQ" were negative numbers. However, there were 3.5 times as many negatives when ordering every quarter, indicating that had there been nonprogrammed items ordered, their numbers would have decreased.

Since orders are being placed at every quarter, only one table is needed to represent the spectrum of SLQ possibilities in Figure 7. When there was 8 orders-per-period, two tables were required as shown in Figure 6. With 4 orders-per-period, 4 tables would be needed to capture all the potential quarters with or without orders being placed. With 2 orders-per-period there would need to be 8 tables, and with 1 order for the entire 16 quarter SLQ period, 16 tables would be needed to track that one order moving from Quarter 1 as the next quarter after the order was placed, and moving down to Quarter 16, upon which another order would be placed.

Figure 8 is a representation of placing only 1 order per period, with the same demand of 32 and lead-time of 24. Similar to the other two examples, the first column is the point at which a requisition is placed. Since the ordering policy in this example is to only order once each period, the last order was at Quarter 16, making the SLQ only 1 at the time of the order. Of that one order is for 32 items, 31 of those items will be coded nonprogrammed. On the positive side, the average SLQ has been reduced to 8.5, which is about a 30% less than with the policy of ordering every other quarter (8 orders-per-period), and about 50% less then the average SLQ using the order every quarter policy (16 orders per quarter).

1 Order for32

1 Order Per 16 Quarters

Average SLQ 8.5

Items Ordered Over SLQ 31

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	0	75.00%	0.000
5	0	68.75%	0.000
6	0	62.50%	0.000
7	0	56.25%	0.000
8	0	50.00%	0.000
9	0	43.75%	0.000
10	0	37.50%	0.000
11	0	31.25%	0.000
12	0	25.00%	0.000
13	0	18.75%	0.000
14	0	12.50%	0.000
15	0	6.25%	0.000
16	32	6.25%	2.000
SUM	**32**		**2**

4 Year Demand = **32**
Avg. Mon. Dmd = 0.0417
SLQ = 1.000
SLQ = 1

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	32	100%	32.000
2	0	94%	0.000
3	0	88%	0.000
4	0	81%	0.000
5	0	75%	0.000
6	0	69%	0.000
7	0	63%	0.000
8	0	56%	0.000
9	0	50%	0.000
10	0	44%	0.000
11	0	38%	0.000
12	0	31%	0.000
13	0	25%	0.000
14	0	19%	0.000
15	0	13%	0.000
16	0	6%	0.000
SUM	**32**		**32**

4 Year Demand = **32**
Avg. Mon. Demand = 0.6667
SLQ = 16.000
SLQ = 16

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	94%	0.000
2	32	94%	30.000
3	0	88%	0.000
4	0	81%	0.000
5	0	75%	0.000
6	0	69%	0.000
7	0	63%	0.000
8	0	56%	0.000
9	0	50%	0.000
10	0	44%	0.000
11	0	38%	0.000
12	0	31%	0.000
13	0	25%	0.000
14	0	19%	0.000
15	0	13%	0.000
16	0	6%	0.000
SUM	**32**		**30**

4 Year Demand = **32**
Avg. Mon. Demand = 0.6250
SLQ = 15.000
SLQ = 15

Figure 8. SLQ Example (Demand 32, Lead Time 24 Months, 1 Order/Period)

Although Figure 8 only is showing only the first 3 tables, it can be seen that the requisitioned quantity of 16 will move from Quarter 1, to Quarter 2, and so forth until the cycle repeats itself when another order occurs at a fashion identical to that shown in the first table. The other 13 tables were not inserted into Figure 8 to save space; Appendix B provides entire sets of tables for all combinations used in this study.

So now examples of 1, 8, and 16 orders-per-period were demonstrated for an item with a demand of 32 and a lead-time of 24 months. Table 4 provides a summary of all of the SLQ averages and items ordered above over the SLQ, for orders-per-period of 1, 2, 4, 8, and 16. This is the type of table that will be used extensively in Chapter IV to examine the range of possible demand levels, lead-times, and order cycles, rather than the individual SLQ formulation tables as used in Figures 6 through 8.

Table 4. Summary of SLQ Example (Demand 32, Lead Time 24 Months)

Orders Per Period									
1	*2*	*4*	*8*	*16*	*1*	*2*	*4*	*8*	*16*
31	20	-4	-64	-224	8.5	9.5	10.5	12.5	16.0
Items Ordered Above/Below SLQ					**Average SLQ**				

The purpose of those were to explain the logic behind the "Average SLQ" and "Items Ordered Above/Below SLQ" calculations. The overall model calculates the information as provided in Table 4 automatically by simply modifying the demand and lead-time in the "CHANGING CELLS" box, as shown in Figure 6 or 7. So changing those two numbers will recalculate all of the "Items Ordered Above/Below SLQ" and "Average SLQ" fields instantly, to provide the summary output as shown in Table 4. The purpose of this section was describe what the "Average SLQ" and "Items Ordered

Above/Below SLQ" actually are, as well as how they are derived, for these two bits of information will be the cornerstone to analyzing the differing requisitioning patterns.

Model Assumptions

This research makes a variety of assumptions (some of which were already alluded too) not only to make the model function properly, but also to create a heuristic that is practical enough to be actually used by FMS countries. As stated previously, one assumption is that the demand and lead-times can be forecasted over the next four year SLQ period. As will be shown in Chapter IV when examining the tables and graphs for various combinations of demand and lead-times, if an FMS country using this model determines that either the demand and/or lead-times may change in the future, they can make a management decision to err on the side of having more or less SLQ levels, and select the appropriate order-per-period requisitioning policy.

For example, if the best ordering cycle was to place one order every year (4 orders per SLQ period) for a quantity of 40 (demand = 160 over SLQ period) with a lead-time of 2 years, but it was believed that the item lead-time might be reduced to only 1 year; and with a 1 year lead-time, the best ordering policy would be to order every six months in this example. With this information, management could decide to go with a policy of ordering every six months instead of every year right now. Under the present lead-time, that would increase the average SLQ by 10 items, of which the FMS country would be paying 5/17 of the value of those items, yet this would ensure a more consistent level of service if the lead-time did in the future drop from 24 to 12 months. Similar decisions can be made for potential changes in demand as well. The actual numbers used in this example were simply for illustrative purposes, but similar types of analysis will be examined in Chapter IV, and with the graphs and table to examine, these tradeoffs between demand, lead-time, average SLQ, and service level will become more readily apparent to the reader.

Another assumption is that the ordering cycle choices are only 1, 2, 4, 8, or 16 orders per SLQ cycle. Although customers can order an item as often as they wish, for the purposes of calculating the SLQ, SAMIS aggregates all of these orders into a single quantity ordered each quarter. Since the SLQ ordering cycle equals 16 quarters, then the choices of 1 and 16 are obvious; however, orders of 3, 5 to 7, and 9 to 15 per cycle are other possibilities not examined in this study. One reason why these orders per SLQ cycle possibilities are not used is because of the enormous possible combinations. With choices limited to 1, 2, 4, 8, or 16 they can be evenly spaced within the 16 quarters, so as to create only one pattern for each possibility. There is only one way that 1, 2, 4, 8, or 16 orders per a 16 quarter cycle can be evenly distributed (e.g. every quarter, every other quarter, etc.). That is not the case with the other choices. With a 6, 11, 14, or any other set of orders per the SLQ period, each one of them would have numerous ordering patterns.

For example if 10 orders per 16 quarter cycle were tested, then some quarters would have back-to-back orders while others would not. Every quarter a decision would have to be made on whether to place an order or not. Or an initial setup could be developed (e.g. quarter 1 order, quarter 2 order, quarter 3 no order...quarter 16 order) and that pattern could cycle continuously. The problem here is on its practical usefulness. The choices used for this research are to either order every quarter, every other quarter, once each year, every two years, or place only one order each SLQ cycle, or once every four years. If the choices became potentially to place requisitions two times the first year, three times the following year, and twice again during years three and four, as well as ordering at different quarters during each of those years, then the requisitioning policy is becoming much more complicated than by using a consistent ordering pattern of consistent quantities. More importantly, this added complexity does not benefit the analytical aspect of this model with respect to understanding the relationships between demand, lead-time, orders-per-cycle, average SLQs, and the number of nonprogrammed requisitions.

With regards to consistent quantities, it is also assumed that with 8 orders per SLQ period, for example, each of the 8 orders will be of the same quantities. This also makes logical sense when considering that the overall demand used to calculate the best ordering cycle would normally be consistent throughout the cycle. For example, there's no reason to believe that if the recurring demand during the four year SLQ period was 16 items that the demand would not be 4 per year, rather than 3 year 1, 9 year 2, 1 year 3, and then 3 year 4; consequently, with 8 orders per SLQ period, each order would be for 2 items when there is a demand level of 16.

With regards to model performance, even if varying sized orders did occur, the results would not show any improvements in either service levels or reduced cost over the consistently sized orders, because any order placed will be carried through all 16 quarters to determine the average SLQ. Since both the overall demand and number of orders during the SLQ period remain constant, by only changing the quantity of the orders (some up and some down to keep the overall SLQ period demand constant), the average SLQ will remain constant; however, the number of items ordered above the SLQ (i.e. nonprogrammed requisitions) will likely increase, because since some of the orders are being reduced and other increased, the orders with the increased quantity will be ordered against the same average SLQ at that particular quarter to determine which items will be coded programmed or nonprogrammed.

Although it is true that the smaller orders will be even further under the SLQ cap, that fact is of no consequence, because for instance if the SLQ is 20 and the order size is 19, 10, or 1, all of those items will be considered programmed requisitions. Normally the only disadvantage to orders extremely below the SLQ is that it indicates an potentially overly high SLQ average that the FMS customer is unnecessarily being charged for; however, in this example as stated previously, by keeping the overall demand and number of orders per SLQ period constant and only modifying the order size, the SLQ average remains constant, so cost is not a factor. So this assumption of equally sized orders poses no real disadvantage to the model.

The final assumption is that the orders will be spread evenly throughout the SLQ period, meaning that if 4 orders per SLQ period were chosen, that would equate to 1 order being placed every 4 quarters, not an order being placed at 4 consecutive quarters with the subsequent 12 quarters being free of any requisitions. As with the previous assumption, this makes not only intuitive sense from an inventory management viewpoint, but also is the optimal way of ensuring the most programmed requisitions. The reason is that if instead of 4 evenly spaced requisitions over the SLQ cycle there was a single clump of 4 quarters where all of the requisitions were placed, leaving the other 12 quarters void of any requisitions, then the results are similar to keeping a even distribution of orders but varying the quantity up on some orders and down others (to ensure a constant demand for the SLQ period).

What happens again is that while the SLQ average remains approximately the same, the number of orders above the SLQ at the time of the requisition increases, again increasing nonprogrammed orders and lowering customer service levels through poorer fill rates. This is because as the single clump of 4 orders in this example moves from quarter to quarter, at the time of the first order to repeat the cycle, the last clump of orders would have been placed in quarters 13, 14, 15, and 16. Since the CLSSA weighting factor reduces 6.25% each time a quarter has zero demand, during quarters 1 through 12 the weighting factor will be reduced each time, so when the requisition is actually placed the SLQ is at it's lowest level. So instead of requisitions being placed when the SLQ is at the highest level, clumping orders creates just the opposite affect.

Since in this example there is a clump of 4 quarters at which all of the requisitions are placed, when at the next quarter an order is placed, since an order was just placed in the previous quarter, the SLQ will go up dramatically, as it will during the next two quarters where items are ordered (again, given a 4 quarter ordering clump). However, as with the consistent ordering quantity assumption, there are no benefits from ordering below the SLQ, only disadvantages to ordering quantities above it, given equal SLQ averages. So this assumption of evenly spread requisitions over the SLQ period also does no real harm to the model usage, but does in fact make it simpler for FMS customers to implementing this model for actual inventory management purposes.

As discussed in this section, the basic assumptions are constant demand and lead-times throughout the SLQ period, orders-per-period of either 1, 2, 4, 8, or 16 evenly spread throughout the SLQ period, and equal order quantities. It is important to remember that CLSSA is not designed for day-to-day flightline inventory management, but rather for wholesale/depot resupply. When FMS customers are trying to create an inventory policy, in general, consistent and even resupply of items is easier to manage, stock, redistribute, etc. then constantly changing order quantities and requisitioning cycles. Additionally, this is not a model designed to recalculate optimal ordering patterns anew every quarter (unless there is a drastic item demand or lead-time change), but rather is a long-term, strategic requisitioning tool.

Selection of Analysis Categories

This section will discuss some of the parameters of the categories to be analyzed in Chapter 4. As stated in the previous section, order frequencies of 1, 2, 4, 8, and 16 orders per SLQ cycle will be examined. The two other parameters are lead-time and demand. The goal is to present realistic ranges, so FMS customers can directly use the tables and graphs without necessarily needing to run the model to their exact specifications. In some ways, the actual trends and general precepts can become a more valuable tool than running the model with specific numbers for a specific output, particularly if it changes some preconception of what a "good" ordering policy should be in the minds of FMS customers.

In general, procurement lead-time ranges from "1 to 60 months" and repair lead-times are "about 7 months" (6: 3-1). With this in mind, model runs with lead-times parameters of 7, 12, 24, 36, 48, and 60 months will be used. Lead-times less than six months lose significance with the SLQ calculations for a variety of reasons. First recall that with SLQs in general, ordering every quarter will always create the highest average SLQ because the weighting factor will never fall below 100%, since it's only reduced by 6.25% when there are zero orders in a particular quarter. So by examining the average SLQ and the number of items ordered over the SLQ using the 16 orders-per-period requisitioning policy, the significance of comparing very small lead-times can be examined. Table 5 will be used as example of a very small lead-time analysis.

Since an examination of seven month lead-times will be used, both five and six month lead-times are close enough to seven, so as to become unnecessary, particularly with the other lead-times chosen being 12 months apart. However, with lead-times of one to four months there could be significant anomalies because they are so small, and because of the fact that SLQ is derived from the average monthly demand (which is the weighted requisition quantity divided by 48) times the lead-time in months, so extremely low lead-times could affect the SLQ is unusual manners.

Another factor concerning very short lead-times is that one point of the SLQ computation is to determine programmed versus nonprogrammed requisitions, with the reasoning that nonprogrammed orders are only guaranteed delivery of lead-time months away from the order. With lead-times of only one or two months, however, the importance of programmed requisitions becomes less critical, since the difference between programmed and nonprogrammed deliveries may be only a few weeks apart. It becomes much more significant with higher lead-times, especially when nonprogrammed requisitions have about a third of their requisitions taking more than 180 days to be filled, as was shown in the Chapter II fill rate examination.

Table 5 shows some examples of very small lead-times, with the headings of 1, 2, 3, 8, and 16 above each table indicating the order-per-period policy. As can be seen in the table, the only viable requisition frequency would be 16 orders-per-period, or basically every quarter. We can see from just looking at the 16 orders-per-period column, the number of orders above the SLQ gets smaller as the lead-time increases; for example, it goes from 32 to 12 to 0 to –16 for the demand of 48 items. So basically any item

Table 5. Low Lead-Time Analysis

Lead Time	Period Demand	Average SLQ					Items Ordered Above SLQ				
		1	*2*	*4*	*8*	*16*	*1*	*2*	*4*	*8*	*16*
1	16	1	1	1	1	1	15	14	12	8	0
1	48	1	1	1	1	1	47	46	44	40	32
1	160	2	2	2	3	3	159	158	152	144	112
1	1000	11	12	13	16	21	999	986	956	880	664
2	16	1	1	1	1	1	15	14	12	8	0
2	48	1	1	1	2	2	47	46	44	40	16
2	160	4	4	4	5	7	159	156	144	120	48
2	1000	22	24	26	32	42	997	972	912	760	328
3	16	1	1	1	1	1	15	14	12	8	0
3	48	2	2	2	2	3	47	46	40	32	0
3	160	5	6	6	8	10	159	154	140	104	0
3	1000	33	35	39	47	63	996	958	868	640	-8
4	16	1	1	1	1	1	15	14	12	8	0
4	48	2	2	3	3	4	47	46	40	24	-16
4	160	7	8	9	10	13	159	150	132	80	-48
4	1000	44	47	52	63	83	995	942	824	520	-328

within this low range of lead-times would be best ordered every quarter. Items with demand levels smaller than 16 also portrayed similar patterns and with them as well, it appears that around a lead-time of 6 months, does it become important to critically analyze the requisitioning pattern. In this study seven months will be the bottom range, because of the stated seven month average for repair lead time; and the optimal requisitioning frequency for items with lead-times less than that will be 16 per SLQ period, or every quarter.

The next criteria range for Chapter IV analysis will be the various item demands during the SLQ period, which will be demand levels of 4, 8, 16, 48, 96, 160, and 1000 items per SLQ period. The low end of the spectrum is four items primarily because CLSSA is designed for recurring demands, and any demand that is less than one item per year cannot be considered *recurring*. The high-end demand level of 1000 was based on discussions with AFSAC personnel (16:1) and previous research (15:90-113) on actual CLSSA demands levels.

Additionally, initial model runs indicate a continuous trend of a proportionally increasing number of orders above the SLQ after approximately a demand level of 100, so additional tests using higher demand levels above 160 and 1000 really wouldn't provide substantially more information. Finally, the remaining intermediary demand numbers were normally multiples of 16 (when above 16 and less than 1000) and gradually increasing, since the lower numbers tended to be more sensitive then larger numbers and provided more useful information. Multiples of 16 were used to simplify the model, so as to eliminate the need for fractional order quantities.

With respect to using large demand levels, even though investment items were the focus of comparing the differences between programmed and nonprogrammed requisitions as explained in Chapter II, expense item requisitioning strategies can still benefit from this SLQ analysis, even though according AFSAC, both DLA and USAF CLSSA expense item requisitions have *all* been coded programmed since 1996. Therefore, using this SLQ analysis for determining effective requisitioning strategies for expense items would not entail trying to ensure programmed support of items, but rather to achieve the lowest average SLQ possible, so as to pay the smallest 5/17 charge of the average SLQ. This would at least be an important goal with respect to reducing overall CLSSA program cost to FMS countries. Of course, other inventory management principles may outweigh the need to minimize SLQ levels.

So based on the previous discussions concerning orders-per-period, items demand levels during the SLQ period, and item lead-times, the basic categories to be analyzed in Chapter IV are in summary:

- Orders per SLQ Period = 1, 2, 4, 8, 16
- Lead-Time in Months = 7, 12, 24, 36, 48, 60
- Demand per SLQ Period = 4, 8, 16, 48, 96, 160, 1000

These analysis categories should be more than sufficient for the FMS customer to be able to understand how their requisitioning policy controls their program costs, as well as service levels; and give them information on creating a improved ordering policy. In addition, research questions two through four of this thesis can also be answered by analyzing these categories of requisitioning cycle, lead-time, and demand.

Summary

The goal of this chapter was to describe how research questions two through four, all of which relate to the affects of FMS country requisitioning frequency and patterns on SLQ levels that directly determine cost and service levels. First the author-created Microsoft® Excel 97 software model that mimics the CLSSA weighted moving average formulation for calculating SLQ levels was described, to provide the reader with an understanding of how the average SLQ and the number of items ordered above the SLQ are actually derived.

This was followed by the model assumptions, which include constant demand and lead-time, specific orders-per-period, and evenly spaced orders of equal quantity. It was determined that none of these assumptions adversely affect either model effectiveness or actual usage by FMS customers. Finally the various categories to be analyzed in the next chapter were described, with rationales given for each of them. With the foundation laid in Chapters II, and this chapter's examination of the methodology now complete, the purpose of Chapter IV will be to analyze the data using the model and answer the research questions.

IV. Analysis and Results

Introduction

This chapter is designed not only to provide an analysis of the data revealed through various model runs and simply then present the results, but rather it is designed to provide a viable tool to the FMS country inventory managers for creating a successful requisitioning strategy, using the information provided within this document. Therefore, the same basic model outputs will be discussed in a variety of manners to provide FMS customers with different ways of viewing their own inventory policies in light of these results. These examinations of the output through several windows will also enable any reader to better understand the implications of the data because, since one perspective of the results can often highlight aspects that other perspectives do not. Appendix C provides all of the figures and tables used in this chapter for ease of field use.

First this chapter will provide an overview of the research up to this point to place the facts, figures, and other details within the wider scope of this study. Then the model output data will be analyzed from the point of view of having a constant demand, so as to examine the result of varying lead-times. Next the lead-time will become the constant to provide a method for testing the influence of demand variations, followed by the orders-per-period choices becoming the constant to allow for additional analysis alternatives. A brief exploration of the factors to consider when establishing a requisitioning policy for expense item will then be separately analyzed, since expense items traditionally are always coded programmed, so the normal ordering policy rules do not apply. Finally, a summary of the ideal requisitioning strategy will be discussed based on the model outputs, and the goal of 100% programmed requisitions at the lowest cost.

Overview

To more fully understand the thrust behind this analysis, and to better relate the results with the overall theme of this study, a brief summary of what this thesis has accomplished up to this point will be reviewed. CLSSA provides follow-on supply support to FMS customers for recurring demands, and these requests are coded either programmed or nonprogrammed (Chapter II demonstrated the importance of programmed support) based in part on if the order is above or below the SLQ level at the time of the order. The SLQ is calculated using FMS customer requisitioning patterns, and although a high SLQ is advantageous for the purposes of maximizing programmed orders, because FMS customers pay an up-front charge of 5/17 the value of the SLQ, a balanced ordering policy that ensures maximum programmed support while minimizing the 5/17 charge produces the ideal CLSSA requisitioning strategy.

Current requisitioning guidance to given FMS customers is to encourage regular orders of smaller quantities, over fewer orders of larger quantities. This analysis will provide FMS country inventory managers with a more detailed requisitioning guidance based on their item demands, item lead-times, and orders-per-period policy, with the goal of ensuring an SLQ that is high enough so when they place their orders, all items will be coded programmed, while at the same time maintaining the lowest possible SLQ average to keep their 5/17 charge at a minimum. Additionally, FMS customers can use the requisitioning strategies provided in this research to work in conjunction with their other inventory management policies, because they will be able to tailor their requisitioning decisions and identify the trade-offs with choosing an alternate ordering pattern to the ones described at the "best" in this thesis.

Demand as a Constant

The analysis in this section will concentrate identifying the best ordering strategies, given that the demand is at some known level. Figure 9 displays one table and two graphs, where the demand level is 4 items over the 4 year SLQ period. This layout will be identical in the analysis for demands of 8, 16, 48, 16, 160, and 1000, so the explanation of Figure 9 will be more detailed than the others. The values filling the table are derived from running the model as described in Chapter III, Figure 6, where the "Average SLQ" and "Items Ordered Above/Below SLQ" are derived by changing the number of orders-per-period and lead-times, and then running the model for each combination. The demand for Figure 9 is fixed at 4, and the lead-times used (7 through 60 months) are displayed on the left and right margins of the table, and across the top are the orders-per-period. The values for orders-per-period of 8 and 16 are N/A because an item with a demand of 4 per period cannot be order 8 or 16 times per period, since half and quarter items cannot be ordered.

The table is split into two halves, with the one on the left showing the average SLQ that is the basis for the 5/17 charge, so here lower numbers are ideal. The right half of the table displays the total number of items ordered above (positive) or below (negative) the SLQ, during the entire SLQ period. Since positive numbers indicate nonprogrammed orders, any value zero or below is ideal. It should be noted that while greater positive numbers indicated greater number of nonprogrammed items being ordered, this does not hold true for the negative numbers. For example in Figure 9 looking at 4 orders-per-period, the –8 is no better than –4, which is no better then 0, because as long as there are not any items being ordered *above* the SLQ, there is no added benefit to being way below the mark. Items ordered below the SLQ don't carry over to the next order; the key is simply to have all programmed orders, which in this table, equates to any value less than one.

The table would be read in this manner. For an item with a lead-time of 48 months, if the ordering policy was 2 orders-per-period (every other year), then the average SLQ would be 2.3, so the FMS customer would pay 5/17 of the cost of 2.3 items; and 2 items would be coded nonprogrammed during the SLQ period. Since there were 2 orders being placed of 2 items each, that means each time an order was placed 1 item would be coded programmed and 1 nonprogrammed. Remember that the number of items ordered above the SLQ is based on the SLQ at the time of the actual requisition, not the average SLQ. As discussed in Chapter III, the purpose of the average SLQ for the FMS customer is solely for calculating the 5/17 charge. The actual SLQ changes on a quarterly basis so again, the SLQ at the time of the order will determine the number of items coded programmed or nonprogrammed.

The shaded areas in the table indicate the "best" ordering-per-period policy for a given lead-time (based on 4 demands per SLQ period, or 1 demand per year, since the

Demand = 4

Lead Time In Months	Average SLQ: Orders per Period 1	2	4	8	16	Items Ordered Above/Below SLQ: Orders per Period 1	2	4	8	16	
7	1.0	1.0	1.0	N/A	N/A	3	2	0	N/A	N/A	7
12	1.0	1.0	1.0	N/A	N/A	3	2	0	N/A	N/A	12
24	1.3	1.1	1.0	N/A	N/A	3	2	0	N/A	N/A	24
36	1.8	1.6	2.0	N/A	N/A	3	2	-4	N/A	N/A	36
48	2.3	2.3	2.5	N/A	N/A	3	2	-4	N/A	N/A	48
60	2.8	2.9	3.3	N/A	N/A	3	0	-8	N/A	N/A	60

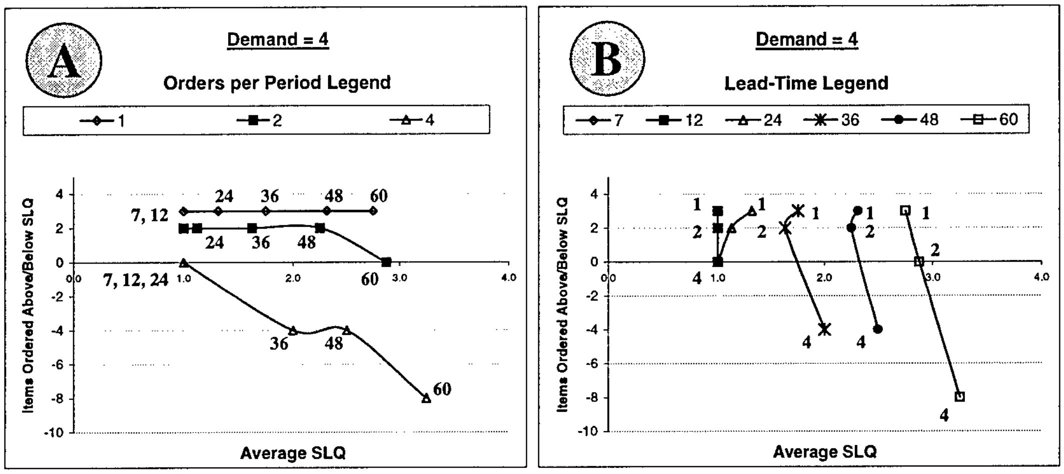


Figure 9. SLQ Analysis - Demand per SLQ Period = 4

SLQ period is 4 years). So if the lead-time for an item was 60 months, the best ordering strategy would be 2 orders-per-period because all items would be ordered programmed with the lowest average SLQ. An orders-per-period policy of 4 would also ensure all items coded programmed, however, the average SLQ would rise to 3.3 from 2.9, which means that an FMS customer would be paying the 5/17 charge on 0.4 more items for no added customer service by using 4 orders-per-period, since 4 and 2 orders-per-period both provide 100% programmed orders, yet it costs more for the 4 order-per-period strategy based on the higher SLQ average. The increase may be small in this example with a demand level of 4, however this is for only a single item, and a small cost savings multiplied by many items can add up to significant cost savings; additionally, the unit cost for this item might be very high. In any event, this logic will be the basis for determining the best or ideal ordering policy—100% programmed requisitions at the lowest average SLQ.

Although the shaded areas in the tables show an obvious pattern, the graphs in Figure 9 are provided to show trends more clearly. The Y-axis represents orders above or below the SLQ, so any point above the X-axis indicates nonprogrammed orders, and the higher above the X-axis, the greater number of items ordered nonprogrammed; points on or below the X-axis indicate 100% programmed orders. The X-axis represents the average SLQ, so left on the X-axis represents a lower 5/17 charge, while the 5/17 charge increases the further right points move. So from a graphical perspective, the general rule is to be as far to the left as possible, while remaining on or below the X-axis.

In Graph A, each line represents a specific order-per-period policy and measures the trends as the lead-time changes. The numbers beside the points on the graph indicate the specific lead-time for that particular point. As the graphs get more complex and the points become closer together, not all of the points will have such numbers representing each point, however, the critical ones surrounding the X-axis will be identified. Graph A can assist the FMS customer that already has set policies for the number of orders-per-period. They can easily see from the graph which order-per-period policy is on or below the X-axis and of those which are more to the left, for differing lead times. With a demand level of four, there is only one line below the X-axis, but as the demand levels increase, so will the choices.

In Graph B, the lines represent the different lead-times. So an FMS customer can take all of their items with demand levels of 4 and based on lead-times, can see which requisitioning policy is best. Here, the values beside the points along the lines on the graph indicate the specific ordering-per-period policy. Again, as the graphs become more complicated, not all of the points will be able to be identified because of their close proximity to each other, however, the ones around the X-axis will be given. So using Graph B, it becomes instantly apparent that any ordering-per-period policy of 1 or 2 will produce nonprogrammed orders until the 60 month lead-time is reached. Additionally, for any given lead-time, Graph B in Figure 9 clearly identifies the range of effects that different possible ordering-per-period policies has on both the average SLQ and the number of items ordered nonprogrammed.

As stated previously, the two graphs are using the same information as from the table, but simply are examining it from different perspectives, to provide FMS customers alternative ways for deciding upon the varying requisitioning strategies. Using a demand of 4 as in Figure 9 is the simplest, so the graphs here do not add considerable benefit to what the table already shows, yet they do provide a way for explaining the mechanics of the graphs and the relationships to each other, and to the table, as well as reinforce where the original data comes from. Each cell in the within each of the tables represents a single run of the SLQ computational model, as explained in Chapter III.

Figure 10 illustrates the same table/graph format, except for a demand level of 8 items each SLQ period, instead of 4. Again, the shaded areas in the table indicate the best orders-per-period strategy; the N/A values because there cannot be 16 orders-per-

period with a demand of 8 items per period. Although Graph A depicts the 8 orders-per-period line going out of the range of the graph, this was purposefully done so as to highlight the region more closely around the X-axis; a similar strategy was used for the subsequent graphs.

Demand = 8

Lead Time In Months	Average SLQ: Orders per Period 1	2	4	8	16	Items Ordered Above/Below SLQ: Orders per Period 1	2	4	8	16	
7	1.0	1.0	1.0	1.0	N/A	7	6	4	0	N/A	7
12	1.3	1.1	1.0	1.5	N/A	7	6	4	0	N/A	12
24	2.3	2.3	2.5	3.0	N/A	7	6	0	-16	N/A	24
36	3.3	3.4	3.8	4.5	N/A	7	4	-4	-24	N/A	36
48	4.5	4.5	5.0	6.0	N/A	7	2	-8	-40	N/A	48
60	5.4	5.6	6.3	7.5	N/A	7	2	-12	-48	N/A	60

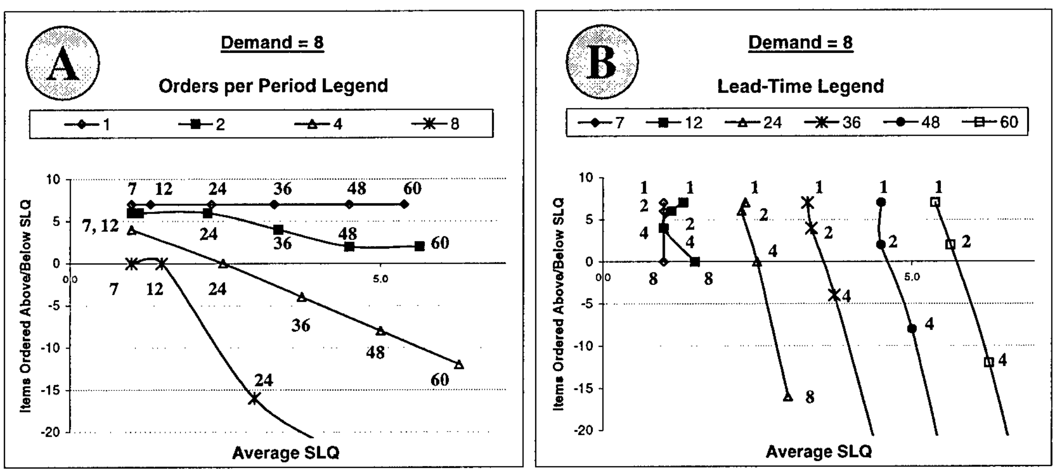


Figure 10. SLQ Analysis - Demand per SLQ Period = 8

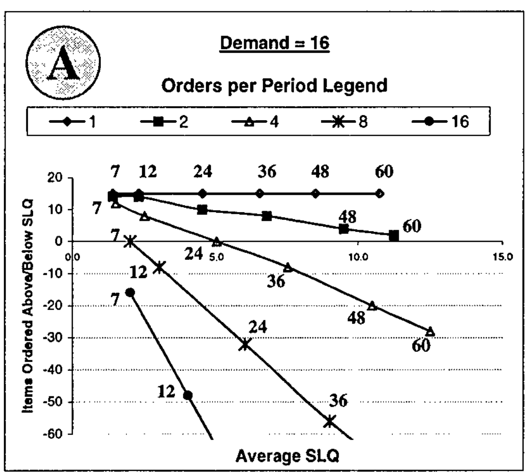
Graph B shows that if the lead-time was 48 or particularly 60 months, the 2 order per lead-time strategy is getting close to 100% programmed support, yet from the angles of the lines in the graph, the 4 orders-per-period point goes further to the right as it goes down the line, thus the greater the average SLQ becomes. So if these were relatively expensive items, the FMS customer might be use the 2 orders-per-period strategy at the 48 or 60 month lead-time, since it provides a lower SLQ and is just above the X-axis.

This is just an example of one of the ways FMS country inventory managers can use these graphs to make tailored requisitioning decisions, based on item cost, criticality, or other issues relating to the FMS country's overall inventory strategy.

Figure 11 is for items with a demand of 16. Ordering strategies of 8 and 16 orders-per-period represent the safest strategies as seen in Graph A, since all points are below the X-axis; this could be a useful requisitioning strategy for FMS customers who desire a single, conservative, ordering policy for all of their items with a demand level of approximately 16, regardless of the lead-time. As the lead-times increase, any given ordering-per-period strategy remains constant or angles downward, indicating reduced orders with respect to the SLQ.

Demand = 16

	Orders per Period	Average SLQ 1	2	4	8	16	Items Ordered Above/Below SLQ 1	2	4	8	16	
	7	1.4	1.4	1.5	2.0	2.0	15	14	12	0	-16	7
Lead	12	2.3	2.3	2.5	3.0	4.0	15	14	8	-8	-48	12
Time	24	4.5	4.5	5.0	6.0	8.0	15	10	0	-32	-112	24
In	36	6.5	6.8	7.5	9.0	12.0	15	8	-8	-56	-176	36
Months	48	8.5	9.5	10.5	12.5	16.0	15	4	-20	-80	-240	48
	60	10.8	11.3	12.5	15.0	20.0	15	2	-28	-96	-304	60



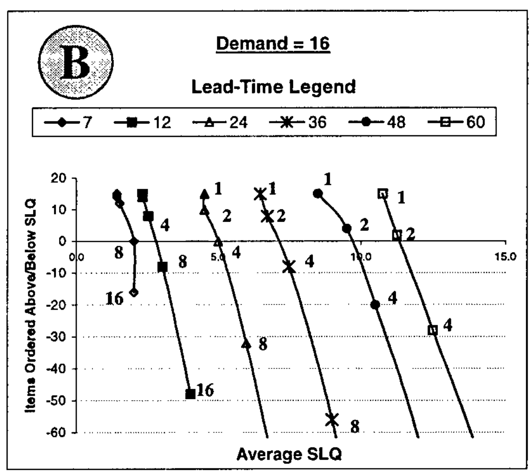


Figure 11. SLQ Analysis - Demand per SLQ Period = 16

From Graph B it can be easily seen that increasing lead-times increases average SLQ, and ordering-per-period strategies such as 2 or 4 that are unacceptable at lead-times of 7 or 12 months, become better strategies as lead-times increase. Similar to the demand level of 8, at the 60 month lead-time line in Graph B, the 2 order-per-period policy is only slightly above the X-axis, so in this case the option of using the 2 order-per-period policy, while not ideal because of the nonprogrammed orders, may be considered for certain high cost items where the lower average SLQ may be the overriding factor.

The data in Figure 12 show that for the first time, a policy of ordering every quarter is now ideal for items with a demand of 48 and lead-time of 7 months. However, if there is some question on the accuracy or consistency of the lead-times, then the FMS customer can make some judgements using these graphs. For example, if the lead-time

Demand = 48

		Average SLQ					Items Ordered Above/Below SLQ					
Orders per Period		1	2	4	8	16	1	2	4	8	16	
	7	3.8	3.9	4.5	5.0	7.0	47	44	32	8	-64	7
Lead	12	6.5	6.8	7.5	9.0	12.0	47	40	24	-24	-144	12
Time	24	13.0	13.5	15.0	18.0	24.0	46	32	-4	-88	-336	24
In	36	19.3	20.3	22.5	27.0	36.0	46	24	-28	-160	-528	36
Months	48	25.5	27.5	30.5	36.5	48.0	45	14	-56	-232	-720	48
	60	32.0	33.8	37.5	45.0	60.0	44	6	-80	-296	-912	60

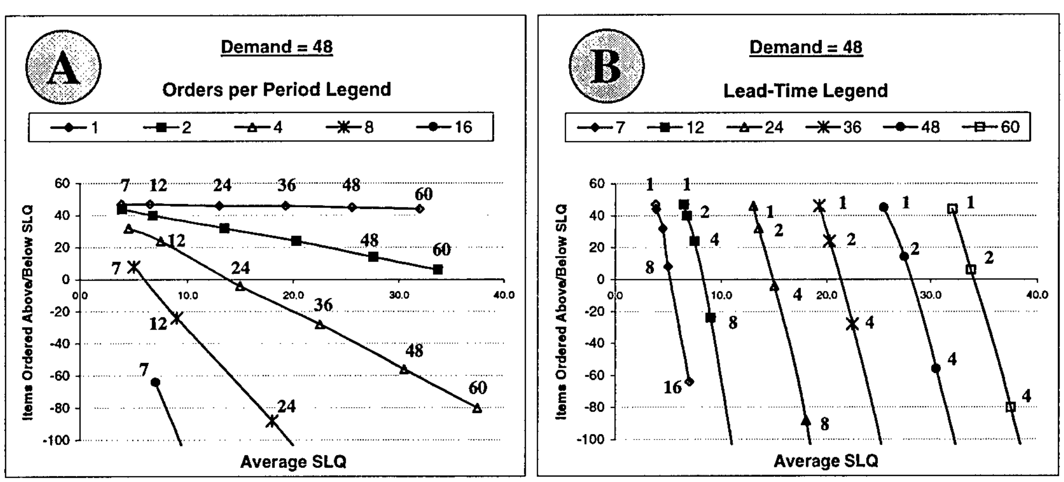


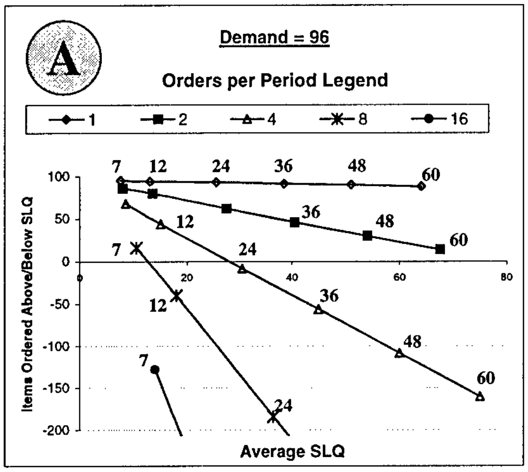
Figure 12. SLQ Analysis - Demand per SLQ Period = 48

varied between 7 and 12 months, or the FMS country has indications that it might move from 7 to 12 months, then Graph B illustrates that it might be beneficial to just go with the 8 orders-per-period, since the 8 orders-per-period value is fairly close to the X-axis. Through their knowledge of the criticality of fast delivery versus the item cost, the compromise of reducing the average SLQ by 2 items now, and possibly 3 in the future should the lead-time change, might be worth the nonprogrammed orders in the event that the lead-time does not change.

It is important to remember that if the item lead-time changes in the future and at that point the ordering strategy adjusts accordingly then that modification to the order-per-period policy after the lead-time change would be effective. However, since the SLQ computation is based on the *previous* 16 quarters, any modifications to the orders-per-period policy *now* based on anticipated *future* changes to either the demand and/or lead-time (the two critical factors in SLQ computations) will produce the improvements in either lower costs or better service levels more rapidly. Therefore it would be to the FMS country's best interest not to simply take the ideal requisitioning policy and apply it, but for critical or high cost items, examine the graphs and tables in light of any future changes, and be knowledgeable of the trends, so at least the ordering policy is going in the same direction. In other words, there will undoubtedly be differences between actual demands and lead-times to those depicted in these graphs and tables; however, when placing the actual numbers along the graphical trend lines, then the inventory manager of the FMS country can vary their requisitioning policy based on those trends, as well as their knowledge of potential future changes.

Demand = 96

Lead Time In Months	Orders per Period	Average SLQ					Items Ordered Above/Below SLQ					
		1	2	4	8	16	1	2	4	8	16	
	7	8	8	9	11	**14**	95	86	68	16	**-128**	7
	12	13	14	15	**18**	24	94	80	44	**-40**	-288	12
	24	26	28	**31**	37	48	93	62	**-8**	-184	-672	24
	36	39	41	**45**	54	72	91	46	**-56**	-320	-1056	36
	48	51	54	**60**	72	96	90	30	**-108**	-456	-1440	48
	60	64	68	**75**	90	120	88	14	**-160**	-592	-1824	60



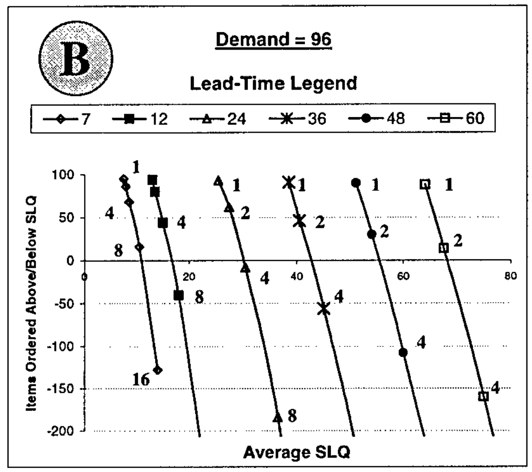


Figure 13. SLQ Analysis - Demand per SLQ Period = 96

Another analysis example would be if an FMS country inventory manager wished for a consistent orders-per-period policy for items with a demand level of approximately 96. By examining Graph A on Figure 13, it could be seen that while 4 orders-per-period provides the best combination of low average SLQ for 100% programmed requisitions for the most lead-time variations, an ordering policy of 8 per period as a more conservative estimate might be the best, especially if a majority of the items had shorter lead-times and the items were of a critical nature. Conversely, if the items were important but not especially critical, then the policy of ordering this category of items only once each year (4 orders-per-period) might make more sense, as well as be much simpler a policy to implement, since it would be just an single requisition at the same time each year.

With larger demand items, although the magnitude of the figures increase, the patterns remain basically the same. So rather than displaying the tables and graphs for the 160 and 1000 demand categories here, they can be seen in Appendix C with the other ones. Table 6 provides a summary of all of the previous figures shown (including the 160 and 1000 demand items) in each of the previous tables, with the demand level as the constant by which the other variables (orders-per-period and lead-time) are modified to determine the impact of their variations. The shaded boxes indicate the best ordering-per-period policy for each of the lead-times.

Research questions two and three of this thesis addressed how customer service levels and costs were altered by the requisitioning patterns of the FMS customer. Several examples can be used to identify the impact, by examining data from Table 6. For instance if the FMS customer is placing orders every quarter (16 orders-per-period) for their items with demand levels of 16 with lead-times of 24 months, that means that the average SLQ is 8 instead of 5 that it would be under the 4 order-per-period policy, which is a 60% increase in average SLQ, or a 60% increase in cost to the FMS customer. So in this example the FMS customer is paying 60% more, for no added benefit in service, since both order policies ensure 100% programmed support, which result in the improved fill rates compared to nonprogrammed requisitions.

If this same FMS customer had a constant policy of ordering only once a year (4 orders-per-period) for their items with a demand level of 16, then generally speaking, for all of the items with lead-times of 12 months or less, the FMS customer through their

Table 6. SLQ Analysis with Constant Demand Summary

	Orders per Period ====>	Average SLQ 1	2	4	8	16	Items Ordered Above/Below SLQ 1	2	4	8	16	
	7	1.0	1.0	**1.0**	N/A	N/A	3	2	**0**	N/A	N/A	Demand per Period 4
	12	1.0	1.0	**1.0**	N/A	N/A	3	2	**0**	N/A	N/A	
	24	1.3	1.1	**1.0**	N/A	N/A	3	2	**0**	N/A	N/A	
	36	1.8	1.6	**2.0**	N/A	N/A	3	2	**-4**	N/A	N/A	
	48	2.3	2.3	**2.5**	N/A	N/A	3	2	**-4**	N/A	N/A	
	60	2.8	**2.9**	3.3	N/A	N/A	3	**0**	-8	N/A	N/A	
	7	1.0	1.0	1.0	**1.0**	N/A	7	6	4	**0**	N/A	Demand per Period 8
	12	1.3	1.1	1.0	**1.5**	N/A	7	6	4	**0**	N/A	
L	24	2.3	2.3	**2.5**	3.0	N/A	7	6	**0**	-16	N/A	
E	36	3.3	3.4	**3.8**	4.5	N/A	7	4	**-4**	-24	N/A	
A	48	4.5	4.5	**5.0**	6.0	N/A	7	2	**-8**	-40	N/A	
D	60	5.4	5.6	**6.3**	7.5	N/A	7	2	**-12**	-48	N/A	
	7	1.4	1.4	1.5	**2.0**	2.0	15	14	12	**0**	-16	Demand per Period 16
	12	2.3	2.3	2.5	**3.0**	4.0	15	14	8	**-8**	-48	
	24	4.5	4.5	**5.0**	6.0	8.0	15	10	**0**	-32	-112	
T	36	6.5	6.8	**7.5**	9.0	12.0	15	8	**-8**	-56	-176	
I	48	8.5	9.5	**10.5**	12.5	16.0	15	4	**-20**	-80	-240	
M	60	10.8	11.3	**12.5**	15.0	20.0	15	2	**-28**	-96	-304	
E	7	3.8	3.9	4.5	5.0	**7.0**	47	44	32	8	**-64**	Demand per Period 48
	12	6.5	6.8	7.5	**9.0**	12.0	47	40	24	**-24**	-144	
	24	13.0	13.5	**15.0**	18.0	24.0	46	32	**-4**	-88	-336	
	36	19.3	20.3	**22.5**	27.0	36.0	46	24	**-28**	-160	-528	
	48	25.5	27.5	**30.5**	36.5	48.0	45	14	**-56**	-232	-720	
I	60	32.0	33.8	**37.5**	45.0	60.0	44	6	**-80**	-296	-912	
N	7	8	8	9	11	**14**	95	86	68	16	**-128**	Demand per Period 96
	12	13	14	15	**18**	24	94	80	44	**-40**	-288	
	24	26	28	**31**	37	48	93	62	**-8**	-184	-672	
	36	39	41	**45**	54	72	91	46	**-56**	-320	-1056	
M	48	51	54	**60**	72	96	90	30	**-108**	-456	-1440	
O	60	64	68	**75**	90	120	88	14	**-160**	-592	-1824	
N	7	12	13	15	18	**23**	159	144	112	24	**-208**	Demand per Period 160
T	12	22	23	25	**30**	40	157	132	76	**-72**	-480	
H	24	43	46	**51**	61	80	155	104	**-12**	-304	-1120	
S	36	64	68	**75**	90	120	152	78	**-96**	-528	-1760	
	48	85	90	**100**	120	160	150	50	**-180**	-760	-2400	
	60	107	113	**125**	150	200	147	22	**-264**	-992	-3040	
	7	77	82	91	110	**146**	991	900	692	160	**-1336**	Demand per Period 1000
	12	133	141	156	**188**	250	984	828	468	**-440**	-3000	
	24	266	281	**313**	375	500	969	656	**-64**	-1872	-7000	
	36	399	422	**469**	563	750	953	484	**-592**	-3312	-11000	
	48	532	563	**625**	750	1000	937	312	**-1124**	-4752	-15000	
	60	664	703	**781**	938	1250	922	140	**-1656**	-6184	-19000	

own ordering policy would be creating nonprogrammed orders for approximately 50% of their items for those items with lead-time of 12 months (8 out of 16), and for 75% of the items with lead-times of 7 months (12 out of 16).

Worse yet is the FMS customer without any knowledge of these facts and relationships in ordering patterns and frequency, since ordering in a haphazard manner usually ends up being a series of large orders followed by a series of quarters with zero orders. This would mostly closely match the 1 or 2 orders-per-period policy and as shown in Table 6, which would dramatically increase nonprogrammed order, thus reduce service levels; and again, solely because of the requisitioning policy of the FMS country rather any some uncontrollable external factors. Conversely, if the FMS country blindly followed the advice offered by AFSAC and placed requisitions at every quarter for small quantities, Table 6 clearly shows the additional costs incurred through the 5/17 charge because of the increase in the average SLQ—an increase which provides zero added benefit to reducing nonprogrammed orders in most cases.

Lead-Time as a Constant

Table 7 provides a summary of the information except grouped by lead-time instead of demand level, because it is possible that an FMS country may categorize their items in this manner, since the lead-time is readily available from AFSAC databases. Even though the shaded boxes indicated the ideal order-per-period policy for a given demand level, at each lead-time category, other strategies can be developed by employing this table.

For example, by using the data in the lead-time segregated format, an FMS customer can examine this table and form a simple requisitioning policy where all items with lead-times around 7 months will be ordered quarterly, items with lead-times of 12

Table 7. SLQ Analysis with Constant Lead-Times

Lead Time	Demands per Period	Average SLQ: Orders per Period 1	2	4	8	16	Items Ordered Above/Below SLQ: Orders per Period 1	2	4	8	16
Lead Time 7	4	1.0	1.0	**1.0**	N/A	N/A	3	2	**0**	N/A	N/A
	8	1.0	1.0	1.0	**1.0**	N/A	7	6	4	**0**	N/A
	16	1.4	1.4	1.5	**2.0**	2.0	15	14	12	**0**	**-16**
	48	3.8	3.9	4.5	5.0	**7.0**	47	44	32	8	**-64**
	96	7.5	7.9	8.5	10.5	**14.0**	95	86	68	16	**-128**
	160	12.4	13.0	14.5	17.5	**23.0**	159	144	112	24	**-208**
	1000	77.4	82.0	91.3	109.5	**146.0**	991	900	692	160	**-1336**
Lead Time 12	4	1.0	1.0	**1.0**	N/A	N/A	3	2	**0**	N/A	N/A
	8	1.3	1.1	1.0	**1.5**	N/A	7	6	4	**0**	N/A
	16	2.3	2.3	2.5	**3.0**	4.0	15	14	8	**-8**	-48
	48	6.5	6.8	7.5	**9.0**	12.0	47	40	24	**-24**	-144
	96	13.0	13.5	15.0	**18.0**	24.0	94	80	44	**-40**	-288
	160	21.5	22.5	25.0	**30.0**	40.0	157	132	76	**-72**	-480
	1000	132.9	140.6	156.3	**187.5**	250.0	984	828	468	**-440**	-3000
Lead Time 24	4	1.3	1.1	**1.0**	N/A	N/A	3	2	**0**	N/A	N/A
	8	2.3	2.3	**2.5**	3.0	N/A	7	6	**0**	-16	N/A
	16	4.5	4.5	**5.0**	6.0	8.0	15	10	**0**	-32	-112
	48	13.0	13.5	**15.0**	18.0	24.0	46	32	**-4**	-88	-336
	96	25.5	27.5	**30.5**	36.5	48.0	93	62	**-8**	-184	-672
	160	42.5	45.5	**50.5**	60.5	80.0	155	104	**-12**	-304	-1120
	1000	265.8	281.3	**312.5**	375.0	500.0	969	656	**-64**	-1872	-7000
Lead Time 36	4	1.8	1.6	**2.0**	N/A	N/A	3	2	**-4**	N/A	N/A
	8	3.3	3.4	**3.8**	4.5	N/A	7	4	**-4**	-24	N/A
	16	6.5	6.8	**7.5**	9.0	12.0	15	8	**-8**	-56	-176
	48	19.3	20.3	**22.5**	27.0	36.0	46	24	**-28**	-160	-528
	96	38.5	40.5	**45.0**	54.0	72.0	91	46	**-56**	-320	-1056
	160	64.0	67.5	**75.0**	90.0	120.0	152	78	**-96**	-528	-1760
	1000	398.5	421.9	**468.5**	562.5	750.0	953	484	**-592**	-3312	-11000
Lead Time 48	4	2.3	2.3	**2.5**	N/A	N/A	3	2	**-4**	N/A	N/A
	8	4.5	4.5	**5.0**	6.0	N/A	7	2	**-8**	-40	N/A
	16	8.5	9.5	**10.5**	12.5	16.0	15	4	**-20**	-80	-240
	48	25.5	27.5	**30.5**	36.5	48.0	45	14	**-56**	-232	-720
	96	51.0	54.0	**60.0**	72.0	96.0	90	30	**-108**	-456	-1440
	160	85.0	90.0	**100.0**	120.0	160.0	150	50	**-180**	-760	-2400
	1000	531.5	562.5	**625.0**	750.0	1000.0	937	312	**-1124**	-4752	-15000
Lead Time 60	4	2.8	**2.9**	3.3	N/A	N/A	3	**0**	-8	N/A	N/A
	8	5.4	5.6	**6.3**	7.5	N/A	7	2	**-12**	-48	N/A
	16	10.8	11.3	**12.5**	15.0	20.0	15	2	**-28**	-96	-304
	48	32.0	33.8	**37.5**	45.0	60.0	44	6	**-80**	-296	-912
	96	64.0	67.5	**75.0**	90.0	120.0	88	14	**-160**	-592	-1824
	160	106.5	112.5	**125.0**	150.0	200.0	147	22	**-264**	-992	-3040
	1000	664.1	703.1	**781.0**	937.5	1250.0	922	140	**-1656**	-6184	-19000

months would be ordered every other quarter, and all other items every four quarters, or annually. While this might not be the ideal choice for every lead-time/demand category, it would provide an FMS customer with a simple requisitioning policy the might prove to do as well as a more complicated one. And while every FMS country will need to tailor a requisitioning policy around their overall inventory strategy, the afor mentioned ordering pattern could be a part of such a strategy.

For instance the FMS country could use a rough estimate of their four year demand, and then order it at one of the above stated intervals based on the approximate lead-time of the items. If as time passes and the demand level goes up or down, then slight variations will be of little consequence. For example, if instead of ordering 8 items per year for a previously forecasted demand of 24 items per SLQ period, the customer could add a certain percentage above or below a given order, or place an additional order during of a small quantity during one of the "non-order" quarters.

The key here would be to not place a huge additional order with respect to the current requisitioning policy. Additionally, if the policy was one order per year and additional items were needed, then it would be better to wait until the halfway point between the two normal ordering points, to place this out-of-sequence order. So for instance if orders for 6 items were placed at quarters 4, 8, 12, and 16 but 2 additional items were needed, then it would be best to add one item to each requisition at quarters 4 and 14.

Again, the whole point of this study and the examinations of these tables and graphs is to get the general flavor of the costs and benefits to various requisitioning policies, since it is unlikely that FMS customers will have items that exactly match the criteria used in this study; the information here is provided as guide from which to developed a long-term requisitioning strategy. The basic knowledge that, for items with lead-times of two years and above, it is not cost effective to place requisitions more than once a year (at least with respect to the CLSSA 5/17 FMSO I case charge) can be a very valuable part of a total inventory management plan, perhaps incorporated into the FMS customers total cost equations they used to manage their inventory overall. So the main thrust of presenting and analyzing the data as displayed in Table 7 is to provide yet another format for depicting the effect FMSO II case requisitioning patterns and frequency have on service levels and CLSSA cost to the FMS customer.

Orders-per-Period as a Constant

Table 8 looks at the same basic data with respect to the number of orders-per-period as constant, rather than either the demand level or lead-times as with the previous two tables. This format was selected because unlike either demand levels that must be forecasted or lead-time that is provided to the FMS customer and is always subject to change, the order-per-period policy is the sole factor completely in the control of each FMS country. They can place their FMSO II requisitions at any quarter they choose, so Table 8 provides the impact of selecting an ordering pattern and frequency from the perspective of the different orders-per-period.

In addition, while each of the previous tables depicts the different trends, Table 8 singularly provides the most obvious visual impression of the impact created by the different ordering policies. By looking at the "Items Ordered Above/Below SLQ" section of the table, it is clear that all of the positive numbers are above the 4 orders-per-period category, while all of negative numbers lie below. And although the positive numbers here indicate actual number of items being ordered nonprogrammed, the negative numbers, particularly the large ones with respect to the demand levels, provide an signal to examine the left section of the table, "Average SLQ" to determine how much additional SLQ the FMS country is paying for, with no additional benefit.

Table 8. SLQ Analysis with Constant Orders Per SLQ Period

Orders per Period	LEAD TIME IN MONTHS	Average SLQ							Items Ordered Above/Below SLQ						
	Demand =======>	4	8	16	48	96	160	1000	4	8	16	48	96	160	1000
Orders per Period 1	7	1.0	1.0	1.4	3.8	7.5	12.4	77.4	3	7	15	47	95	159.0	991.0
	12	1.0	1.3	2.3	6.5	13.0	21.5	132.9	3	7	15	47	94	157.0	984.0
	24	1.3	2.3	4.5	13.0	25.5	42.5	265.8	3	7	15	46	93	155.0	969.0
	36	1.8	3.3	6.5	19.3	38.5	64.0	398.5	3	7	15	46	91	152.0	953.0
	48	2.3	4.5	8.5	25.5	51.0	85.0	531.5	3	7	15	45	90	150.0	937.0
	60	2.8	5.4	10.8	32.0	64.0	106.5	664.1	3	7	15	44	88	147.0	922.0
Orders per Period 2	7	1.0	1.0	1.4	3.9	7.9	13.0	82.0	2	6	14	44	86	144	900.0
	12	1.0	1.1	2.3	6.8	13.5	22.5	140.6	2	6	14	40	80	132	828.0
	24	1.1	2.3	4.5	13.5	27.5	45.5	281.3	2	6	10	32	62	104	656.0
	36	1.6	3.4	6.8	20.3	40.5	67.5	421.9	2	4	8	24	46	78	484.0
	48	2.3	4.5	9.5	27.5	54.0	90.0	562.5	2	2	4	14	30	50	312.0
	60	2.9	5.6	11.3	33.8	67.5	112.5	703.1	0	2	2	6	14	22	140.0
Orders per Period 4	7	1.0	1.0	1.5	4.5	8.5	14.5	91.3	0	4	12	32	68	112	692
	12	1.0	1.0	2.5	7.5	15.0	25.0	156.3	0	4	8	24	44	76	468
	24	1.0	2.5	5.0	15.0	30.5	50.5	312.5	0	0	0	-4	-8	-12	-64
	36	2.0	3.8	7.5	22.5	45.0	75.0	468.5	-4	-4	-8	-28	-56	-96	-592
	48	2.5	5.0	10.5	30.5	60.0	100.0	625.0	-4	-8	-20	-56	-108	-180	-1124
	60	3.3	6.3	12.5	37.5	75.0	125.0	781.0	-8	-12	-28	-80	-160	-264	-1656
Orders per Period 8	7	N/A	1.0	2.0	5.0	10.5	17.5	109.5	N/A	0	0	8	16	24	160
	12	N/A	1.5	3.0	9.0	18.0	30.0	187.5	N/A	0	-8	-24	-40	-72	-440
	24	N/A	3.0	6.0	18.0	36.5	60.5	375.0	N/A	-16	-32	-88	-184	-304	-1872
	36	N/A	4.5	9.0	27.0	54.0	90.0	562.5	N/A	-24	-56	-160	-320	-528	-3312
	48	N/A	6.0	12.5	36.5	72.0	120.0	750.0	N/A	-40	-80	-232	-456	-760	-4752
	60	N/A	7.5	15.0	45.0	90.0	150.0	937.5	N/A	-48	-96	-296	-592	-992	-6184
Orders per Period 16	7	N/A	N/A	2	7	14	23	146	N/A	N/A	-16	-64	-128	-208	-1336
	12	N/A	N/A	4	12	24	40	250	N/A	N/A	-48	-144	-288	-480	-3000
	24	N/A	N/A	8	24	48	80	500	N/A	N/A	-112	-336	-672	-1120	-7000
	36	N/A	N/A	12	36	72	120	750	N/A	N/A	-176	-528	-1056	-1760	-11000
	48	N/A	N/A	16	48	96	160	1000	N/A	N/A	-240	-720	-1440	-2400	-15000
	60	N/A	N/A	20	60	120	200	1250	N/A	N/A	-304	-912	-1824	-3040	-19000

When a FMS customer compares their requisitioning history with this table and finds that they are ordering more in the ranges to the top or bottom of Table 8, this can point them into the proper direction for a deeper analysis of their data. That deeper analysis can be done by using some of the other graphs and tables not only within this chapter, but also in Chapter II which provide actual numerical differences in fill rates for the programmed and nonprogrammed items. Perhaps the FMS customer finds that they are making more nonprogrammed orders then they need to; however, after examining the fill rate tables in Chapter II, decide that the differences are not significant enough to warrant a change, but at least the knowledge of the impact of their requisitioning policy is now understood.

If CLSSA program cost is the most important factor rather than service levels, then eliminating an ordering policy of 8 or 16 requisitions per SLQ period altogether may be the answer. A change from a requisitioning policy of one order every quarter, to one order every year can have significant impacts to the average SLQ and ultimately to the 5/17 charge FMS customers pay on that average, especially for items with very high lead-times. Table 8, as well as the other tables, can provide the amount of those savings by calculating the difference in the average SLQ from one orders-per-period strategy to another, and then multiplying that number by the unit cost of the item to determine the 5/17 CLSSA FMSO I charge. So Table 8 is another format for FMS inventory managers participating in CLSSA to adjust their ordering policy by analyzing the model output data from the viewpoint of constant orders-per-period.

Expense Items

Earlier it was stated that since 1996, all requisitions for USAF and DLA expense items were being coded programmed. With that information, then the ideal ordering policy for all expense items would be once every four years, or once every SLQ period. That would produce the smallest average SLQ, therefore the lowest total cost of the

CLSSA program. On the one hand this might seem like a difficult policy for an FMS country to manage—having this huge influx of parts coming in every four years. On the other hand, CLSSA is designed for wholesale support to the customer, meaning it is going to a depot-like facility in the FMS country, or should be; however, the potentially large influx of items would be another factor for the FMS country to consider.

Yet placing requisitions only once every four years does not necessarily imply that *every* item is ordered at the exact same quarter. In our 16 quarter world, 1/16 of the expense items could be requisitioned at the first quarter, then another 1/16 at the next quarter, and so on. This would produce a requisitioning policy aimed at keeping the average SLQ at the lowest possible point, and it could be done in such a way so as only 1/16 of the total expense items are being requisitioned, and thus entering the FMS country, during any given quarter. While there still may be other serious internal inventory issues that would preclude this requisitioning strategy, from a purely CLSSA lowest cost reasoning, it could be done. Based on this information, for the purposes of managing expense item requisitions, the CLSSA 5/17 charge can be reduced the most by a less frequent ordering policy.

Ideal Requisitioning Strategy Summary

Finally, only the best orders-per-period for the given demand and lead-time parameters, or the shaded areas from the previous tables, will be examined in a single, concise format, as shown in Figure 14. Graph A portrays how the optimal requisitioning strategy is to decrease the number of orders per SLQ period as the lead-time increases.

Recall from Table 5 in Chapter III, that for very small lead-times it was generally best to place orders every quarter (16 orders-per-period). Graph B illustrates that while it is better to increase the number of orders-per-period as the demand increases initially, items with low lead-times are more sensitive to the increases in demand, yet items with high lead-times less sensitive.

Best Order per Period Strategy

Lead Time In Months	Demand per Period: 4	8	16	48	96	160	1000
7	4	8	8	16	16	16	16
12	4	8	8	8	8	8	8
24	4	4	4	4	4	4	4
36	4	4	4	4	4	4	4
48	4	4	4	4	4	4	4
60	2	4	4	4	4	4	4

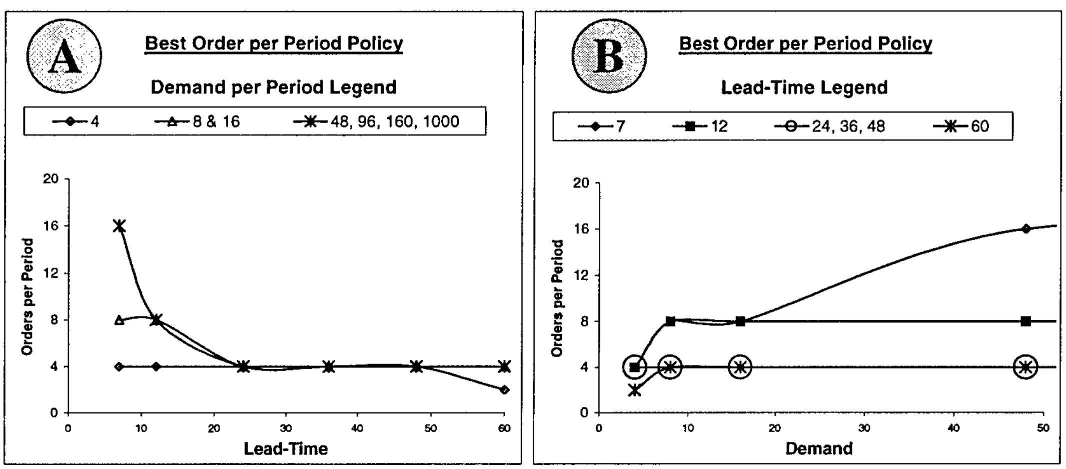


Figure 14. Best Order per Period Strategy Summary

The table itself in Figure 14 almost acts like a visual graph when examining the sets of numbers starting with 2 in the lower left corner of the table (low demand, high lead-time), and as you move to the upper right corner of the table (high demand, low lead-time) the best choice for orders-per-period moves from 2, to the large set of 4s, then to the 8s, then finally to the 16s, visually depicting the general trend of lower orders-per-period for items having low demand and high lead-times, and higher orders-per-period when the lead-times are low and demand is high. It is not a perfect trend, however, as the lead-time factor appears to have more influence then the demand factor as seen in the table. Even though this single table properly depicts the ideal ordering pattern and frequency for the various demand levels, lead-times, and order-per-period choices that were modeled in this study, it is critical that any FMS country using the information provided in Figure 14 refer back to the previous tables and graphs throughout this research to hone any final requisitioning strategy.

Summary

In this chapter the results from the SLQ computational model were analyzed and the results shown through several tables and graphs, all of which are located in Appendix C. Because of the nature of this analysis, there is not any single, definitive statement that can made about the results, which is exactly why the results were presented in the format that they were. The purpose is for the reader, specifically an FMS country, to use the information provided as a tool for establishing an effective requisitioning policy, given the processes and formulations inherent in the CLSSA program.

This chapter went step by step through a series of evaluations of the model output via changing constants, so as to highlight the impact of the other factors. Finally a summary of the ideal ordering strategy based on the model parameters was provided to give the reader a condensed version of the result, from which a detailed examination can begin. Chapter V concludes this study, with a review of the research questions and a summary of their answers.

V. Conclusion and Recommendations

Introduction

CLSSA needs to remain a viable security assistance program, not only as a means for promoting global stability, but also to provide the US with additional economies of scale when procuring new weapon systems, or supporting current ones. One of the main reasons FMS countries use CLSSA is because it is perceived to be the best available option, otherwise they would choose some other method for follow-on logistics support, as they are free to do so.

One way to keep FMS countries within the realm of CLSSA is to provide them the best customer service at the lowest total cost. This research analyzed the impacts to customer service and cost created through the requisitioning patterns of FMS customers. When to order and how much to order are two fundamental questions that need to be answered to create an effective requisitioning, and ultimately, inventory strategy.

Research Questions Revisited

This section will answer the research questions discussed in Chapter I, based on the analysis covered throughout this report.

1. *How are FMS customer service levels impacted by programmed versus nonprogrammed FMSO II requisitions, following the advent of the new CLSSA automation features implemented in 1994?*

In 1994, the method for forecasting FMSO I case requirements was changed to the automated, weighted moving average SLQ computational formula, from the previous which was based on the FMS customer manually adjusting the FMSO I case. These FMSO I requirements generate an stock level requirement (SLQ) that is used to determine whether the FMSO II requisition is coded programmed (able to be filled from stock) or nonprogrammed (guaranteed only lead-time away). Investment items, rather than expense items, were used for the comparison of fill rates, because since 1996 all expense items have been coded programmed.

Based on the tables provided in Chapter II and Appendix A, investment items coded programmed provided superior service levels than those coded nonprogrammed. First, over calendar years 1994 to 1999, approximately 51.5% of all investment items (both H-Code and Non-H) coded programmed were filled within 30 days, compared to only 39.1% of items coded nonprogrammed. This represents a relative 50% increase in those items requisitioned programmed being filled within 30 days. Additionally over the same six year period, while only 21.0% of programmed items took over 180 days to be filled, 31.5% of nonprogrammed items took longer—representing a 32% increase in nonprogrammed items exceeding 180 days to be filled.

Although the previous figures represent significant customer service improvements (through better fill rates) over the six year average following the 1994 change to the automation of requirements generation, since the 1994 change, performance for the programmed requisitions has gradually improved at a faster rate then nonprogrammed orders. Comparing the fill rates for only 1999 instead of the six year average attests to even greater support levels for items coded programmed.

First, approximately 56.9% of all investment items coded programmed were filled within 30 days, compared to only 41.1% of items coded nonprogrammed—a relative increase of 38%. At the other end of the spectrum, only 17.7% of programmed items in 1999 took over 180 days to be filled, while during the same year 31.3% of nonprogrammed items exceeded 180 days—a relative increase of 77%. So not only have programmed requisitions been filled at a faster rate on average over the previous six years, but the improvement in fill rates are steadily widening between programmed and nonprogrammed requisitions. This tends to support the premise that ensuring requisitions are coded programmed has been show to be historically important, and will continue to be so in the future.

2. *Given that customer service levels are impacted by whether FMSO II cases are coded programmed or nonprogrammed, how do the requisitioning policies of FMS countries affect SLQ levels, which in part determine whether FMSO II cases are in fact coded programmed or nonprogrammed?*

Now that it has been determined that requisitions being coded either programmed or nonprogrammed impacts the fill rates through the answer given in research question one, the specific ordering policies of FMS countries can be examined to determine their impact. The results detailed in Chapter IV indicate that because of the computational methods CLSSA incorporates in the determination of the SLQ, the greater the number of requisitions throughout the previous four years, equates to higher SLQ levels at the time that an order is placed.

So if during the 16 quarter, or 4 year SLQ period, their were only 1 or 2 quarters where an actual requisition was placed, and during the other 14 or 15 quarters there were zero orders being placed, then the SLQ level would be reduced, and the number of items being ordered above the SLQ level would increase, thus increasing the number of items being coded nonprogrammed. Conversely, if there were orders being placed for 14 or 15 quarters (with a smaller quantity being ordered each time), then the SLQ quantity would increase, thus less items being coded nonprogrammed. So in general, from the analysis in this research, increased frequency of FMSO II orders placed by FMS countries during the SLQ period generates higher SLQ levels, higher number of programmed orders, and therefore improves the customer service levels they receive.

3. How do the requisitioning policies of FMS countries affect overall CLSSA cost through the 5/17 charge of the SLQ level being paid for by the FMS country?

It has been determined that programmed requisitions are better then nonprogrammed ones, and increased frequency of ordering increases the number of programmed orders; however, there is a cost for all of this, and that cost comes in the form of the 5/17 charge of the value of the item, based on the average SLQ level for that item. In reality, by increasing the number of orders during the SLQ period, not only will this increase the number of items being coded programmed, but it will also increase the overall SLQ average in the FMSO I case and increase the costs to the FMS country.

Since the cost increases due to the increased average SLQ levels vary based on parameters such as demand levels, item lead-times, as well as the actual cost of the items, specific cost increases can be determined by examining the tables in Chapter IV and Appendix C, as well as the actual cost for individual items.

So using the same example used for research question two, if during the previous 4 years there were only 1 or 2 quarters during which an actual requisition was placed, then with the reduced average SLQ would come reduced costs in the form of a reduced 5/17 charge; however, if the FMS customer decided to place requisitions nearly every quarter for a particular item, then the SLQ average would rise, along with the cost. So with respect to cost alone, the less frequent an FMS country places FMSO II orders, the less cost they will incur through a reduced 5/17 charge; and therefore, the less the overall cost for participating in CLSSA.

4. Based on the method CLSSA uses to compute SLQs, what requisitioning strategy, or tool, can be used by FMS countries to optimize the SLQ level, so that it is high enough to ensure programmed requisition support, yet not higher then it needs to be, so as to remain fiscally efficient.

Now that it is clear that high SLQ averages are more costly, yet low SLQs at the time of a requisition leads to more nonprogrammed items being ordered, the key is devise a methodology to have a high enough SLQ, so at the time of the order all items are coded programmed, while at the same time keeping the average SLQ as low as possible to hold the costs down. The following answer is based solely on that premise—an average SLQ as low as possible *and* all items requisitioned coded programmed. Individual FMS country's inventory policy, cost structure, critically of their items, and other factors may impact this generalized strategy, but FMS customers can always tailor this strategy to their own needs. If nothing else, it can be used as a strategic starting point, or point of reference, particularly since prior to this study no such information has been provided to FMS countries, nor has any research been done in this area of requisitioning pattern analysis for CLSSA.

There is not any single ordering policy that can be stated, except that in general, as item lead-times increase, the ordering frequency should decrease; and as demand increases, so should the ordering frequency. Since the specific ordering frequency will vary based on lead-times and demand levels (see figures and tables in Chapter IV and Appendix C), generalizations are difficult; however, some overall rules can be stated to create the best requisitioning policy using the current CLSSA model and the analysis parameters used in this study:

1. Requisitions should be placed on a *regular* schedule (i.e. every quarter, every other quarter, every year, every two years, etc.).

2. Order quantities should be *consistent* based on a projected four year demand (e.g. demand of 48 = 4 orders of 12 items).

3. Items with low lead-times (6 months or less) should be ordered every quarter.

4. Items with lead-times of 24 months or greater should generally be requisitioned once each year for a quantity 25% of the 4 year SLQ period.

5. Items with demands of 4 or less should be ordered once per year, except for items with lead-times of 60 months that should be ordered every other year.

6. Items with 12 month lead-times and demands greater then 8 per period, and items with lead-times of 7 months and demands of 8 or 16 per period, should be ordered every other quarter.

7. Items with lead-times of 7 months and demands of over 16 items per period should be ordered every quarter.

Figure 14 in Chapter IV provides the range of best ordering frequencies, and the other tables and figures in Chapters III and IV and Appendix B and C highlight the origin and reasoning behind these results, as well as the tradeoffs to ordering at different frequencies, with respect to increased nonprogrammed requisitions, and/or increased cost due to increased average SLQ.

In answering research question four, a model was created in Microsoft® Excel 97 to duplicate the CLSSA SLQ weighted moving average calculations, and to provide the average SLQ and the number of items ordered above the SLQ automatically for a given demand level and lead-time, for a range of orders-per-period. This research selected various categories of demand and lead-time from which this analysis and these recommendations resulted from; however, the model is capable of accepting *any* values for the lead-time and demand levels, and the model will still provide the optimal ordering-per-period strategy. Therefore, while the model was used in this research for only specific categories of demand and lead-time, FMS countries can use it for their own specific values if they choose. The goal of this study was to demonstrate overall trends and relationships between demand, lead-time, orders-per-period, average SLQ, number of items ordered above the SLQ, customer service levels, and overall program cost.

Further Research Areas

The potential for subsequent research along the vein of this study can occur among a variety of fronts. More study can be conducted on the differences between programmed and nonprogrammed requisitions, beyond the overall averages as used in this study, to segregate the items into different categories. Research specifically related to the price factors to determine actual financial costs to specific FMS countries resulting from using one requisitioning strategy over another could be simulated. Additionally, simulation could be used to take historic requisitioning data, costs, and fill-rates, and using the same demand and lead-time data, modify the requisitioning pattern to the optimal manner as suggested by this research to determine cost and fill-rate differences. Finally, this type of research relating to requisitioning patterns and frequencies to customer service levels with respect to the CLSSA program could be broadened to other inventory programs.

Conclusion

CLSSA has been historically the program of choice for FMS countries for follow-on logistics support. In 1994 the forecasting method for creating the FMSO I case requirements was modified from a manual to automated process, using the CLSSA SLQ weighted moving average formulation with the intention of providing better customer service to FMS countries. The goal of this study was to provide FMS countries an incentive to continue to regard CLSSA as an effective tool as part of an overall US weapon systems package both now and in the future, by providing FMS customers with a model for ensuring the highest level of service level support possible, without unnecessarily high costs.

Additionally, it is hoped that the FMS country's inventory managers now more fully understand the concepts and relationships between the strategies FMS countries employ in their FMSO II requisitioning processes, to the actual customer service levels they receive, as well as the financial charges they incur. It is through this understanding of the relationship between the frequency and patterns of FMSO II case requisitions to the FMSO I case requirements that a more effective total inventory strategy can be created. This effective inventory strategy will not only aid the FMS country, but also the United States, both as a means of helping ensure the nation's national defense, and promote overall global security.

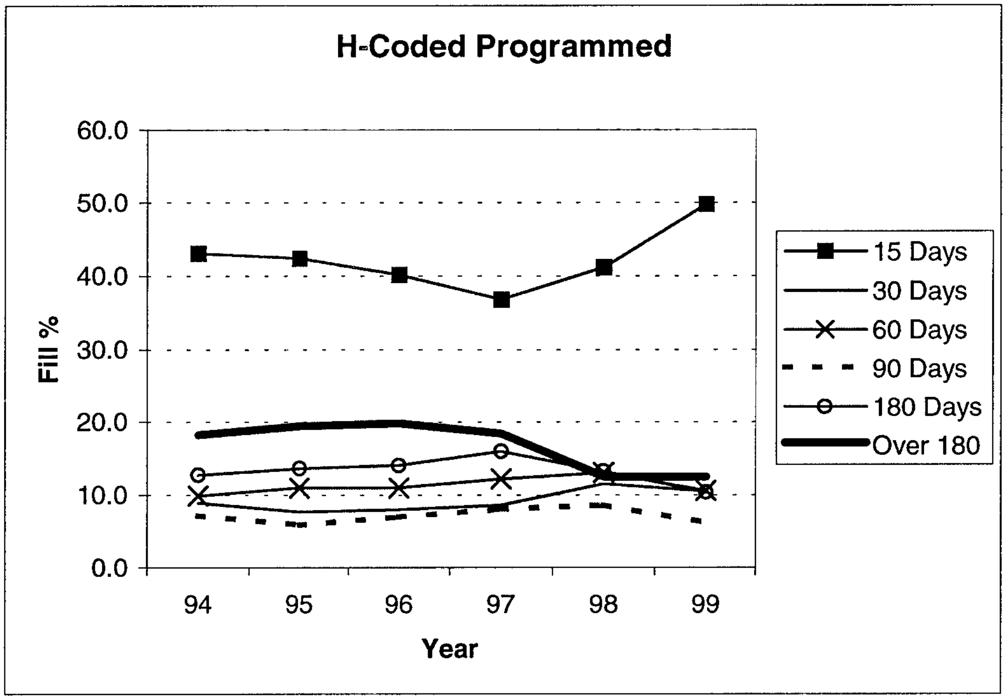
Appendix A: Fill Rates (Chapter II)

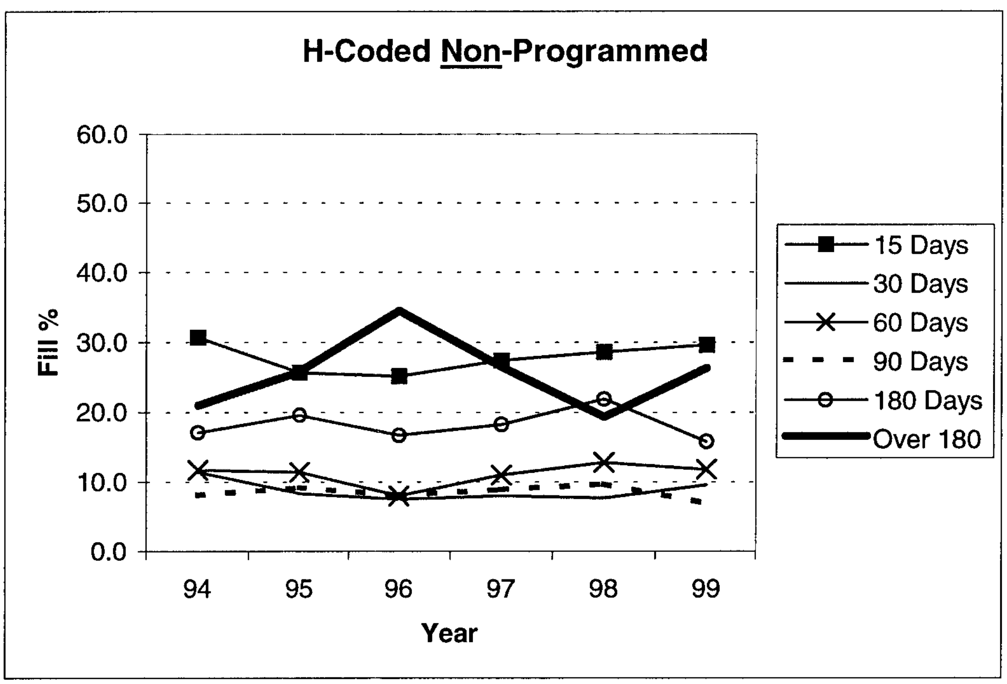
H-Coded

Shipped by Day "X"	94	95	96	97	98	99	Mean
Programmed							
15	43.1	42.4	40.2	36.8	41.2	49.8	42.3
30	8.9	7.7	8.0	8.6	11.5	10.5	9.2
60	9.9	11.0	11.0	12.2	13.0	10.6	11.3
90	7.2	5.9	7.0	8.1	8.6	6.2	7.2
180	12.7	13.6	14.0	15.9	13.2	10.4	13.3
>180	18.2	19.4	19.8	18.4	12.5	12.5	16.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	
Non-Programmed							
15	30.7	25.7	25.2	27.4	28.6	29.6	27.9
30	11.4	8.3	7.5	8.0	7.7	9.6	8.8
60	11.7	11.4	8.0	11.0	12.8	11.8	11.1
90	8.1	9.2	8.1	8.9	9.7	6.9	8.5
180	17.1	19.6	16.7	18.2	21.9	15.8	18.2
>180	21.0	25.8	34.5	26.5	19.3	26.3	25.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	

Cumulative Data

Programmed							
15	43.1	42.4	40.2	36.8	41.2	49.8	42.3
30	52.0	50.1	48.2	45.4	52.7	60.3	51.5
60	61.9	61.1	59.2	57.6	65.7	70.9	62.7
90	69.1	67.0	66.2	65.7	74.3	77.1	69.9
180	81.8	80.6	80.2	81.6	87.5	87.5	83.2
>180	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Non-Programmed							
15	30.7	25.7	25.2	27.4	28.6	29.6	27.9
30	42.1	34.0	32.7	35.4	36.3	39.2	36.6
60	53.8	45.4	40.7	46.4	49.1	51.0	47.7
90	61.9	54.6	48.8	55.3	58.8	57.9	56.2
180	79.0	74.2	65.5	73.5	80.7	73.7	74.4
>180	100.0	100.0	100.0	100.0	100.0	100.0	100.0


H-Coded Programmed
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Fill %
94
95
96
97
98
99
Year
15 Days
30 Days
60 Days
90 Days
180 Days
Over 180


H-Coded Non-Programmed
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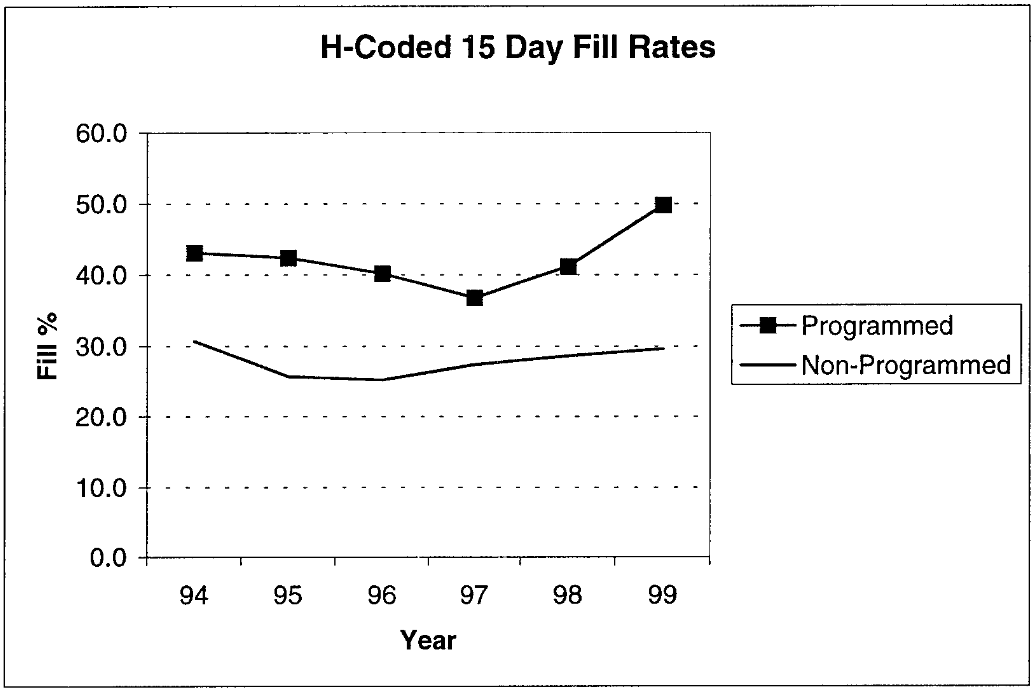
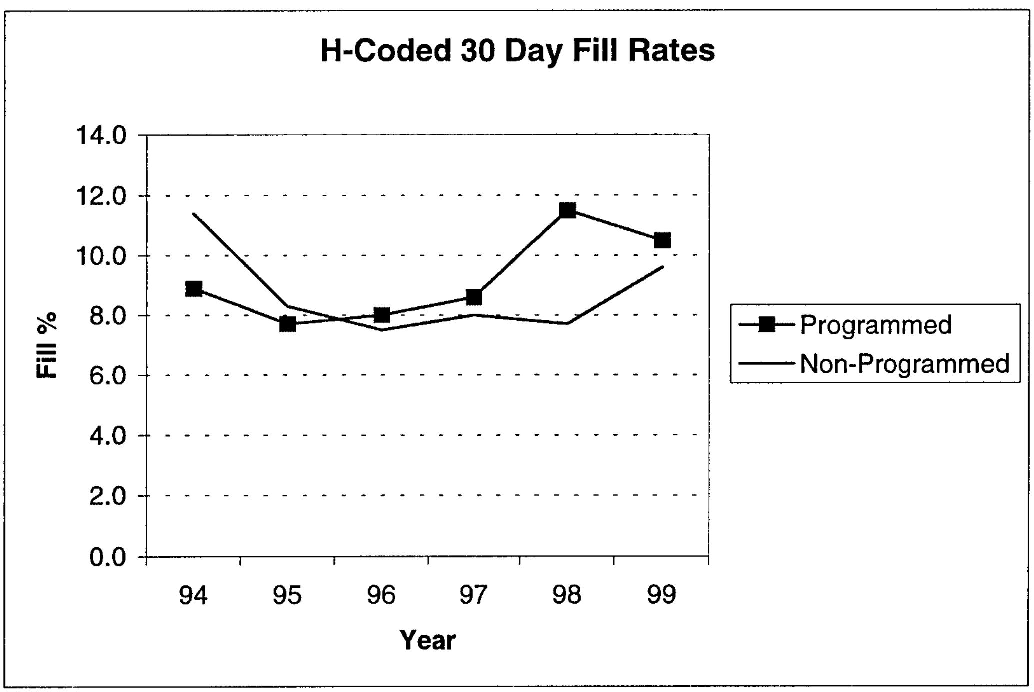
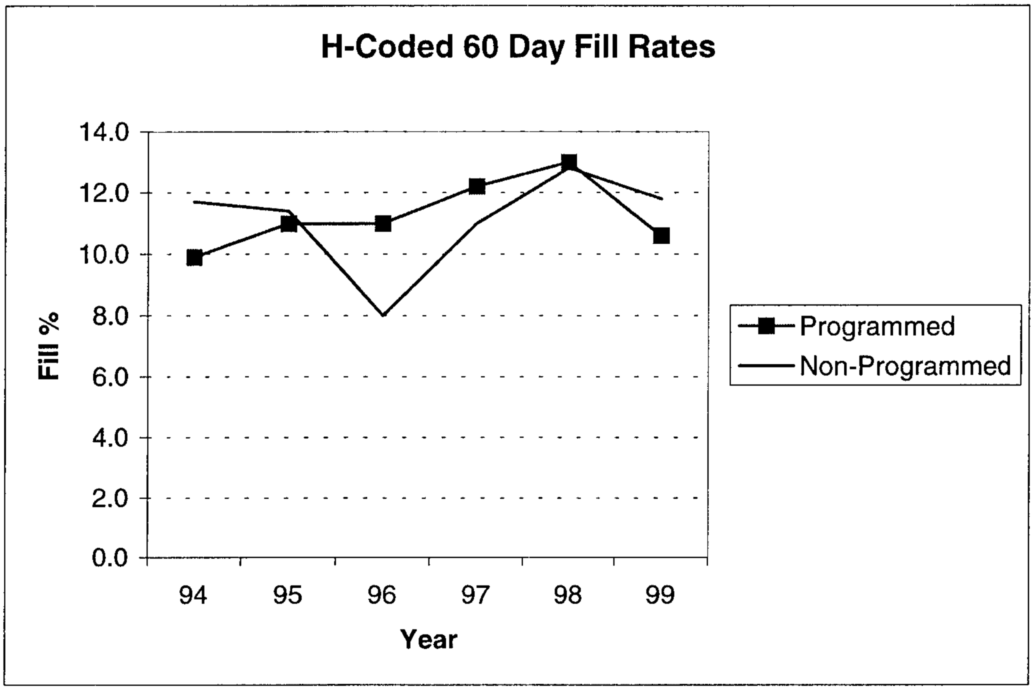
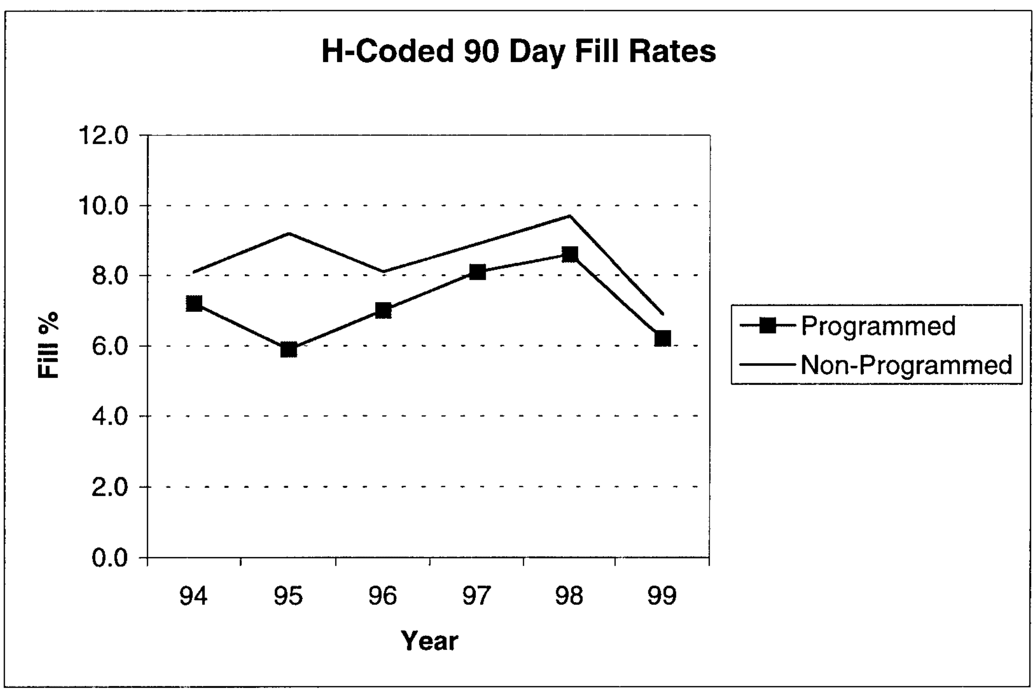
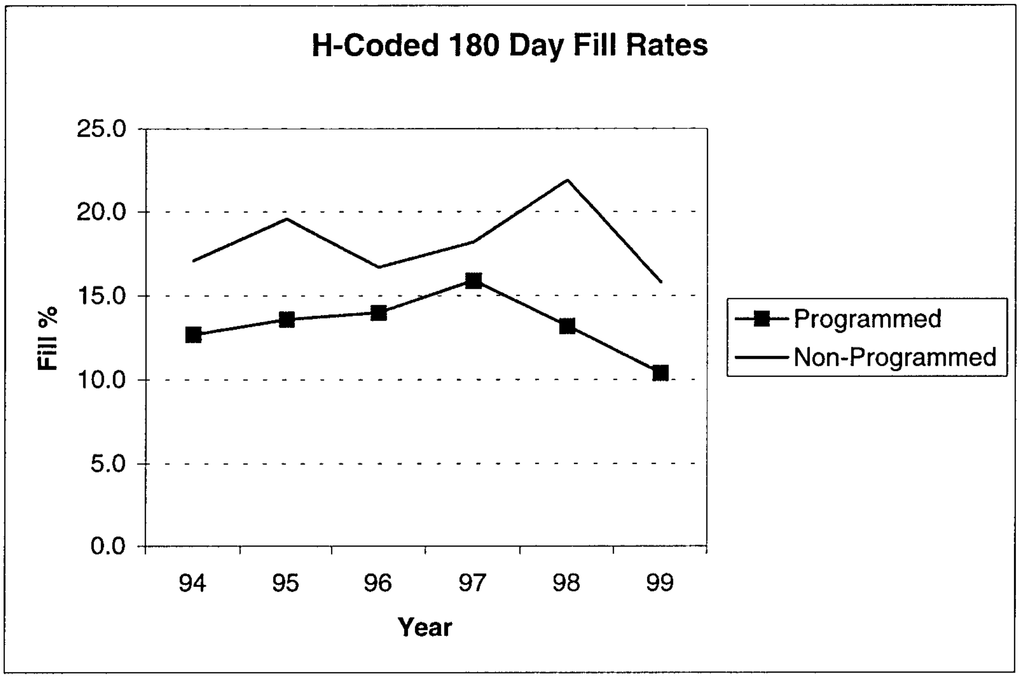
50.0
40.0
30.0
20.0
10.0
0.0
Fill %
94
95
96
97
98
99
Year
15 Days
30 Days
60 Days
90 Days
180 Days
Over 180

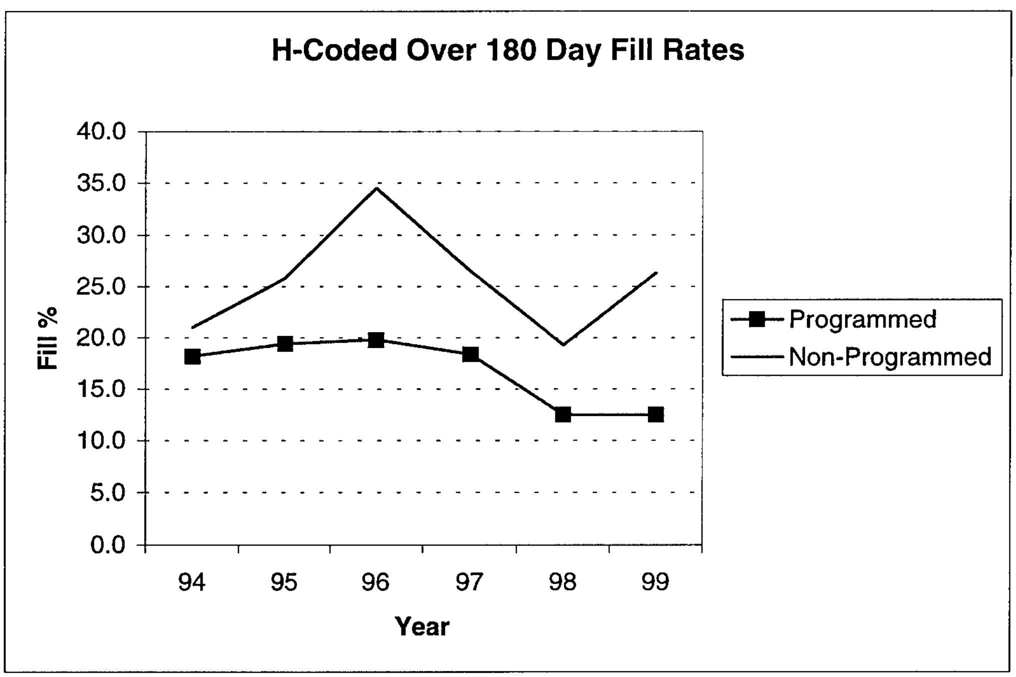

H-Coded 15 Day Fill Rates
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Fill %
94
95
96
97
98
99
Year
Programmed
Non-Programmed

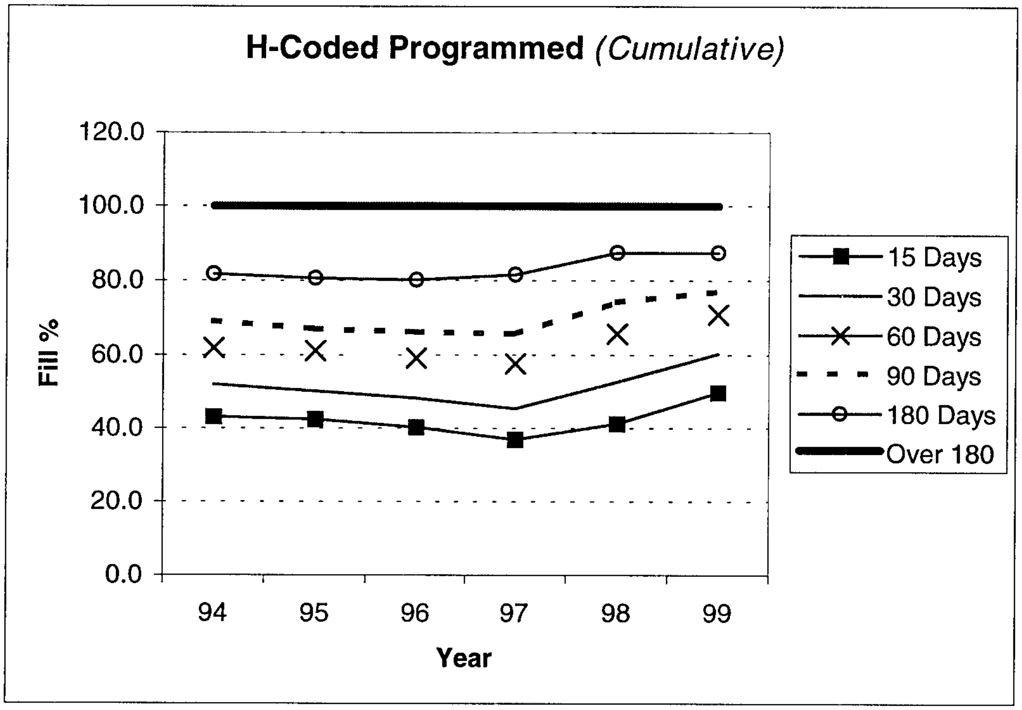

H-Coded 30 Day Fill Rates
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Fill %
94
95
96
97
98
99
Year
Programmed
Non-Programmed

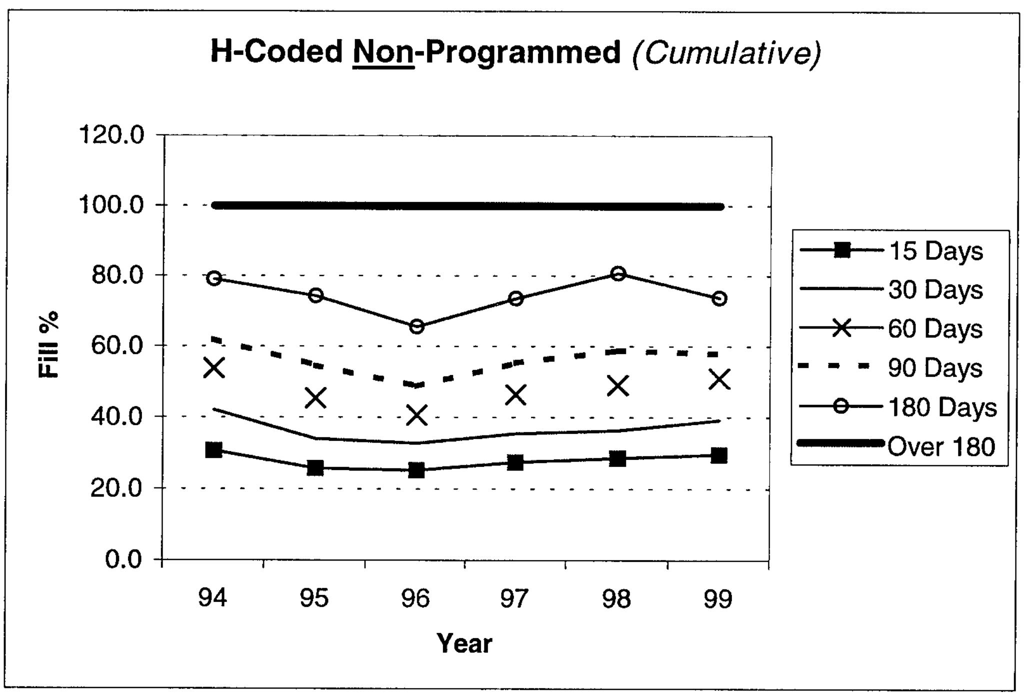

H-Coded 60 Day Fill Rates
Fill %
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
94
95
96
97
98
99
Year
Programmed
Non-Programmed

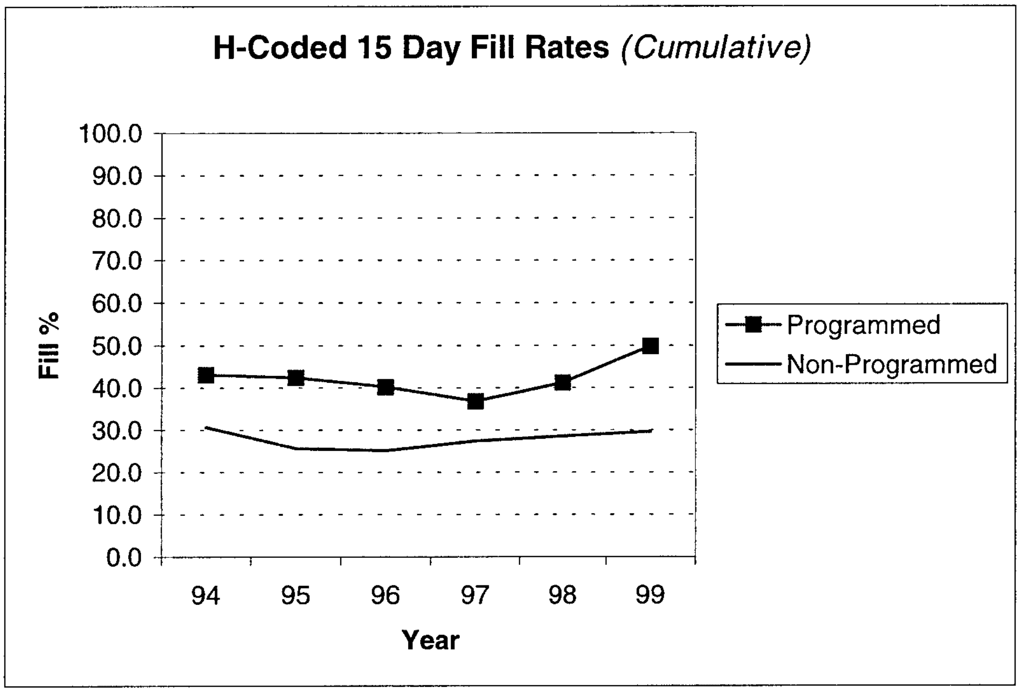

H-Coded 90 Day Fill Rates
Fill %
12.0
10.0
8.0
6.0
4.0
2.0
0.0
94
95
96
97
98
99
Year
Programmed
Non-Programmed

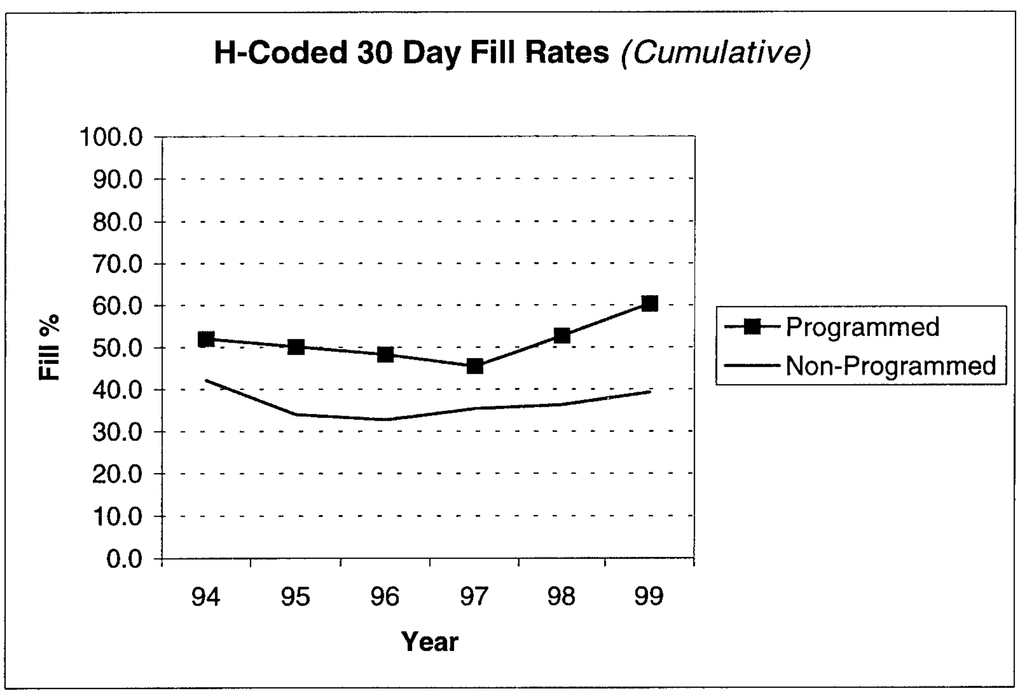

H-Coded 180 Day Fill Rates
25.0
20.0
15.0
10.0
5.0
0.0
Fill %
94
95
96
97
98
99
Year
Programmed
Non-Programmed


H-Coded Over 180 Day Fill Rates
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Fill %
94
95
96
97
98
99
Year
Programmed
Non-Programmed

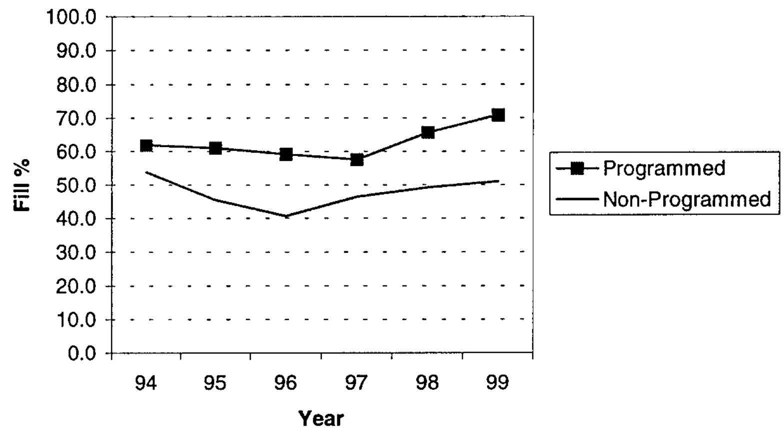

H-Coded Programmed (Cumulative)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Fill %
94
95
96
97
98
99
Year
15 Days
30 Days
60 Days
90 Days
180 Days
Over 180


H-Coded Non-Programmed (Cumulative)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Fill %
94
95
96
97
98
99
Year
15 Days
30 Days
60 Days
90 Days
180 Days
Over 180

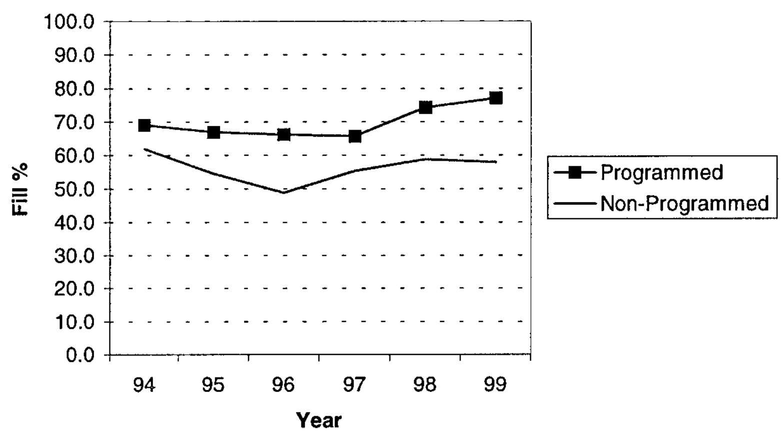

H-Coded 15 Day Fill Rates (Cumulative)
Fill %
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
94
95
96
97
98
99
Year
Programmed
Non-Programmed


H-Coded 30 Day Fill Rates (Cumulative)
Fill %
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
94
95
96
97
98
99
Year
Programmed
Non-Programmed

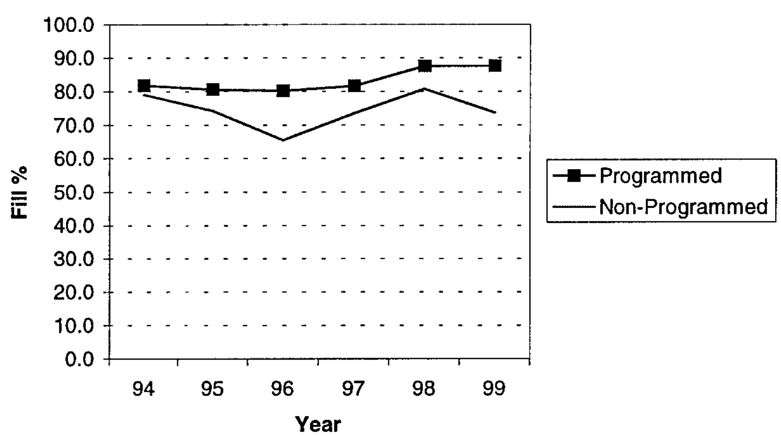
H-Coded 60 Day Fill Rates *(Cumulative)*



H-Coded 90 Day Fill Rates *(Cumulative)*



H-Coded 180 Day Fill Rates *(Cumulative)*

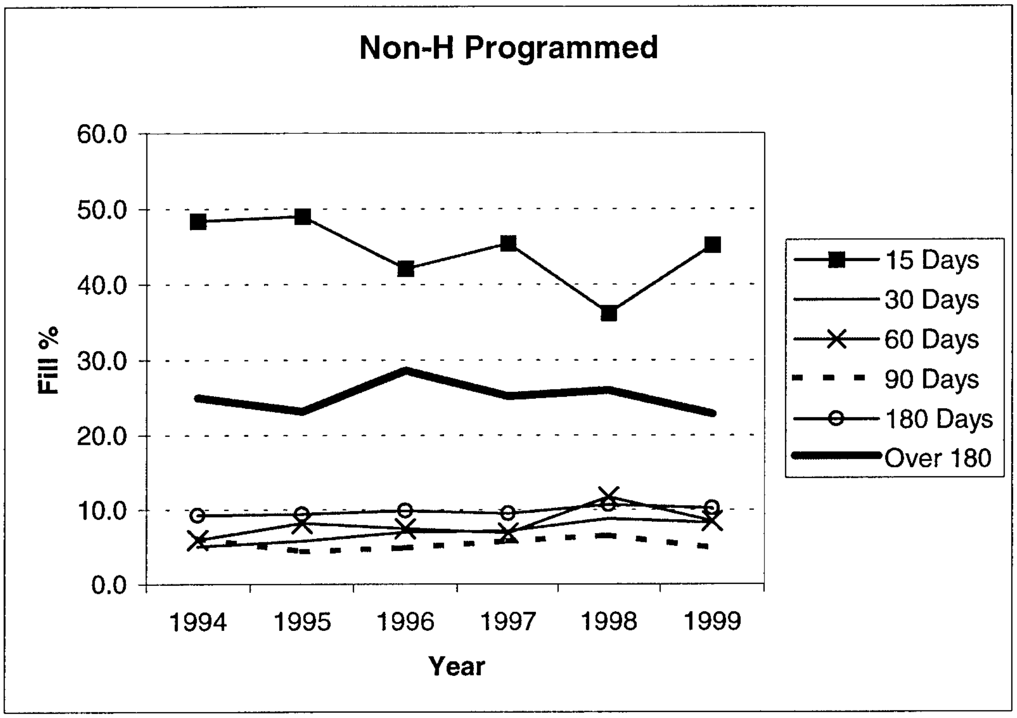


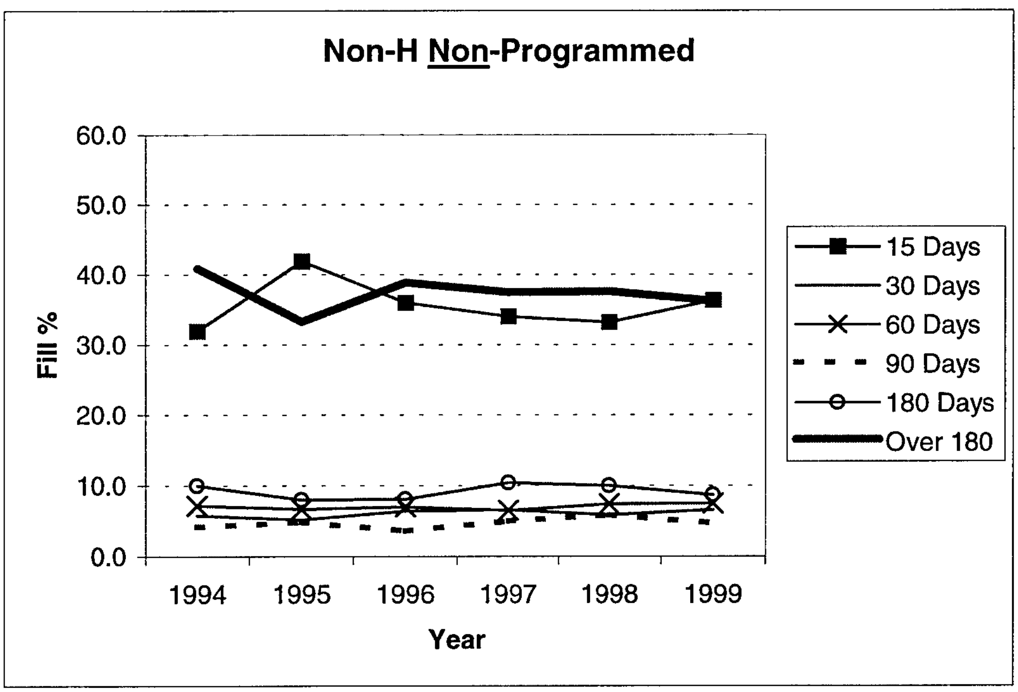
Non-H

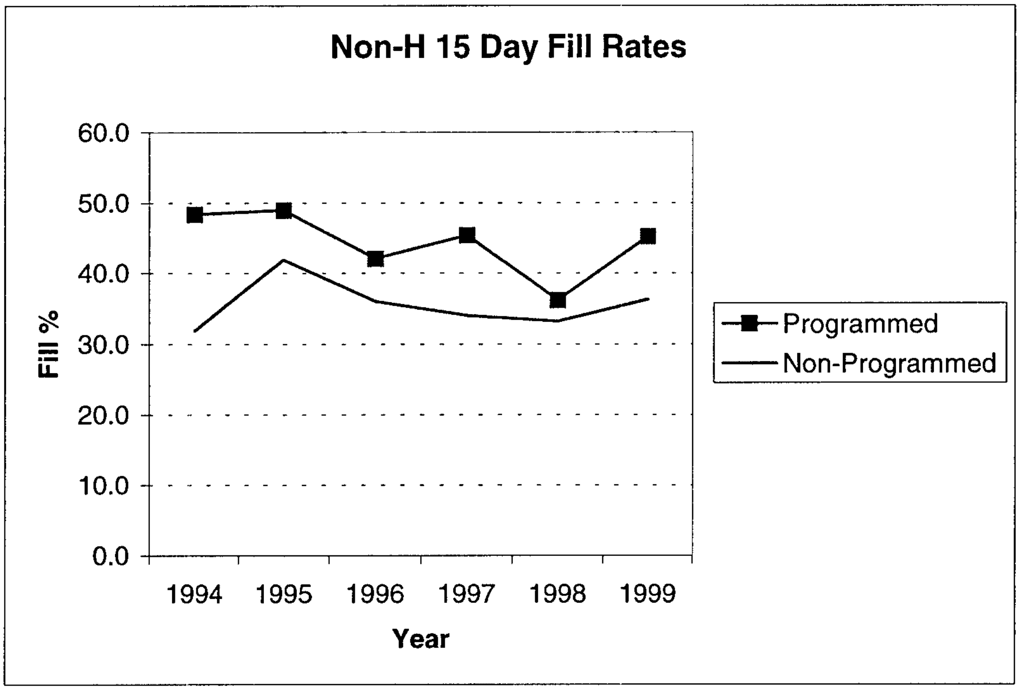
Shipped by Day "X"	94	95	96	97	98	99	Mean
Programmed							
15	48.4	49.0	42.1	45.4	36.2	45.2	44.4
30	5.1	5.8	7.0	7.2	8.8	8.3	7.0
60	6.0	8.2	7.5	6.9	11.7	8.5	8.1
90	6.2	4.4	4.9	5.8	6.6	4.9	5.5
180	9.3	9.4	9.9	9.5	10.7	10.2	9.8
>180	25.0	23.2	28.6	25.2	26.0	22.9	25.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	
Non-Programmed							
15	31.9	41.9	36.0	34.0	33.2	36.3	35.6
30	5.8	5.2	6.4	6.6	5.9	6.6	6.1
60	7.2	6.7	7.0	6.5	7.4	7.5	7.1
90	4.2	4.9	3.6	5.0	5.9	4.7	4.7
180	10.0	8.0	8.1	10.4	10.0	8.7	9.2
>180	40.9	33.3	38.9	37.5	37.6	36.2	37.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	

Cumulative Data

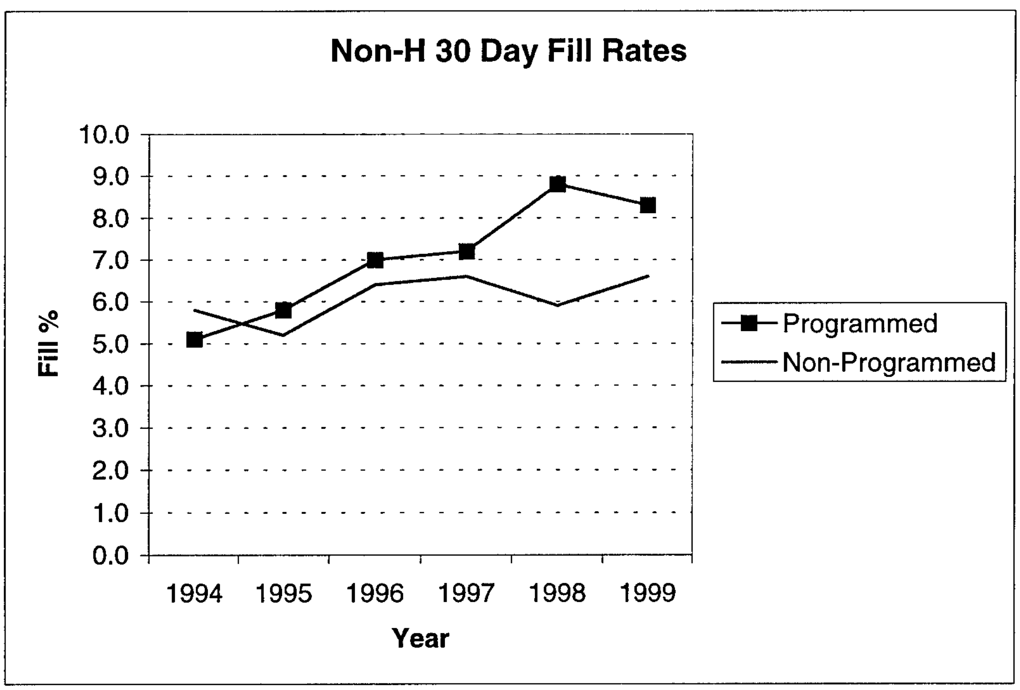
Programmed							
15	48.4	49.0	42.1	45.4	36.2	45.2	44.4
30	53.5	54.8	49.1	52.6	45.0	53.5	51.4
60	59.5	63.0	56.6	59.5	56.7	62.0	59.6
90	65.7	67.4	61.5	65.3	63.3	66.9	65.0
180	75.0	76.8	71.4	74.8	74.0	77.1	74.9
>180	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Non-Programmed							
15	31.9	41.9	36.0	34.0	33.2	36.3	35.6
30	37.7	47.1	42.4	40.6	39.1	42.9	41.6
60	44.9	53.8	49.4	47.1	46.5	50.4	48.7
90	49.1	58.7	53.0	52.1	52.4	55.1	53.4
180	59.1	66.7	61.1	62.5	62.4	63.8	62.6
>180	100.0	100.0	100.0	100.0	100.0	100.0	100.0


Non-H Programmed
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Fill %
1994
1995
1996
1997
1998
1999
Year
15 Days
30 Days
60 Days
90 Days
180 Days
Over 180

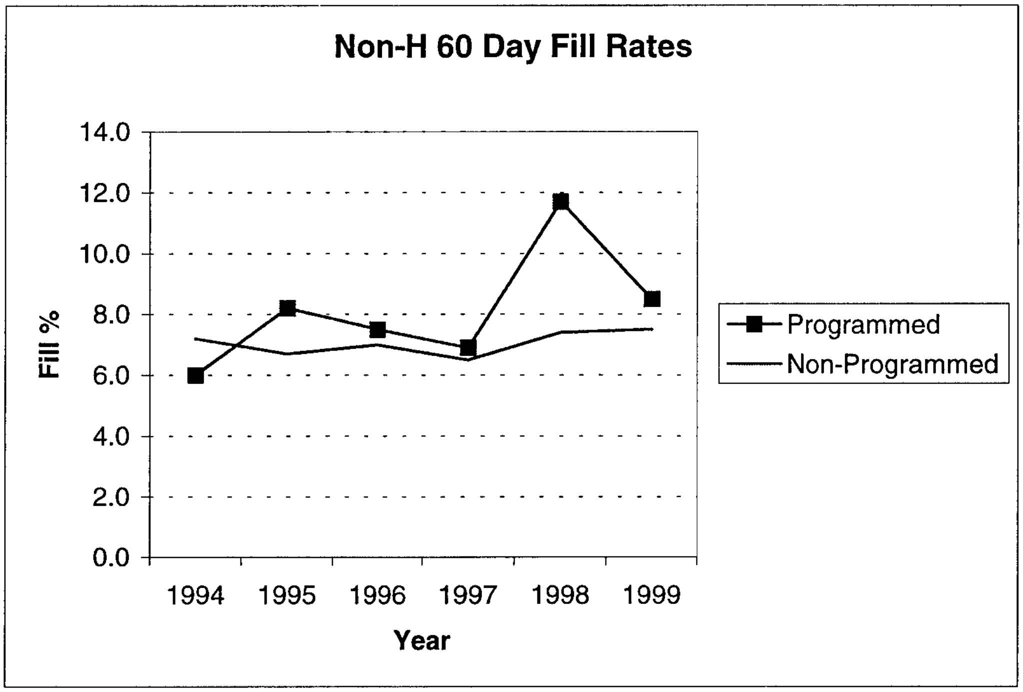

Non-H Non-Programmed
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Fill %
1994
1995
1996
1997
1998
1999
Year
15 Days
30 Days
60 Days
90 Days
180 Days
Over 180



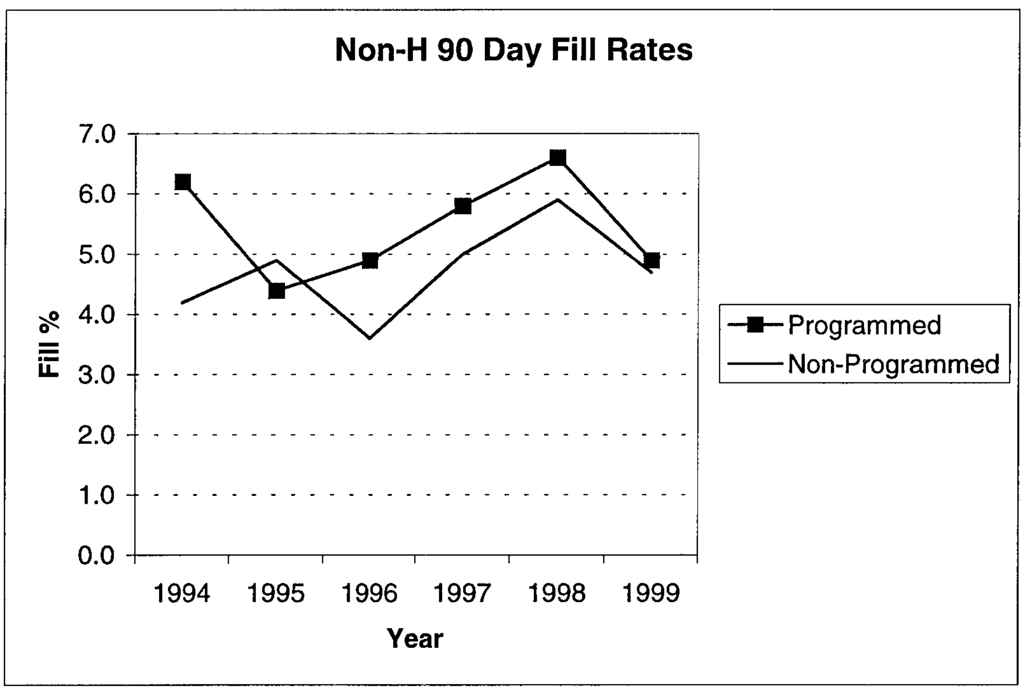
Non-H 15 Day Fill Rates
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Fill %
1994
1995
1996
1997
1998
1999
Year
Programmed
Non-Programmed



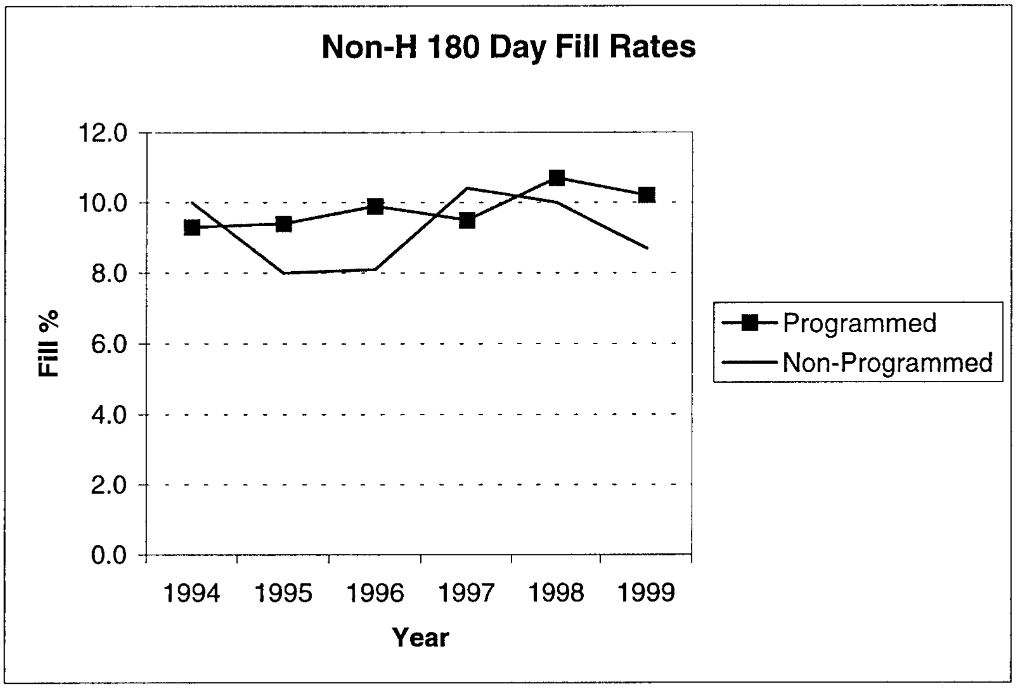
Non-H 30 Day Fill Rates
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Fill %
1994
1995
1996
1997
1998
1999
Year
Programmed
Non-Programmed

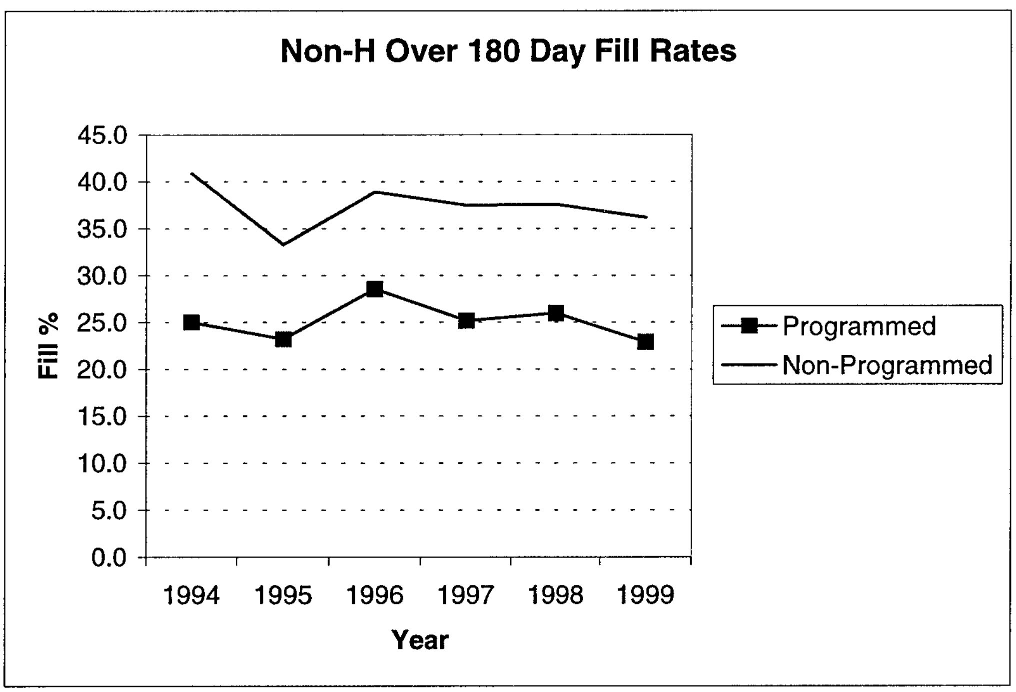


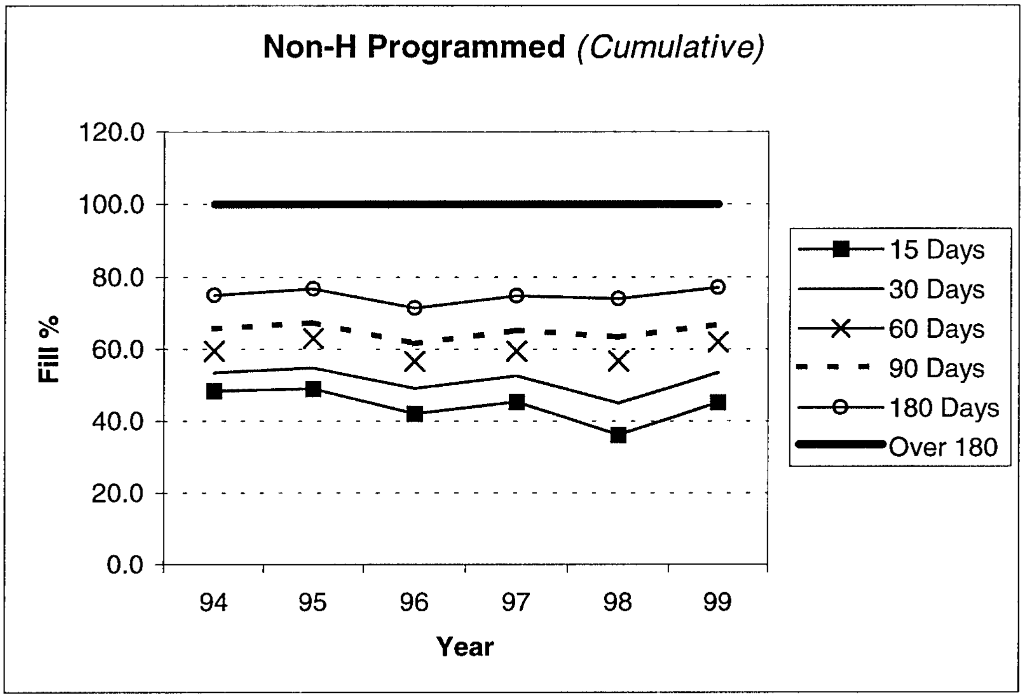
Non-H 60 Day Fill Rates
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Fill %
1994
1995
1996
1997
1998
1999
Year
Programmed
Non-Programmed

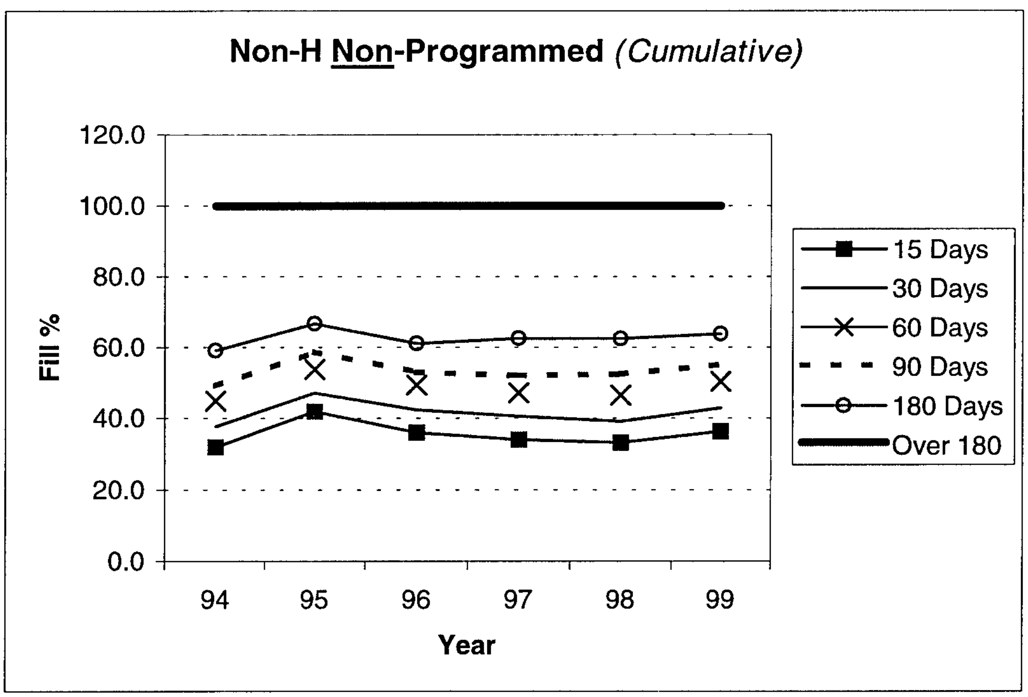


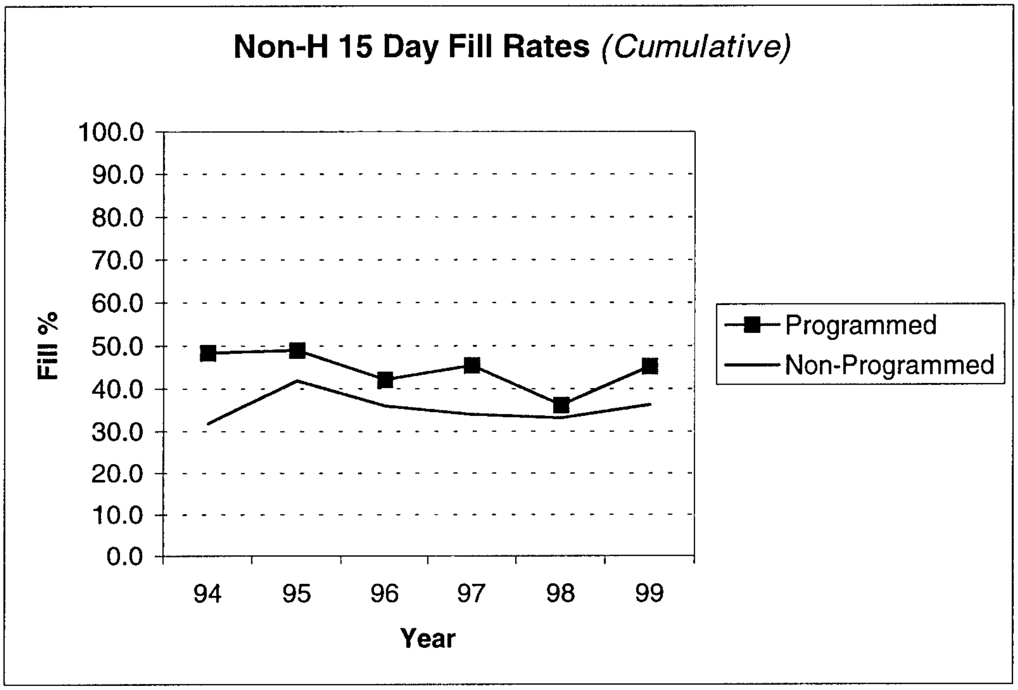
Non-H 90 Day Fill Rates
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Fill %
1994
1995
1996
1997
1998
1999
Year
Programmed
Non-Programmed

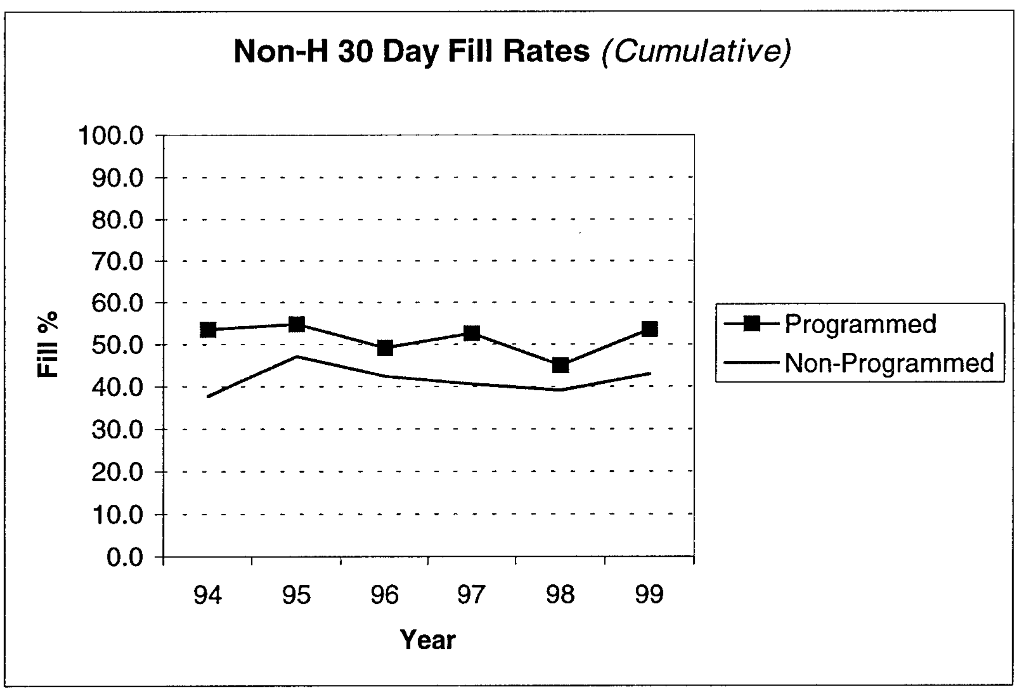

Non-H 180 Day Fill Rates
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Fill %
1994
1995
1996
1997
1998
1999
Year
Programmed
Non-Programmed

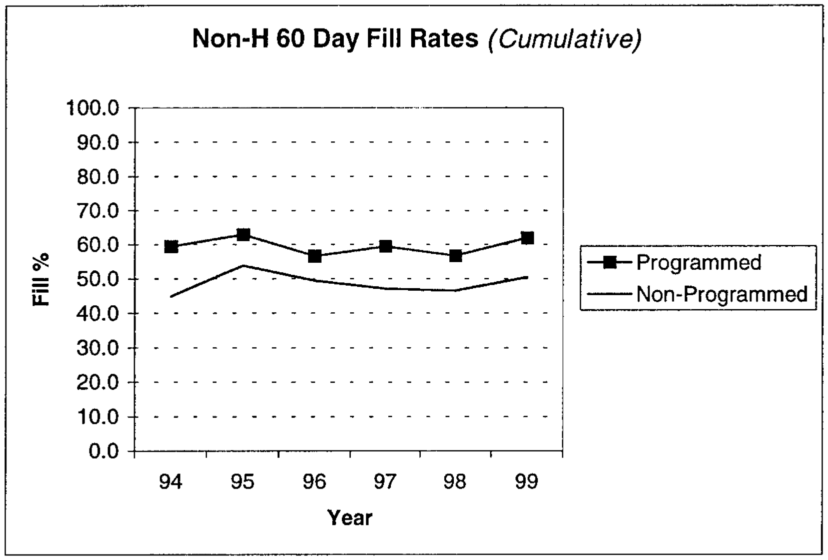

Non-H Over 180 Day Fill Rates
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Fill %
1994
1995
1996
1997
1998
1999
Year
Programmed
Non-Programmed

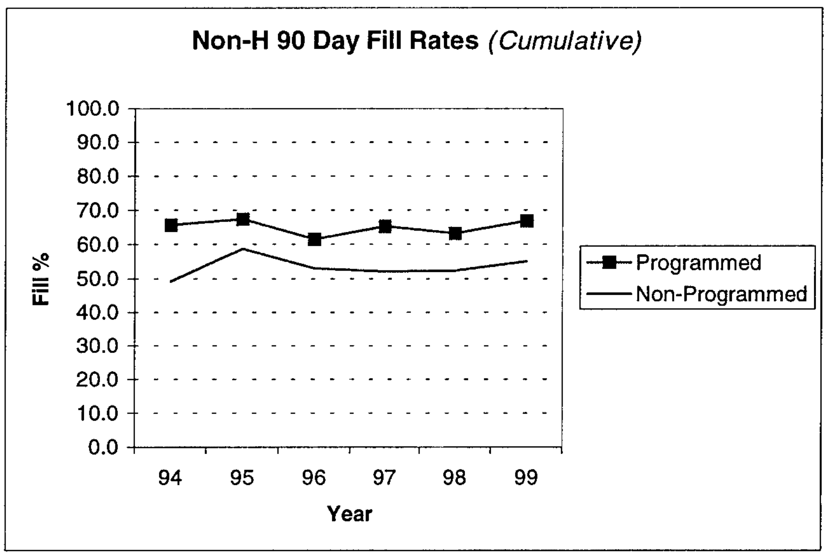

Non-H Programmed (Cumulative)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Fill %
94
95
96
97
98
99
Year
15 Days
30 Days
60 Days
90 Days
180 Days
Over 180

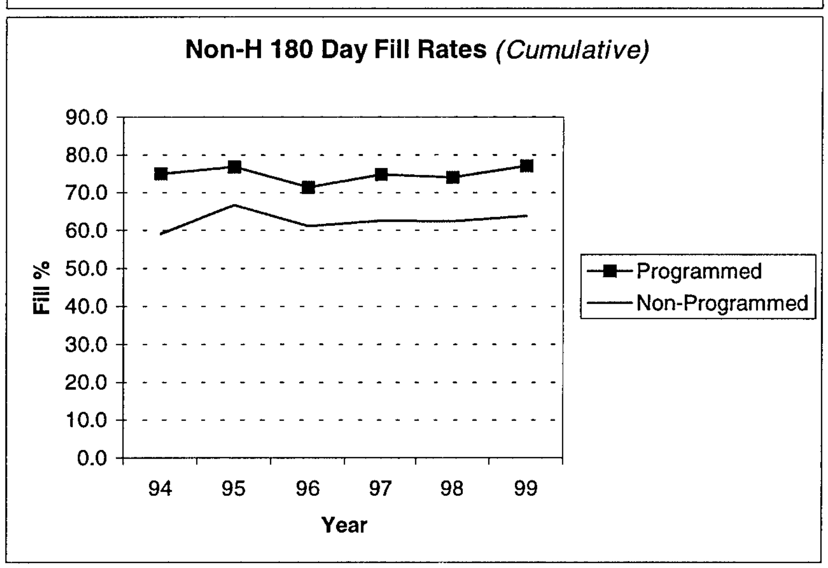

Non-H Non-Programmed (Cumulative)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Fill %
94
95
96
97
98
99
Year
15 Days
30 Days
60 Days
90 Days
180 Days
Over 180


Non-H 15 Day Fill Rates (Cumulative)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Fill %
94
95
96
97
98
99
Year
Programmed
Non-Programmed


Non-H 30 Day Fill Rates (Cumulative)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Fill %
94
95
96
97
98
99
Year
Programmed
Non-Programmed


Non-H 60 Day Fill Rates (Cumulative)
Fill %
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
94
95
96
97
98
99
Year
Programmed
Non-Programmed


Non-H 90 Day Fill Rates (Cumulative)
Fill %
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
94
95
96
97
98
99
Year
Programmed
Non-Programmed


Non-H 180 Day Fill Rates (Cumulative)
Fill %
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
94
95
96
97
98
99
Year
Programmed
Non-Programmed

Appendix B: SLQ Model Examples (Chapter III)

Stock Level Quantity (SLQ) Computation Model

(e.g. Demand = 96, Lead-Time = 24 months)

Summary

Items = **96**
Lead Time = **24**

Items Ordered Above/Below SLQ

1	2	4	8	16
93	62	-8	-184	-672

Average SLQ

1	2	4	8	16
25.5	27.5	30.5	36.5	48.0

NOTE: *Top row of numbers are the orders per period.*

1 Order Per 16 Quarters

Average SLQ 25.5

Items Ordered Over SLQ 93

CHANGING CELLS
4 Year Forecasted Demand = **96**
Item Lead Time in Months = **24**

1 Order per SLQ Period for 96 Items.

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	0	75.00%	0.000
5	0	68.75%	0.000
6	0	62.50%	0.000
7	0	56.25%	0.000
8	0	50.00%	0.000
9	0	43.75%	0.000
10	0	37.50%	0.000
11	0	31.25%	0.000
12	0	25.00%	0.000
13	0	18.75%	0.000
14	0	12.50%	0.000
15	0	6.25%	0.000
16	96	6.25%	6.000
SUM	**96**		**6**

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	96	100.0%	96.000
2	0	93.75%	0.000
3	0	87.50%	0.000
4	0	81.25%	0.000
5	0	75.00%	0.000
6	0	68.75%	0.000
7	0	62.50%	0.000
8	0	56.25%	0.000
9	0	50.00%	0.000
10	0	43.75%	0.000
11	0	37.50%	0.000
12	0	31.25%	0.000
13	0	25.00%	0.000
14	0	18.75%	0.000
15	0	12.50%	0.000
16	0	6.25%	0.000
SUM	**96**		**96**

	First table	Second table
	4 Year Demand = **96**	4 Year Demand = **96**
Weighted Req'd Quantity divided by 48 Months =	Avg. Mon. Dmd = 0.1250	Avg. Mon. Demand = 2.0000
Average Monthly Demand x Lead Time = ...	SLQ = 3.000	SLQ = 48.000
Rounded SLQ (1.0 if less than 1.0) = ...	**SLQ = 3**	**SLQ = 48**

1 Order per SLQ Period for 96 Items (continued)

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	96	93.75%	90.000
3	0	87.50%	0.000
4	0	81.25%	0.000
5	0	75.00%	0.000
6	0	68.75%	0.000
7	0	62.50%	0.000
8	0	56.25%	0.000
9	0	50.00%	0.000
10	0	43.75%	0.000
11	0	37.50%	0.000
12	0	31.25%	0.000
13	0	25.00%	0.000
14	0	18.75%	0.000
15	0	12.50%	0.000
16	0	6.25%	0.000
SUM	**96**		**90**

4 Year Demand = **96**
Avg. Mon. Demand = 1.8750
SLQ = 45.000
SLQ = 45

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	96	87.50%	84.000
4	0	81.25%	0.000
5	0	75.00%	0.000
6	0	68.75%	0.000
7	0	62.50%	0.000
8	0	56.25%	0.000
9	0	50.00%	0.000
10	0	43.75%	0.000
11	0	37.50%	0.000
12	0	31.25%	0.000
13	0	25.00%	0.000
14	0	18.75%	0.000
15	0	12.50%	0.000
16	0	6.25%	0.000
SUM	**96**		**84**

4 Year Demand = **96**
Avg. Mon. Demand = 1.7500
SLQ = 42.000
SLQ = 42

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	96	81.25%	78.000
5	0	75.00%	0.000
6	0	68.75%	0.000
7	0	62.50%	0.000
8	0	56.25%	0.000
9	0	50.00%	0.000
10	0	43.75%	0.000
11	0	37.50%	0.000
12	0	31.25%	0.000
13	0	25.00%	0.000
14	0	18.75%	0.000
15	0	12.50%	0.000
16	0	6.25%	0.000
SUM	**96**		**78**

4 Year Demand = **96**
Avg. Mon. Demand = 1.6250
SLQ = 39.000
SLQ = 39

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	0	75.00%	0.000
5	96	75.00%	72.000
6	0	68.75%	0.000
7	0	62.50%	0.000
8	0	56.25%	0.000
9	0	50.00%	0.000
10	0	43.75%	0.000
11	0	37.50%	0.000
12	0	31.25%	0.000
13	0	25.00%	0.000
14	0	18.75%	0.000
15	0	12.50%	0.000
16	0	6.25%	0.000
SUM	**96**		**72**

4 Year Demand = **96**
Avg. Mon. Demand = 1.5000
SLQ = 36.000
SLQ = 36

1 Order per SLQ Period for 96 Items (continued)

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	0	75.00%	0.000
5	0	68.75%	0.000
6	96	68.75%	66.000
7	0	62.50%	0.000
8	0	56.25%	0.000
9	0	50.00%	0.000
10	0	43.75%	0.000
11	0	37.50%	0.000
12	0	31.25%	0.000
13	0	25.00%	0.000
14	0	18.75%	0.000
15	0	12.50%	0.000
16	0	6.25%	0.000
SUM	**96**		**66**

4 Year Demand = **96**
Avg. Mon. Demand = 1.3750
SLQ = 33.000
SLQ = 33

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	0	75.00%	0.000
5	0	68.75%	0.000
6	0	62.50%	0.000
7	96	62.50%	60.000
8	0	56.25%	0.000
9	0	50.00%	0.000
10	0	43.75%	0.000
11	0	37.50%	0.000
12	0	31.25%	0.000
13	0	25.00%	0.000
14	0	18.75%	0.000
15	0	12.50%	0.000
16	0	6.25%	0.000
SUM	**96**		**60**

4 Year Demand = **96**
Avg. Mon. Demand = 1.2500
SLQ = 30.000
SLQ = 30

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	0	75.00%	0.000
5	0	68.75%	0.000
6	0	62.50%	0.000
7	0	56.25%	0.000
8	96	56.25%	54.000
9	0	50.00%	0.000
10	0	43.75%	0.000
11	0	37.50%	0.000
12	0	31.25%	0.000
13	0	25.00%	0.000
14	0	18.75%	0.000
15	0	12.50%	0.000
16	0	6.25%	0.000
SUM	**96**		**54**

4 Year Demand = **96**
Avg. Mon. Demand = 1.1250
SLQ = 27.000
SLQ = 27

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	0	75.00%	0.000
5	0	68.75%	0.000
6	0	62.50%	0.000
7	0	56.25%	0.000
8	0	50.00%	0.000
9	96	50.00%	48.000
10	0	43.75%	0.000
11	0	37.50%	0.000
12	0	31.25%	0.000
13	0	25.00%	0.000
14	0	18.75%	0.000
15	0	12.50%	0.000
16	0	6.25%	0.000
SUM	**96**		**48**

4 Year Demand = **96**
Avg. Mon. Demand = 1.0000
SLQ = 24.000
SLQ = 24

1 Order per SLQ Period for 96 Items (continued)

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	0	75.00%	0.000
5	0	68.75%	0.000
6	0	62.50%	0.000
7	0	56.25%	0.000
8	0	50.00%	0.000
9	0	43.75%	0.000
10	96	43.75%	42.000
11	0	37.50%	0.000
12	0	31.25%	0.000
13	0	25.00%	0.000
14	0	18.75%	0.000
15	0	12.50%	0.000
16	0	6.25%	0.000
SUM	**96**		**42**

4 Year Demand = **96**
Avg. Mon. Demand = 0.8750
SLQ = 21.000
SLQ = 21

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	0	75.00%	0.000
5	0	68.75%	0.000
6	0	62.50%	0.000
7	0	56.25%	0.000
8	0	50.00%	0.000
9	0	43.75%	0.000
10	0	37.50%	0.000
11	96	37.50%	36.000
12	0	31.25%	0.000
13	0	25.00%	0.000
14	0	18.75%	0.000
15	0	12.50%	0.000
16	0	6.25%	0.000
SUM	**96**		**36**

4 Year Demand = **96**
Avg. Mon. Demand = 0.7500
SLQ = 18.000
SLQ = 18

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	0	75.00%	0.000
5	0	68.75%	0.000
6	0	62.50%	0.000
7	0	56.25%	0.000
8	0	50.00%	0.000
9	0	43.75%	0.000
10	0	37.50%	0.000
11	0	31.25%	0.000
12	96	31.25%	30.000
13	0	25.00%	0.000
14	0	18.75%	0.000
15	0	12.50%	0.000
16	0	6.25%	0.000
SUM	**96**		**30**

4 Year Demand = **96**
Avg. Mon. Demand = 0.6250
SLQ = 15.000
SLQ = 15

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	0	75.00%	0.000
5	0	68.75%	0.000
6	0	62.50%	0.000
7	0	56.25%	0.000
8	0	50.00%	0.000
9	0	43.75%	0.000
10	0	37.50%	0.000
11	0	31.25%	0.000
12	0	25.00%	0.000
13	96	25.00%	24.000
14	0	18.75%	0.000
15	0	12.50%	0.000
16	0	6.25%	0.000
SUM	**96**		**24**

4 Year Demand = **96**
Avg. Mon. Demand = 0.5000
SLQ = 12.000
SLQ = 12

1 Order per SLQ Period for 96 Items (continued)

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	0	75.00%	0.000
5	0	68.75%	0.000
6	0	62.50%	0.000
7	0	56.25%	0.000
8	0	50.00%	0.000
9	0	43.75%	0.000
10	0	37.50%	0.000
11	0	31.25%	0.000
12	0	25.00%	0.000
13	0	18.75%	0.000
14	96	18.75%	18.000
15	0	12.50%	0.000
16	0	6.25%	0.000
SUM	**96**		**18**

4 Year Demand = **96**
Avg. Mon. Demand = 0.3750
SLQ = 9.000
SLQ = 9

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	0	75.00%	0.000
5	0	68.75%	0.000
6	0	62.50%	0.000
7	0	56.25%	0.000
8	0	50.00%	0.000
9	0	43.75%	0.000
10	0	37.50%	0.000
11	0	31.25%	0.000
12	0	25.00%	0.000
13	0	18.75%	0.000
14	0	12.50%	0.000
15	96	12.50%	12.000
16	0	6.25%	0.000
SUM	**96**		**12**

4 Year Demand = **96**
Avg. Mon. Demand = 0.2500
SLQ = 6.000
SLQ = 6

2 Orders per SLQ Period for 48 Items.

2 Orders Per 16 Quarters

Average SLQ 27.5

Items Ordered Over SLQ 62

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	0	75.00%	0.000
5	0	68.75%	0.000
6	0	62.50%	0.000
7	0	56.25%	0.000
8	48	56.25%	27.000
9	0	50.00%	0.000
10	0	43.75%	0.000
11	0	37.50%	0.000
12	0	31.25%	0.000
13	0	25.00%	0.000
14	0	18.75%	0.000
15	0	12.50%	0.000
16	48	12.50%	6.000
SUM	**96**		**33**

4 Year Demand = **96**
Avg. Mon. Demand = 0.6875
SLQ = 16.500
SLQ = 17

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	48	100.0%	48.000
2	0	93.75%	0.000
3	0	87.50%	0.000
4	0	81.25%	0.000
5	0	75.00%	0.000
6	0	68.75%	0.000
7	0	62.50%	0.000
8	0	56.25%	0.000
9	48	56.25%	27.000
10	0	50.00%	0.000
11	0	43.75%	0.000
12	0	37.50%	0.000
13	0	31.25%	0.000
14	0	25.00%	0.000
15	0	18.75%	0.000
16	0	12.50%	0.000
SUM	**96**		**75**

4 Year Demand = **96**
Avg. Mon. Demand = 1.5625
SLQ = 37.500
SLQ = 38

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	48	93.75%	45.000
3	0	87.50%	0.000
4	0	81.25%	0.000
5	0	75.00%	0.000
6	0	68.75%	0.000
7	0	62.50%	0.000
8	0	56.25%	0.000
9	0	50.00%	0.000
10	48	50.00%	24.000
11	0	43.75%	0.000
12	0	37.50%	0.000
13	0	31.25%	0.000
14	0	25.00%	0.000
15	0	18.75%	0.000
16	0	12.50%	0.000
SUM	**96**		**69**

4 Year Demand = **96**
Avg. Mon. Demand = 1.4375
SLQ = 34.500
SLQ = 35

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	48	87.50%	42.000
4	0	81.25%	0.000
5	0	75.00%	0.000
6	0	68.75%	0.000
7	0	62.50%	0.000
8	0	56.25%	0.000
9	0	50.00%	0.000
10	0	43.75%	0.000
11	48	43.75%	21.000
12	0	37.50%	0.000
13	0	31.25%	0.000
14	0	25.00%	0.000
15	0	18.75%	0.000
16	0	12.50%	0.000
SUM	**96**		**63**

4 Year Demand = **96**
Avg. Mon. Demand = 1.3125
SLQ = 31.500
SLQ = 32

2 Orders per SLQ Period for 48 Items (continued)

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	48	81.25%	39.000
5	0	75.00%	0.000
6	0	68.75%	0.000
7	0	62.50%	0.000
8	0	56.25%	0.000
9	0	50.00%	0.000
10	0	43.75%	0.000
11	0	37.50%	0.000
12	48	37.50%	18.000
13	0	31.25%	0.000
14	0	25.00%	0.000
15	0	18.75%	0.000
16	0	12.50%	0.000
SUM	**96**		**57**

4 Year Demand = **96**
Avg. Mon. Demand = 1.1875
SLQ = 28.500
SLQ = 29

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	0	75.00%	0.000
5	48	75.00%	36.000
6	0	68.75%	0.000
7	0	62.50%	0.000
8	0	56.25%	0.000
9	0	50.00%	0.000
10	0	43.75%	0.000
11	0	37.50%	0.000
12	0	31.25%	0.000
13	48	31.25%	15.000
14	0	25.00%	0.000
15	0	18.75%	0.000
16	0	12.50%	0.000
SUM	**96**		**51**

4 Year Demand = **96**
Avg. Mon. Demand = 1.0625
SLQ = 25.500
SLQ = 26

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	0	75.00%	0.000
5	0	68.75%	0.000
6	48	68.75%	33.000
7	0	62.50%	0.000
8	0	56.25%	0.000
9	0	50.00%	0.000
10	0	43.75%	0.000
11	0	37.50%	0.000
12	0	31.25%	0.000
13	0	25.00%	0.000
14	48	25.00%	12.000
15	0	18.75%	0.000
16	0	12.50%	0.000
SUM	**96**		**45**

4 Year Demand = **96**
Avg. Mon. Demand = 0.9375
SLQ = 22.500
SLQ = 23

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	0	75.00%	0.000
5	0	68.75%	0.000
6	0	62.50%	0.000
7	48	62.50%	30.000
8	0	56.25%	0.000
9	0	50.00%	0.000
10	0	43.75%	0.000
11	0	37.50%	0.000
12	0	31.25%	0.000
13	0	25.00%	0.000
14	0	18.75%	0.000
15	48	18.75%	9.000
16	0	12.50%	0.000
SUM	**96**		**39**

4 Year Demand = **96**
Avg. Mon. Demand = 0.8125
SLQ = 19.500
SLQ = 20

4 Orders per SLQ Period for 24 Items.

4 Orders Per 16 Quarters

Average SLQ 30.5

Items Ordered Over SLQ -8

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	0	81.25%	0.000
4	24	81.25%	19.500
5	0	75.00%	0.000
6	0	68.75%	0.000
7	0	62.50%	0.000
8	24	62.50%	15.000
9	0	56.25%	0.000
10	0	50.00%	0.000
11	0	43.75%	0.000
12	24	43.75%	10.500
13	0	37.50%	0.000
14	0	31.25%	0.000
15	0	25.00%	0.000
16	24	25.00%	6.000
SUM	**96**		**51**

4 Year Demand = **96**
Avg. Mon. Demand = 1.0625
SLQ = 25.500
SLQ = 26

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	24	100.0%	24.000
2	0	93.75%	0.000
3	0	87.50%	0.000
4	0	81.25%	0.000
5	24	81.25%	19.500
6	0	75.00%	0.000
7	0	68.75%	0.000
8	0	62.50%	0.000
9	24	62.50%	15.000
10	0	56.25%	0.000
11	0	50.00%	0.000
12	0	43.75%	0.000
13	24	43.75%	10.500
14	0	37.50%	0.000
15	0	31.25%	0.000
16	0	25.00%	0.000
SUM	**96**		**69**

4 Year Demand = **96**
Avg. Mon. Demand = 1.4375
SLQ = 34.500
SLQ = 35

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	24	93.75%	22.500
3	0	87.50%	0.000
4	0	81.25%	0.000
5	0	75.00%	0.000
6	24	75.00%	18.000
7	0	68.75%	0.000
8	0	62.50%	0.000
9	0	56.25%	0.000
10	24	56.25%	13.500
11	0	50.00%	0.000
12	0	43.75%	0.000
13	0	37.50%	0.000
14	24	37.50%	9.000
15	0	31.25%	0.000
16	0	25.00%	0.000
SUM	**96**		**63**

4 Year Demand = **96**
Avg. Mon. Demand = 1.3125
SLQ = 31.500
SLQ = 32

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	0	87.50%	0.000
3	24	87.50%	21.000
4	0	81.25%	0.000
5	0	75.00%	0.000
6	0	68.75%	0.000
7	24	68.75%	16.500
8	0	62.50%	0.000
9	0	56.25%	0.000
10	0	50.00%	0.000
11	24	50.00%	12.000
12	0	43.75%	0.000
13	0	37.50%	0.000
14	0	31.25%	0.000
15	24	31.25%	7.500
16	0	25.00%	0.000
SUM	**96**		**57**

4 Year Demand = **96**
Avg. Mon. Demand = 1.1875
SLQ = 28.500
SLQ = 29

8 Orders per SLQ Period for 12 Items.

8 Orders Per 16 Quarters

Average SLQ 36.5

Items Ordered Over SLQ -184

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	0	93.75%	0.000
2	12	93.75%	11.250
3	0	87.50%	0.000
4	12	87.50%	10.500
5	0	81.25%	0.000
6	12	81.25%	9.750
7	0	75.00%	0.000
8	12	75.00%	9.000
9	0	68.75%	0.000
10	12	68.75%	8.250
11	0	62.50%	0.000
12	12	62.50%	7.500
13	0	56.25%	0.000
14	12	56.25%	6.750
15	0	50.00%	0.000
16	12	50.00%	6.000
SUM	96		69

4 Year Demand = **96**
Avg. Mon. Demand = 1.4375
SLQ = 34.500
SLQ = 35

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	12	100.0%	12.000
2	0	93.75%	0.000
3	12	93.75%	11.250
4	0	87.50%	0.000
5	12	87.50%	10.500
6	0	81.25%	0.000
7	12	81.25%	9.750
8	0	75.00%	0.000
9	12	75.00%	9.000
10	0	68.75%	0.000
11	12	68.75%	8.250
12	0	62.50%	0.000
13	12	62.50%	7.500
14	0	56.25%	0.000
15	12	56.25%	6.750
16	0	50.00%	0.000
SUM	96		75

4 Year Demand = **96**
Avg. Mon. Demand = 1.5625
SLQ = 37.500
SLQ = 38

16 Orders per SLQ Period for 6 Items.

16 Orders Per 16 Quarters

Average SLQ **48**

Items Ordered Over SLQ **-672**

Quarter	Req'd Qnty	Weight Factor 100%	Weight Req'd Qnty
1	6	100.0%	6.000
2	6	100.0%	6.000
3	6	100.0%	6.000
4	6	100.0%	6.000
5	6	100.0%	6.000
6	6	100.0%	6.000
7	6	100.0%	6.000
8	6	100.0%	6.000
9	6	100.0%	6.000
10	6	100.0%	6.000
11	6	100.0%	6.000
12	6	100.0%	6.000
13	6	100.0%	6.000
14	6	100.0%	6.000
15	6	100.0%	6.000
16	6	100.0%	6.000
SUM	96		96

4 Year Demand = **96**
Avg. Mon. Demand = 2.0000
SLQ = 48.000
SLQ = 48

Low Lead-Time Analysis (From Chapter III, Table 5.)

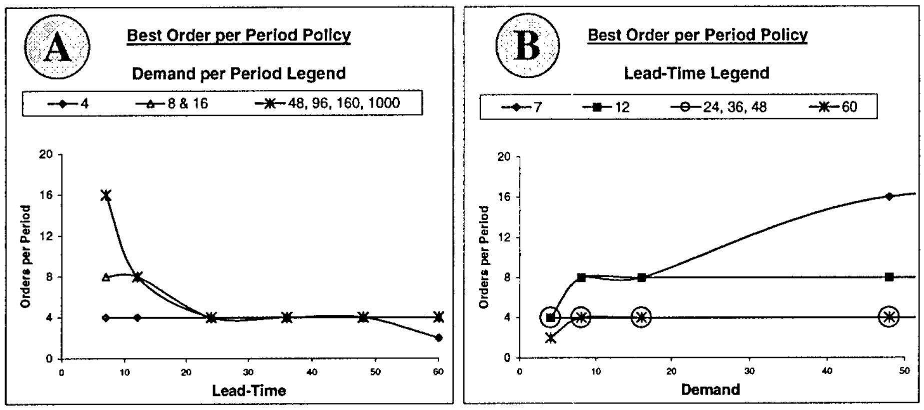
Lead Time	Period Demand	Average SLQ					Items Ordered Above SLQ				
		1	*2*	*4*	*8*	*16*	*1*	*2*	*4*	*8*	*16*
1	16	1	1	1	1	1	15	14	12	8	0
1	48	1	1	1	1	1	47	46	44	40	32
1	160	2	2	2	3	3	159	158	152	144	112
1	1000	11	12	13	16	21	999	986	956	880	664
2	16	1	1	1	1	1	15	14	12	8	0
2	48	1	1	1	2	2	47	46	44	40	16
2	160	4	4	4	5	7	159	156	144	120	48
2	1000	22	24	26	32	42	997	972	912	760	328
3	16	1	1	1	1	1	15	14	12	8	0
3	48	2	2	2	2	3	47	46	40	32	0
3	160	5	6	6	8	10	159	154	140	104	0
3	1000	33	35	39	47	63	996	958	868	640	-8
4	16	1	1	1	1	1	15	14	12	8	0
4	48	2	2	3	3	4	47	46	40	24	-16
4	160	7	8	9	10	13	159	150	132	80	-48
4	1000	44	47	52	63	83	995	942	824	520	-328

Appendix C: SLQ Model Analysis (Chapter IV)

Best Order per Period Strategy

Demand per Period

Lead Time In Months	4	8	16	48	96	160	1000
7	4	8	8	16	16	16	16
12	4	8	8	8	8	8	8
24	4	4	4	4	4	4	4
36	4	4	4	4	4	4	4
48	4	4	4	4	4	4	4
60	2	4	4	4	4	4	4



Best Order per Period Strategy Summary *(As shown in Figure 14.)*

Orders per Period	Lead Time in Months (Demand =======>)	Average SLQ 4	Average SLQ 8	Average SLQ 16	Average SLQ 48	Average SLQ 96	Average SLQ 160	Average SLQ 1000	Items Ordered Above/Below SLQ 4	Items 8	Items 16	Items 48	Items 96	Items 160	Items 1000
Orders per Period 1	7	1.0	1.0	1.4	3.8	7.5	12.4	77.4	3	7	15	47	95	159.0	991.0
	12	1.0	1.3	2.3	6.5	13.0	21.5	132.9	3	7	15	47	94	157.0	984.0
	24	1.3	2.3	4.5	13.0	25.5	42.5	265.8	3	7	15	46	93	155.0	969.0
	36	1.8	3.3	6.5	19.3	38.5	64.0	398.5	3	7	15	46	91	152.0	953.0
	48	2.3	4.5	8.5	25.5	51.0	85.0	531.5	3	7	15	45	90	150.0	937.0
	60	2.8	5.4	10.8	32.0	64.0	106.5	664.1	3	7	15	44	88	147.0	922.0
Orders per Period 2	7	1.0	1.0	1.4	3.9	7.9	13.0	82.0	2	6	14	44	86	144	900.0
	12	1.0	1.1	2.3	6.8	13.5	22.5	140.6	2	6	14	40	80	132	828.0
	24	1.1	2.3	4.5	13.5	27.5	45.5	281.3	2	6	10	32	62	104	656.0
	36	1.6	3.4	6.8	20.3	40.5	67.5	421.9	2	4	8	24	46	78	484.0
	48	2.3	4.5	9.5	27.5	54.0	90.0	562.5	2	2	4	14	30	50	312.0
	60	2.9	5.6	11.3	33.8	67.5	112.5	703.1	0	2	2	6	14	22	140.0
Orders per Period 4	7	1.0	1.0	1.5	4.5	8.5	14.5	91.3	0	4	12	32	68	112	692
	12	1.0	1.0	2.5	7.5	15.0	25.0	156.3	0	4	8	24	44	76	468
	24	1.0	2.5	5.0	15.0	30.5	50.5	312.5	0	0	0	-4	-8	-12	-64
	36	2.0	3.8	7.5	22.5	45.0	75.0	468.5	-4	-4	-8	-28	-56	-96	-592
	48	2.5	5.0	10.5	30.5	60.0	100.0	625.0	-4	-8	-20	-56	-108	-180	-1124
	60	3.3	6.3	12.5	37.5	75.0	125.0	781.0	-8	-12	-28	-80	-160	-264	-1656
Orders per Period 8	7	N/A	1.0	2.0	5.0	10.5	17.5	109.5	N/A	0	0	8	16	24	160
	12	N/A	1.5	3.0	9.0	18.0	30.0	187.5	N/A	0	-8	-24	-40	-72	-440
	24	N/A	3.0	6.0	18.0	36.5	60.5	375.0	N/A	-16	-32	-88	-184	-304	-1872
	36	N/A	4.5	9.0	27.0	54.0	90.0	562.5	N/A	-24	-56	-160	-320	-528	-3312
	48	N/A	6.0	12.5	36.5	72.0	120.0	750.0	N/A	-40	-80	-232	-456	-760	-4752
	60	N/A	7.5	15.0	45.0	90.0	150.0	937.5	N/A	-48	-96	-296	-592	-992	-6184
Orders per Period 16	7	N/A	N/A	2	7	14	23	146	N/A	N/A	-16	-64	-128	-208	-1336
	12	N/A	N/A	4	12	24	40	250	N/A	N/A	-48	-144	-288	-480	-3000
	24	N/A	N/A	8	24	48	80	500	N/A	N/A	-112	-336	-672	-1120	-7000
	36	N/A	N/A	12	36	72	120	750	N/A	N/A	-176	-528	-1056	-1760	-11000
	48	N/A	N/A	16	48	96	160	1000	N/A	N/A	-240	-720	-1440	-2400	-15000
	60	N/A	N/A	20	60	120	200	1250	N/A	N/A	-304	-912	-1824	-3040	-19000

SLQ Analysis with Constant Orders Per SLQ Period *(As shown in Table 8.)*

Lead Time in Months	Orders per Period ====>	Average SLQ 1	Average SLQ 2	Average SLQ 4	Average SLQ 8	Average SLQ 16	Items Ordered Above/Below SLQ 1	Items Ordered Above/Below SLQ 2	Items Ordered Above/Below SLQ 4	Items Ordered Above/Below SLQ 8	Items Ordered Above/Below SLQ 16	
	7	1.0	1.0	**1.0**	N/A	N/A	3	2	**0**	N/A	N/A	**Demand per Period 4**
	12	1.0	1.0	**1.0**	N/A	N/A	3	2	**0**	N/A	N/A	
	24	1.3	1.1	**1.0**	N/A	N/A	3	2	**0**	N/A	N/A	
	36	1.8	1.6	**2.0**	N/A	N/A	3	2	**-4**	N/A	N/A	
	48	2.3	2.3	**2.5**	N/A	N/A	3	2	**-4**	N/A	N/A	
	60	2.8	**2.9**	3.3	N/A	N/A	3	**0**	-8	N/A	N/A	
	7	1.0	1.0	1.0	**1.0**	N/A	7	6	4	**0**	N/A	**Demand per Period 8**
	12	1.3	1.1	1.0	**1.5**	N/A	7	6	4	**0**	N/A	
	24	2.3	2.3	**2.5**	3.0	N/A	7	6	**0**	-16	N/A	
	36	3.3	3.4	**3.8**	4.5	N/A	7	4	**-4**	-24	N/A	
	48	4.5	4.5	**5.0**	6.0	N/A	7	2	**-8**	-40	N/A	
	60	5.4	5.6	**6.3**	7.5	N/A	7	2	**-12**	-48	N/A	
	7	1.4	1.4	1.5	**2.0**	2.0	15	14	12	**0**	-16	**Demand per Period 16**
	12	2.3	2.3	2.5	**3.0**	4.0	15	14	8	**-8**	-48	
	24	4.5	4.5	**5.0**	6.0	8.0	15	10	**0**	-32	-112	
	36	6.5	6.8	**7.5**	9.0	12.0	15	8	**-8**	-56	-176	
	48	8.5	9.5	**10.5**	12.5	16.0	15	4	**-20**	-80	-240	
	60	10.8	11.3	**12.5**	15.0	20.0	15	2	**-28**	-96	-304	
	7	3.8	3.9	4.5	5.0	**7.0**	47	44	32	8	**-64**	**Demand per Period 48**
	12	6.5	6.8	7.5	**9.0**	12.0	47	40	24	**-24**	-144	
	24	13.0	13.5	**15.0**	18.0	24.0	46	32	**-4**	-88	-336	
	36	19.3	20.3	**22.5**	27.0	36.0	46	24	**-28**	-160	-528	
	48	25.5	27.5	**30.5**	36.5	48.0	45	14	**-56**	-232	-720	
	60	32.0	33.8	**37.5**	45.0	60.0	44	6	**-80**	-296	-912	
	7	8	8	9	11	**14**	95	86	68	16	**-128**	**Demand per Period 96**
	12	13	14	15	**18**	24	94	80	44	**-40**	-288	
	24	26	28	**31**	37	48	93	62	**-8**	-184	-672	
	36	39	41	**45**	54	72	91	46	**-56**	-320	-1056	
	48	51	54	**60**	72	96	90	30	**-108**	-456	-1440	
	60	64	68	**75**	90	120	88	14	**-160**	-592	-1824	
	7	12	13	15	18	**23**	159	144	112	24	**-208**	**Demand per Period 160**
	12	22	23	25	**30**	40	157	132	76	**-72**	-480	
	24	43	46	**51**	61	80	155	104	**-12**	-304	-1120	
	36	64	68	**75**	90	120	152	78	**-96**	-528	-1760	
	48	85	90	**100**	120	160	150	50	**-180**	-760	-2400	
	60	107	113	**125**	150	200	147	22	**-264**	-992	-3040	
	7	77	82	91	110	**146**	991	900	692	160	**-1336**	**Demand per Period 1000**
	12	133	141	156	**188**	250	984	828	468	**-440**	-3000	
	24	266	281	**313**	375	500	969	656	**-64**	-1872	-7000	
	36	399	422	**469**	563	750	953	484	**-592**	-3312	-11000	
	48	532	563	**625**	750	1000	937	312	**-1124**	-4752	-15000	
	60	664	703	**781**	938	1250	922	140	**-1656**	-6184	-19000	

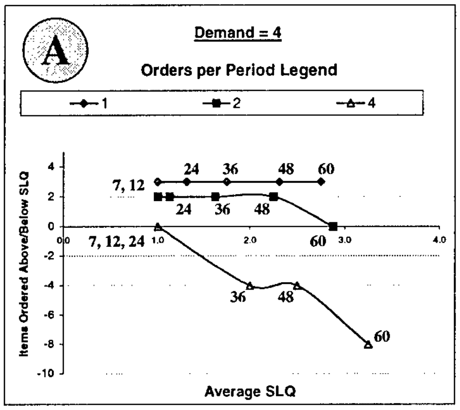
SLQ Analysis with Constant Demand Summary *(As shown in Table 6.)*

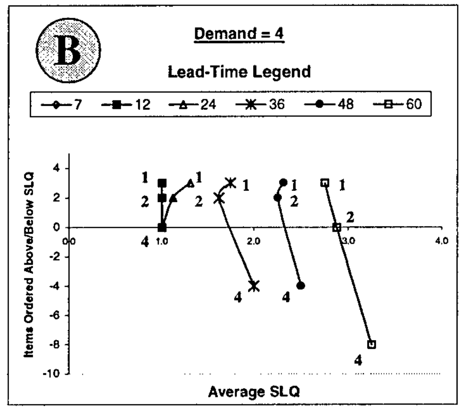
Lead Time	Demands per Period (Orders per Period ====>)	Average SLQ 1	Average SLQ 2	Average SLQ 4	Average SLQ 8	Average SLQ 16	Items Ordered Above/Below SLQ 1	Items Ordered Above/Below SLQ 2	Items Ordered Above/Below SLQ 4	Items Ordered Above/Below SLQ 8	Items Ordered Above/Below SLQ 16
Lead Time 7	4	1.0	1.0	**1.0**	N/A	N/A	3	2	**0**	N/A	N/A
	8	1.0	1.0	1.0	**1.0**	N/A	7	6	4	**0**	N/A
	16	1.4	1.4	1.5	**2.0**	2.0	15	14	12	**0**	**-16**
	48	3.8	3.9	4.5	5.0	**7.0**	47	44	32	8	**-64**
	96	7.5	7.9	8.5	10.5	**14.0**	95	86	68	16	**-128**
	160	12.4	13.0	14.5	17.5	**23.0**	159	144	112	24	**-208**
	1000	77.4	82.0	91.3	109.5	**146.0**	991	900	692	160	**-1336**
Lead Time 12	4	1.0	1.0	**1.0**	N/A	N/A	3	2	**0**	N/A	N/A
	8	1.3	1.1	1.0	**1.5**	N/A	7	6	4	**0**	N/A
	16	2.3	2.3	2.5	**3.0**	4.0	15	14	8	**-8**	-48
	48	6.5	6.8	7.5	**9.0**	12.0	47	40	24	**-24**	-144
	96	13.0	13.5	15.0	**18.0**	24.0	94	80	44	**-40**	-288
	160	21.5	22.5	25.0	**30.0**	40.0	157	132	76	**-72**	-480
	1000	132.9	140.6	156.3	**187.5**	250.0	984	828	468	**-440**	-3000
Lead Time 24	4	1.3	1.1	**1.0**	N/A	N/A	3	2	**0**	N/A	N/A
	8	2.3	2.3	**2.5**	3.0	N/A	7	6	**0**	-16	N/A
	16	4.5	4.5	**5.0**	6.0	8.0	15	10	**0**	-32	-112
	48	13.0	13.5	**15.0**	18.0	24.0	46	32	**-4**	-88	-336
	96	25.5	27.5	**30.5**	36.5	48.0	93	62	**-8**	-184	-672
	160	42.5	45.5	**50.5**	60.5	80.0	155	104	**-12**	-304	-1120
	1000	265.8	281.3	**312.5**	375.0	500.0	969	656	**-64**	-1872	-7000
Lead Time 36	4	1.8	1.6	**2.0**	N/A	N/A	3	2	**-4**	N/A	N/A
	8	3.3	3.4	**3.8**	4.5	N/A	7	4	**-4**	-24	N/A
	16	6.5	6.8	**7.5**	9.0	12.0	15	8	**-8**	-56	-176
	48	19.3	20.3	**22.5**	27.0	36.0	46	24	**-28**	-160	-528
	96	38.5	40.5	**45.0**	54.0	72.0	91	46	**-56**	-320	-1056
	160	64.0	67.5	**75.0**	90.0	120.0	152	78	**-96**	-528	-1760
	1000	398.5	421.9	**468.5**	562.5	750.0	953	484	**-592**	-3312	-11000
Lead Time 48	4	2.3	2.3	**2.5**	N/A	N/A	3	2	**-4**	N/A	N/A
	8	4.5	4.5	**5.0**	6.0	N/A	7	2	**-8**	-40	N/A
	16	8.5	9.5	**10.5**	12.5	16.0	15	4	**-20**	-80	-240
	48	25.5	27.5	**30.5**	36.5	48.0	45	14	**-56**	-232	-720
	96	51.0	54.0	**60.0**	72.0	96.0	90	30	**-108**	-456	-1440
	160	85.0	90.0	**100.0**	120.0	160.0	150	50	**-180**	-760	-2400
	1000	531.5	562.5	**625.0**	750.0	1000.0	937	312	**-1124**	-4752	-15000
Lead Time 60	4	2.8	**2.9**	3.3	N/A	N/A	3	**0**	-8	N/A	N/A
	8	5.4	5.6	**6.3**	7.5	N/A	7	2	**-12**	-48	N/A
	16	10.8	11.3	**12.5**	15.0	20.0	15	2	**-28**	-96	-304
	48	32.0	33.8	**37.5**	45.0	60.0	44	6	**-80**	-296	-912
	96	64.0	67.5	**75.0**	90.0	120.0	88	14	**-160**	-592	-1824
	160	106.5	112.5	**125.0**	150.0	200.0	147	22	**-264**	-992	-3040
	1000	664.1	703.1	**781.0**	937.5	1250.0	922	140	**-1656**	-6184	-19000

SLQ Analysis with Constant Lead-Times *(As shown in Table 7.)*

Demand = 4

Lead Time In Months	Average SLQ: 1	2	4	8	16	Items Ordered Above/Below SLQ: 1	2	4	8	16	
Orders per Period →											
7	1.0	1.0	1.0	N/A	N/A	3	2	0	N/A	N/A	7
12	1.0	1.0	1.0	N/A	N/A	3	2	0	N/A	N/A	12
24	1.3	1.1	1.0	N/A	N/A	3	2	0	N/A	N/A	24
36	1.8	1.6	2.0	N/A	N/A	3	2	-4	N/A	N/A	36
48	2.3	2.3	2.5	N/A	N/A	3	2	-4	N/A	N/A	48
60	2.8	2.9	3.3	N/A	N/A	3	0	-8	N/A	N/A	60

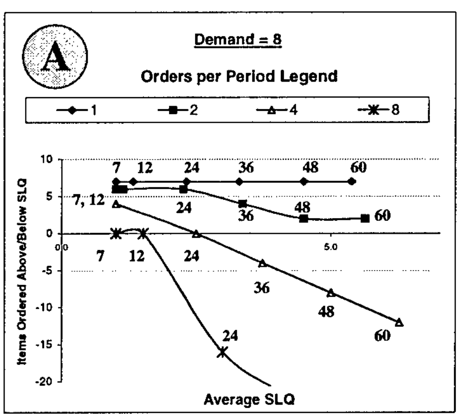


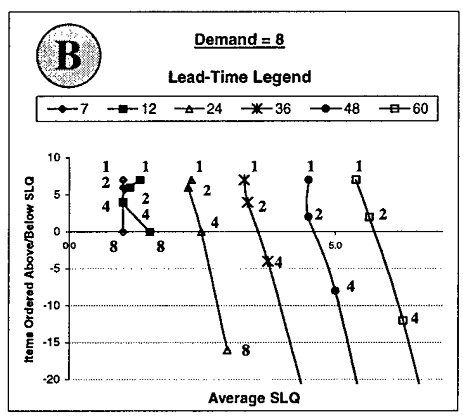


SLQ Analysis - Demand per SLQ Period = 4 *(As shown in Figure 9.)*

Demand = 8

Lead Time In Months	Average SLQ: 1	2	4	8	16	Items Ordered Above/Below SLQ: 1	2	4	8	16	
Orders per Period →											
7	1.0	1.0	1.0	1.0	N/A	7	6	4	0	N/A	7
12	1.3	1.1	1.0	1.5	N/A	7	6	4	0	N/A	12
24	2.3	2.3	2.5	3.0	N/A	7	6	0	-16	N/A	24
36	3.3	3.4	3.8	4.5	N/A	7	4	-4	-24	N/A	36
48	4.5	4.5	5.0	6.0	N/A	7	2	-8	-40	N/A	48
60	5.4	5.6	6.3	7.5	N/A	7	2	-12	-48	N/A	60

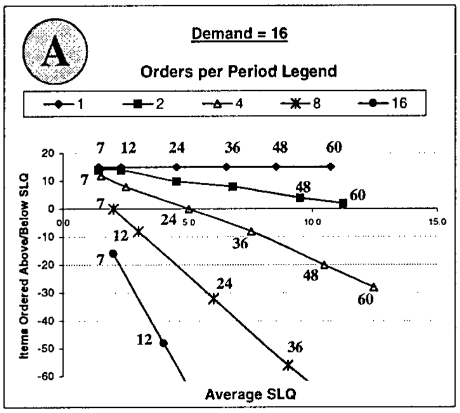


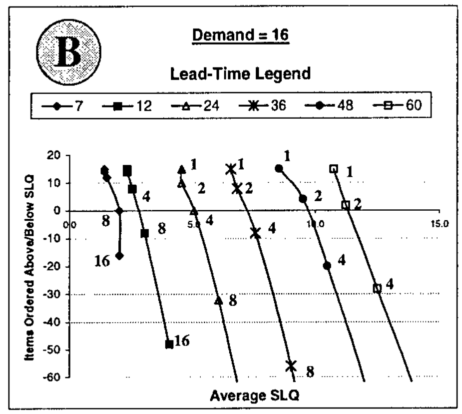


SLQ Analysis - Demand per SLQ Period = 8 *(As shown in Figure 10.)*

Demand = 16

Lead Time in Months (Orders per Period →)	Average SLQ 1	Average SLQ 2	Average SLQ 4	Average SLQ 8	Average SLQ 16	Items Ordered Above/Below SLQ 1	Items Ordered Above/Below SLQ 2	Items Ordered Above/Below SLQ 4	Items Ordered Above/Below SLQ 8	Items Ordered Above/Below SLQ 16	
7	1.4	1.4	1.5	2.0	2.0	15	14	12	0	-16	7
12	2.3	2.3	2.5	3.0	4.0	15	14	8	-8	-48	12
24	4.5	4.5	5.0	6.0	8.0	15	10	0	-32	-112	24
36	6.5	6.8	7.5	9.0	12.0	15	8	-8	-56	-176	36
48	8.5	9.5	10.5	12.5	16.0	15	4	-20	-80	-240	48
60	10.8	11.3	12.5	15.0	20.0	15	2	-28	-96	-304	60

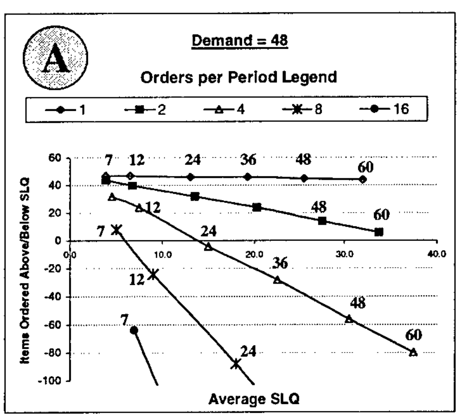


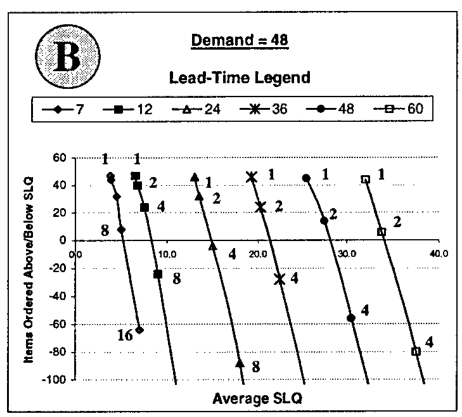


SLQ Analysis - Demand per SLQ Period = 16 *(As shown in Figure 11.)*

Demand = 48

Lead Time in Months (Orders per Period →)	Average SLQ 1	Average SLQ 2	Average SLQ 4	Average SLQ 8	Average SLQ 16	Items Ordered Above/Below SLQ 1	Items Ordered Above/Below SLQ 2	Items Ordered Above/Below SLQ 4	Items Ordered Above/Below SLQ 8	Items Ordered Above/Below SLQ 16	
7	3.8	3.9	4.5	5.0	7.0	47	44	32	8	-64	7
12	6.5	6.8	7.5	9.0	12.0	47	40	24	-24	-144	12
24	13.0	13.5	15.0	18.0	24.0	46	32	-4	-88	-336	24
36	19.3	20.3	22.5	27.0	36.0	46	24	-28	-160	-528	36
48	25.5	27.5	30.5	36.5	48.0	45	14	-56	-232	-720	48
60	32.0	33.8	37.5	45.0	60.0	44	6	-80	-296	-912	60

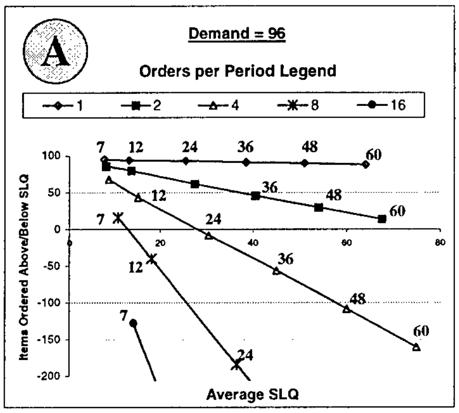


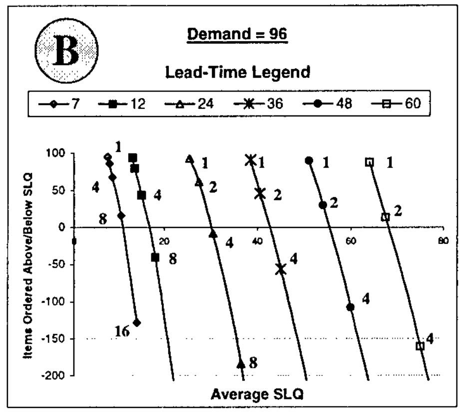


SLQ Analysis - Demand per SLQ Period = 48 *(As shown in Figure 12.)*

Demand = 96

Orders per Period	Average SLQ 1	2	4	8	16	Items Ordered Above/Below SLQ 1	2	4	8	16	
7	8	8	9	11	**14**	95	86	68	16	**-128**	7
Lead 12	13	14	15	**18**	24	94	80	44	**-40**	-288	12
Time 24	26	28	**31**	37	48	93	62	**-8**	-184	-672	24
In 36	39	41	**45**	54	72	91	46	**-56**	-320	-1056	36
Months 48	51	54	**60**	72	96	90	30	**-108**	-456	-1440	48
60	64	68	**75**	90	120	88	14	**-160**	-592	-1824	60

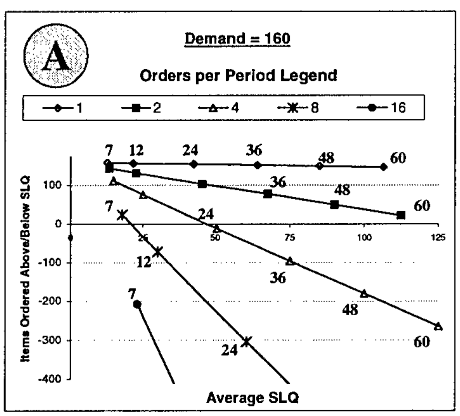


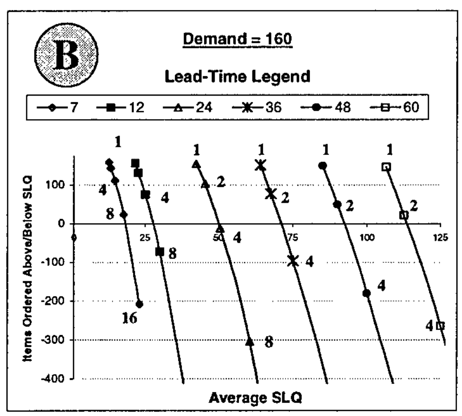


SLQ Analysis - Demand per SLQ Period = 96 *(As shown in Figure 13.)*

Demand = 160

Orders per Period	Average SLQ 1	2	4	8	16	Items Ordered Above/Below SLQ 1	2	4	8	16	
7	12	13	15	18	**23**	159	144	112	24	**-208**	7
Lead 12	22	23	25	**30**	40	157	132	76	**-72**	-480	12
Time 24	43	46	**51**	61	80	155	104	**-12**	-304	-1120	24
In 36	64	68	**75**	90	120	152	78	**-96**	-528	-1760	36
Months 48	85	90	**100**	120	160	150	50	**-180**	-760	-2400	48
60	107	113	**125**	150	200	147	22	**-264**	-992	-3040	60

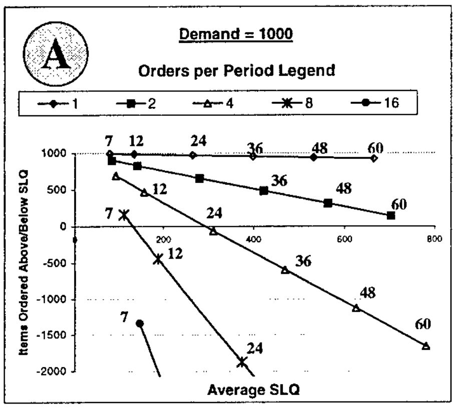


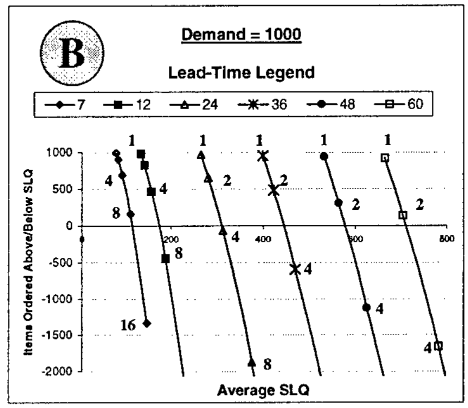


SLQ Analysis - Demand per SLQ Period = 160

Demand = 1000

Lead Time In Months	Average SLQ: 1	2	4	8	16	Items Ordered Above/Below SLQ: 1	2	4	8	16	
Orders per Period	1	2	4	8	16	1	2	4	8	16	
7	77	82	91	110	**146**	991	900	692	160	**-1336**	7
12	133	141	156	**188**	250	984	828	468	**-440**	-3000	12
24	266	281	**313**	375	500	969	656	**-64**	-1872	-7000	24
36	399	422	**469**	563	750	953	484	**-592**	-3312	-11000	36
48	532	563	**625**	750	1000	937	312	**-1124**	-4752	-15000	48
60	664	703	**781**	938	1250	922	140	**-1656**	-6184	-19000	60





SLQ Analysis - Demand per SLQ Period = 1000

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14. ABSTRACT

The Cooperative Logistics Supply Support Arrangement (CLSSA) is a program designed to provide follow-on supply support for weapon systems procured by foreign military sales (FMS) countries from the United States. CLSSA calculates a Stock Level Quantity (SLQ) for each item based on demand history, item lead-time, and requisitioning patterns. Item SLQs affects program cost and service levels to FMS customers; a high SLQ level improves service levels, but also creates higher costs. The author created a model to replicate the CLSSA formulation used to calculate SLQs, using different combinations of demand levels and item lead-times to determine the impact that different ordering patterns have on SLQ levels. The results provide optimal ordering patterns for the various combinations used in this study to ensure maximum service levels while minimizing customer program costs. Although each different combination of demand level and lead-time produced a specific optimal ordering frequency, in general, items with lead-times of 24 months or greater, 12 months, and 7 months or less, had optimal requisitioning frequencies of annually, semiannually, and quarterly respectively. The complete results can be used by FMS countries to tailor their CLSSA requisitioning strategy to meet their needs of service levels and cost.

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