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COST-BENEFIT ANALYSIS OF THE ENHANCED TRANSPORTATION SERVICE PROGRAM

by

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13. ABSTRACT *(maximum 200 words)*This thesis is a cost-benefit analysis of the Enhanced Transportation Service (ETS) Program, which is a proposed initiative under the Marine Corps' "Precision Logistics" concept. The general focus of "Precision Logistics" is to provide the warfighter with the right thing, at the right place, at the right time, with the least amount of effort and cost. (Hamilton, 1996) The specific focus of the ETS Program is to utilize premium transportation service (i.e., next day air) to reduce order ship time (OST), which will result in lower stockage levels. The intent of this study was to determine if the benefit derived from reduced stockage levels outweighs the additional cost of air shipment. This is intended to be the first in a series of studies of the ETS Program. The study was based on the requisitioning objective (RO) stockage level. A computer spreadsheet model of the RO formula was built and two Monte Carlo simulation runs conducted to determine if the ETS Program is cost effective. Results of the analysis suggest that the cost of premium transportation service is significantly less than the cost of additional inventory that would have to be carried if premium transportation were not utilized. Therefore, further research of the ETS Program is warranted. Recommendations on the direction of future studies are provided.

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ABSTRACT

This thesis is a cost-benefit analysis of the Enhanced Transportation Service (ETS) Program, which is a proposed initiative under the Marine Corps' "Precision Logistics" concept. The general focus of "Precision Logistics" is to provide the warfighter with the right thing, at the right place, at the right time, with the least amount of effort and cost. (Hamilton, 1996) The specific focus of the ETS Program is to utilize premium transportation service (i.e., next day air) to reduce order ship time (OST), which will result in lower stockage levels.

The intent of this study was to determine if the benefit derived from reduced stockage levels outweighs the additional cost of air shipment. This is intended to be the first in a series of studies of the ETS Program. The study was based on the requisitioning objective (RO) stockage level. A computer spreadsheet model of the RO formula was built and two Monte Carlo simulation runs conducted to determine if the ETS Program is cost effective.

Results of the analysis suggest that the cost of premium transportation service is significantly less than the cost of additional inventory that would have to be carried if premium transportation were not utilized. Therefore, further research of the ETS Program is warranted. Recommendations on the direction of future studies are provided.

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I. INTRODUCTION

A. BACKGROUND

In today's uncertain world, the United States military is faced with an ever increasing operational tempo. However, as the list of missions and requirements grows, the available fiscal resources continue to shrink. In order to maintain the greatest military force in the world, all efforts must be focused on being able to fight "smarter not harder". This starts by analyzing basic activities, and asking "Is this the best way to carry out the mission?" The Marine Corps' inventory management system is one area that can be analyzed in search of improvement. Constrained fiscal resources now demand efficient management of supply inventories.

"The Commandant's Planning Guidance" (Krulak, 1995) set a vision for where the Marine Corps is heading. The concept of "the right support at the right time" (Krulak, 1995, p. 9) must be followed today if the Marine Corps is to be successful on the battlefield in the future.

"Precision Logistics" is a current Marine Corps concept that seeks a complete overhaul of the way logistics is provided at the tactical, operational and strategic levels. The initial focus is reducing logistics response times (LRTs). Order ship time (OST) reduction is currently the main focus of the "Precision Logistics" initiative.

An attempt to reduce OST is the Enhanced Transportation Service (ETS) program, in which <u>all</u> requisitions would be funded for air transportation. Decreased OST should result in a decrease in customer stockage levels and thus a savings to the Marine Corps. Air transportation is the fastest mode of shipment, but it is also the most expensive. The question becomes, "Does the benefit derived from reduced stockage levels outweigh the additional cost of air shipment?" Answering this question is the focus of this research.

This chapter is divided into four sections (not including the current section). Section B answers the question, "What is Precision Logistics"? Section C defines "order ship time" and explain the different steps involved. Section D discusses the concept of the Enhanced Transportation Service (ETS) program. Section E lays out the questions answered by this research. Finally, section F outlines the remainder of the study.

B. WHAT IS PRECISION LOGISTICS?

1. Definition

"'Precision Logistics' is the art and science of providing the warfighter with the right thing, at the right place, at the right time, with the least amount of effort, signature, and cost." (Hamilton, 1996) "Precision Logistics" is not a single program; rather, it is a collection of programs that are currently under way in the Marine Corps. The concept of "Precision Logistics" is a vehicle by which to pull projects together to ensure they are all working toward the same goal(s). Moreover, "Precision Logistics" will lead to a cultural change in the way that support is provided in the Marine Corps. (Krulak, 1997)

2. Why?

"Precision Logistics" is primarily the result of two factors. First, more than ever, shrinking budgets require that the Marine Corps operate as efficiently as possible to maximize use of the funds provided. The funds freed up through faster and less costly support can be utilized in other critical areas, such as force modernization. (Krulak, 1997) Secondly, slow logistics response times have caused the "customers" to lose faith in the Marine Corps supply system. This has resulted in customers increasing their inventories to compensate for the unresponsive system. (Hamilton, 1996) The current level of customer service is unacceptable.

3. How?

New projects are being instituted that adapt commercial procedures with innovative technology to improve logistics and reduce costs. These procedures and technology are being tailored to the Marine Corps and its unique requirements. Merely automating current procedures and systems would prove ineffective. Therefore, existing procedures and systems are being reviewed to identify and eliminate "non-value added" steps to help streamline the flow of information. There are currently many individual projects underway and in planning.

4. Goals (Hamilton, 1996)

The goals of the "Precision Logistics" initiative can be stated as five objectives. First, to provide dependable and responsive logistics support to the customers. If this is achieved it should lead to fulfilling the second objective, which is to improve customer satisfaction. The third objective is to increase the Marine Corps' capability to deploy and sustain itself. The fourth objective is to increase supply and maintenance readiness, which will directly have a positive impact on increasing overall unit readiness. Finally, the fifth objective is to reduce inventories. The initial focus of the "Precision Logistics" initiative is to reduce order ship time (OST) (CMC Washington DC//L//, 1996). The following section will explain what OST is, and break it down at two levels.

C. WHAT IS ORDER SHIP TIME?

1. **Retail Level Supply** (see Glossary)

Order ship time (OST) is the time between the initiation of a supply requisition (i.e., a requirement is identified) and the receipt for that requisition by the requesting unit (DoD 4140.1-R). The following are a chronological list of the steps in the order and ship process at the retail level[1]:

1. An individual (e.g., mechanic, technician) identifies that a repair part is required.

2. The shop/section supervisor verifies the requirement.

3. The requesting shop/section completes an Equipment Repair Order Shopping List (EROSL). This initiates the requisitioning process.

4. The EROSL is delivered to the unit's supply section. A supply clerk will "key punch" the EROSL into the Asset Tracking for Logistics and Supply System (ATLASS). This is an automated program that, among other things, initiates and tracks supply requisitions from the requesting unit level (e.g., infantry battalion, maintenance company) up through the supply chain. ATLASS interfaces with the Supported Activities Supply Support System (SASSY), which is the automated system that is used by the retail level supply activities (i.e., supply battalions). Refer to Figure 1-1.

5. The computer disk that contains all the requesting unit's supply transactions for that day is delivered to the SASSY Management Unit (SMU) at the Supply Battalion. The diskette may be either hand delivered or sent through email. Refer to Figure 1-1.

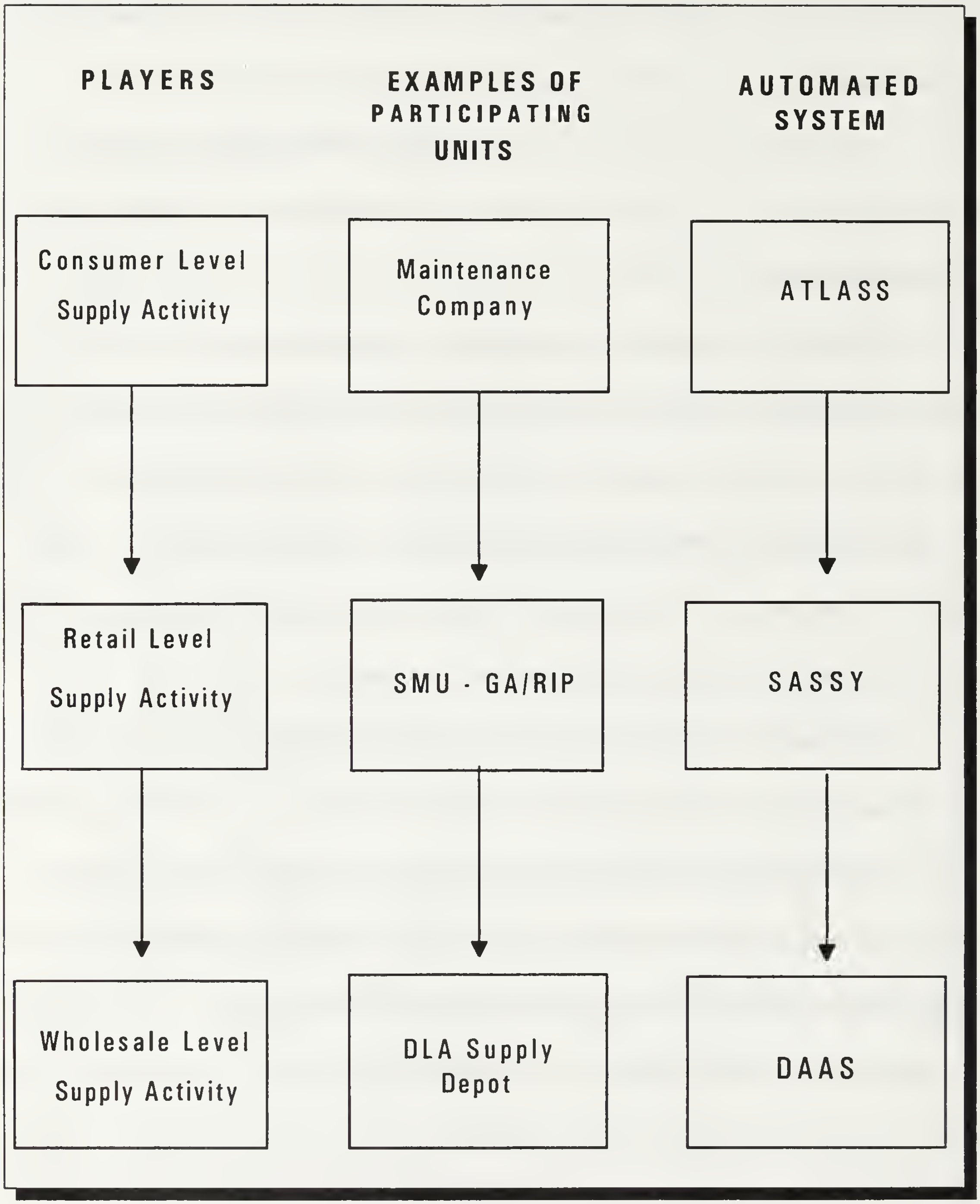
6. The SMU processes the supply transactions of all requesting units. Daily, usually, the transactions are run through SASSY, which determines part availability at the retail level supply activity.

7. If the requested item is on hand within Supply Battalion, the SMU's computer files indicate the warehouse location. The "General Account" section handles consumable items and the "Reparables Issue Point" section (RIP) handles reparable components. This study is limited to the activities of the RIP. Refer to Figure 1-1. If the requested item is not on hand, the request is forwarded to the wholesale level supply activity(s). Wholesale level supply is addressed in sub-section 2.

8. The SMU creates a material release order (MRO), then a warehouse clerk retrieves the item from the storage location.

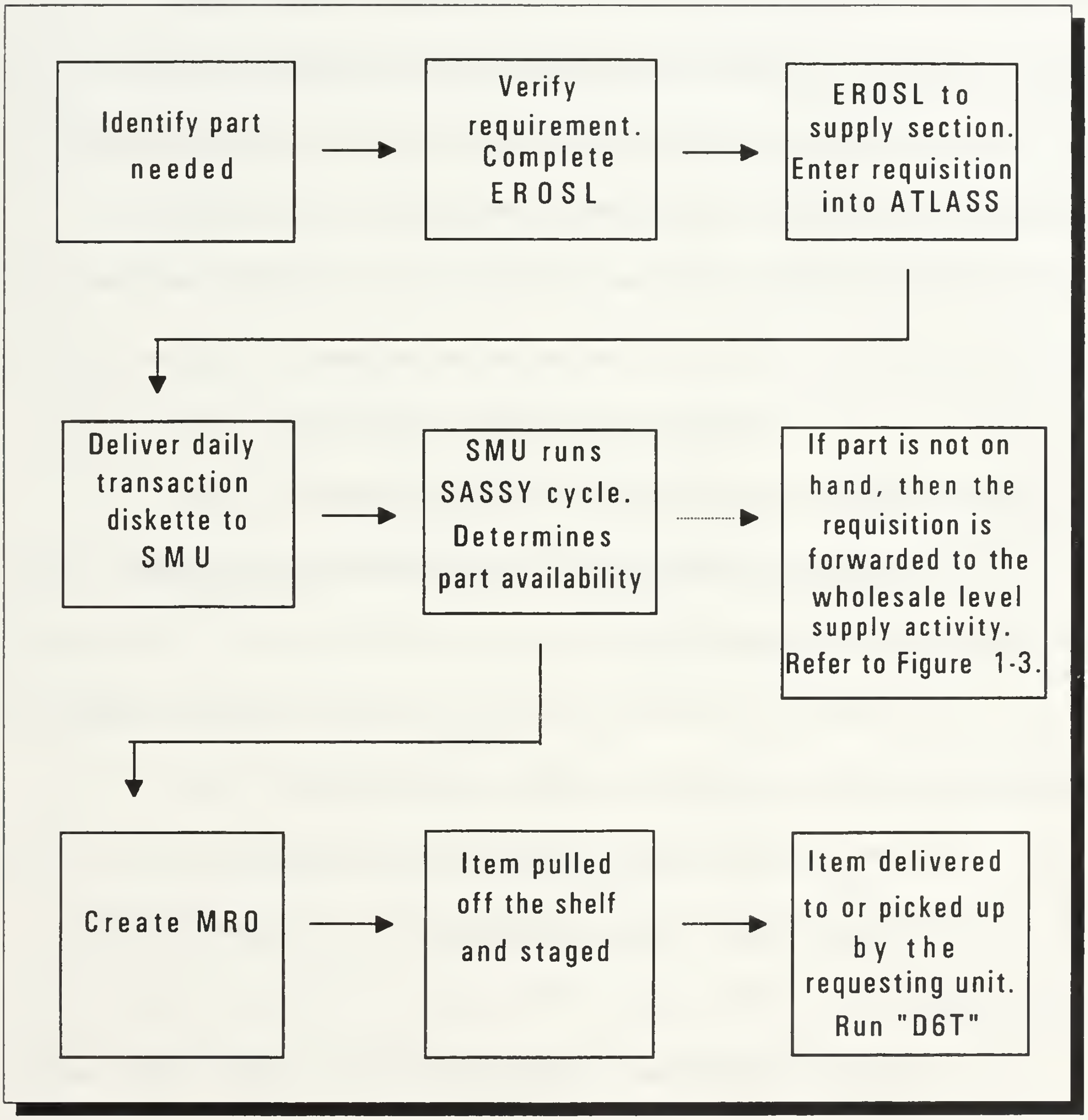
9. Finally, the item is either delivered to the requesting unit or the requesting unit retrieves the item from Supply Battalion. The requesting unit then processes a "D6T" transaction, which closes out the requisition in SASSY (DoD 4140.22-M).

The retail level order & ship process is outlined in Figure 1-2.



Order and Ship Process Information Flow -- General

Figure 1-1.



Retail Level Order and Ship Process[1]

Figure 1-2.

2. **Wholesale Level Supply** (see Glossary)

Once it is determined that the retail level supply activity (e.g., supply battalion) does not possess the requested item, then one of two things occurs. First, if the requisition is a high priority, then it is forwarded to the wholesale system for action. Second, if the requisition is a low priority, then the supply battalion may wait to fill the requisition until the their stocks are replenished at some point in the future. Refer to Appendix A for an outline of the Marine Corps Uniform Material Movement and Issue Priority System (UMMIPS). At this point assume that the requisition is a high enough priority, and is passed to the wholesale level for action. The following are a chronological list of the steps in the order and ship process at the wholesale level[1]:

1. SASSY passes the requisition to the Defense Automated Addressing System (DAAS), located in Dayton, Ohio.

2. The requisition is rerouted to the appropriate National Inventory Control Point (NICP). If the item is on hand at the NICP, an MRO is created.

3. The MRO is sent to the appropriate supply depot via DAAS,

4. The Defense Logistic Agency (DLA) supply depots pull MROs off DAAS usually once a day.

5. The MROs are prioritized by requisition priority and required delivery date (RDD). See Glossary.

6. The requested item is retrieved from the storage location. The amount of time it takes the warehouse personnel to retrieve the item is a function of where the

request falls within the priority system. Once the item is picked from the shelf, it is prepared for shipping.

7. The mode of shipment is determined by cost effectiveness and UMMIPS time frames. See Appendix B for the current timeframe requirements. Appendix C outlines the new timeframes that are currently under review.

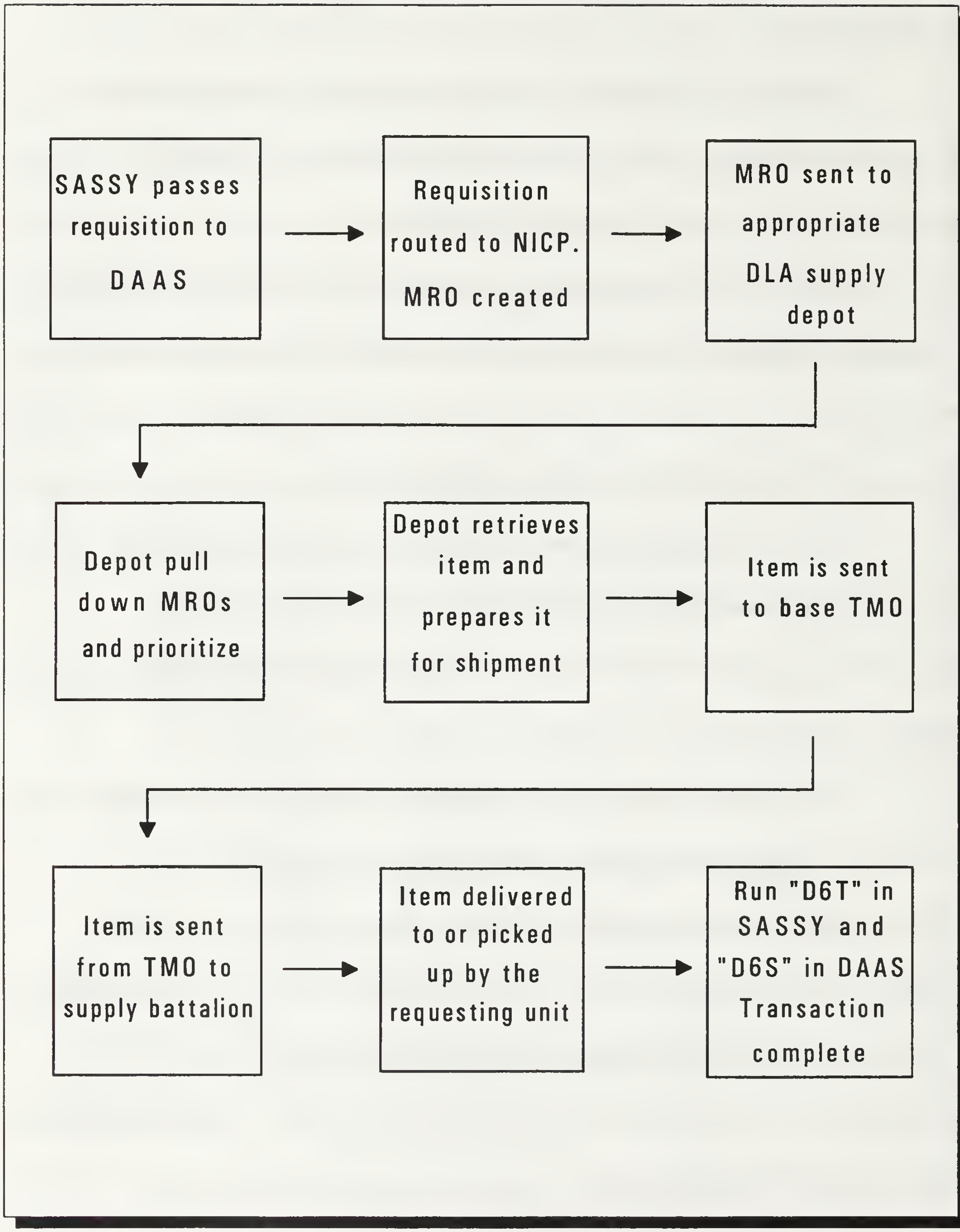
8. The item is then shipped to the base/installation of the requesting unit (e.g., Camp Pendleton, California). The Traffic Management Office (TMO) usually receipts for the item.

9. TMO then sends the item to the supply battalion.

10. Supply battalion either delivers the item to the requesting unit or the requesting unit retrieves the item from supply battalion. The requesting unit then processes a "D6T" transaction, which closes out the requisition in SASSY (DoD 4140.22-M).

11. Once the SMU receives the "D6T" transaction in SASSY, they process a "D6S" transaction, which closes out the requisition in DAAS (DoD 4140.22-M).

The wholesale level order & ship process is outlined in Figure 1-3. A program called Enhanced Transportation Service (ETS) is currently under review, and the program intent is to reduce OST. The ETS program focuses on minimizing the amount of time spent during step #8 of the wholesale level supply process (see above). The next section discusses the vision of the ETS program.



Wholesale Level Order and Ship Process[1]

Figure 1-3.

D. THE ENHANCED TRANSPORTATION SERVICE PROGRAM[2]

As discussed above, the ETS program is intended to reduce OST. The ETS program accomplishes this by shipping all requisitions by way of next day air delivery. Moreover, this decrease in OST also leads to a decrease in stockage levels at the retail supply activities (e.g., FSSG RIPs), which yields savings for the Marine Corps. The Defense Logistics Agency (DLA) funds for all high priority requisitions, as they currently do, and the Marine Corps funds for the air shipment of all "medium" and "low" priority requisitions. The current transportation cost structure is outlined in Table 1-1.

Transportation Costs

Destination	From	To	Who Pays
1st*	Manufacturer Vendor	Wholesale Activity (e.g., DLA supply depot)	Part of contract negotiation
2nd*	Wholesale Activity	Next Customer (e.g., FSSG RIP)	DLA
3rd**	Next Customer	Final Customer	Marine Corps (USMC)

Table 1-1.[3]

* See Glossary for definitions

** Only applicable if the "Next Customer" is not the retail level customer. This is usually not the case.

The DLA currently funds all "second destination" transportation costs. The mode of shipment is determined by cost effectiveness and UMMIPS timeframes. See Appendix B for the current timeframe requirements. However, to implement the ETS program the transportation cost structure has to be realigned as shown in Table 1-2.

ETS Transportation Costs

Destination	From	To	Who Pays
1st	Manufacturer Vendor	Wholesale Activity (e.g., DLA supply depot)	Part of contract negotiation
2nd	Wholesale Activity	Next Customer (e.g., FSSG RIP)	High Priority -- DLA Med. Priority -- USMC Low Priority -- USMC
3rd*	Next Customer	Final Customer	USMC

Table 1-2.

* Only applicable if the "Next Customer" is not the retail level customer. This is usually not the case.

Full-scale testing of this program is risky and cost prohibitive. To determine the merits/shortcomings of ETS, this research investigates how OST and stockage levels react when the ETS concept is implemented. This is done with a simulation model. The specific research questions are outlined below.

E. RESEARCH QUESTIONS

1. Primary

The ETS Program funds for the air shipment of all requisitions. Air transportation is the fastest mode of shipment, but it is also the most expensive as well. The intent is that ETS decrease OST and result in a decrease in customer stockage levels. The primary research question is "Does the benefit derived from reduced stockage levels outweigh the additional cost of air shipment?" This is the primary research question. At the conclusion, a decision is made as to whether or not the ETS program is a viable option for reducing

OST in a cost effective manner. This includes a recommendation of whether or not further research of the ETS program should be conducted.

2. Secondary

The primary research question examines the cost effectiveness of the ETS program under the present UMMIPS time standards outlined in Appendix B. Appendix C outlines the new UMMIPS time standards that are currently under review. The research determines if the new time standards make the ETS program more or less cost effective, as compared to the results obtained under the current time standards.

F. OUTLINE

In Chapter I background material was presented to familiarize the reader with the Marine Corps supply system and the proposed ETS program. The remainder of the study will be broken down into five more chapters. The following is a brief outline:

Chapter II: Literature review -- Review of current literature on the subject of inventory management.

Chapter III: Description of the Marine Corps inventory position (i.e., requisitioning objective) model. Describe the components and define the variables.

Chapter IV: Methodology -- Build and run simulation model.

Chapter V: Analysis - Review of the results obtained during the data gathering.

Chapter VI: Conclusion/Recommendations - Conclude what the effects are of sending all requisitions by air shipment. Make any recommendations for further improvements.

ENDNOTES

[1] Information on the order and ship process was provided courtesy of Dr. Marc Robbins, RAND Corporation. The source of the information is an unpublished RAND report which discusses the order and ship process. The RAND researcher's knowledge of the order and ship process is the result of interviews with key personnel, observation of the process (i.e., a requisition was initiated and tracked through the entire process), and previous RAND research.

[2] The information on ETS was obtained from an "Information Paper" entitled *MARCORLOGBASES Albany Enhanced Transportation Service,* dated July 11, 1996. This paper was provided by Major Scott Allen, Logistic Center Operations Office, and Captain Andy Stokes, Integrated Logistics Support Directorate; both from Marine Corps Logistics Bases Albany, Georgia. Enhanced Transportation Service is merely a concept under review at this point, and there is very little literature on this topic.

[3] The current transportation cost structure was outlined during an interview December 17, 1996 with Captain Andy Stokes and Master Sergeant John Robinson, both of the Integrated Logistics Support Directorate, Marine Corps Logistics Bases Albany, Georgia.

II. LITERATURE REVIEW

A. INTRODUCTION

The idea of using premium transportation service in order to reduce inventory stockage levels is not new. Nearly forty years ago the Commander-in-Chief, United States Pacific Fleet initiated a study titled the "Pacific Air Cargo Evaluation" (PACE). That study was similar to this current research of the cost-benefit of the ETS program. Specifically, "It covered the relationships between air, other forms of transportation, supply policy and practice and the administrative controls by which supply and transportation are made to work together." (PACE, 1958)

The PACE study was initiated because it was theorized that using air transportation to deliver parts results in decreased inventory stockage levels, which yields savings to the military. It focused on savings in two areas: 1) reduction in "pipeline" stocks, and 2) reduction in "normal" stocks. Pipeline stocks are reduced because air transportation results in a faster delivery time, which reduces the amount of stock in transit. In addition, "normal" stocks are reduced because the replenishment leadtime is shortened.

The study found that air transportation was not as dependable or as fast as initially suspected. For example, when discussing a supply shipment from CONUS to Hawaii it was stated that, "Only in most exceptional cases is it possible to provide a customer with a bona fide emergency shipment in a week from CONUS from the time he submits a requisition. Only by superhuman effort can it be done in less time." The conclusion was that at that time air transportation was not an economical means of providing logistics support for the military.

However, the PACE study should not be viewed as failure. The results are only a "snapshot in time". Aviation was still in its infancy in 1958, and many, many improvements have taken place since that time. For instance, it does not take a "superhuman" effort to deliver supplies from CONUS to Hawaii in less than a week. Almost forty years have passed since the completion of the PACE study, and it is time once again to ask the question, "Can the military provide better logistics support?"

To shed light on this question, the following five sections are broken down as follows:

1. Section B looks at the functional classifications of inventory. These classifications are relevant to inventory management decisions.

2. Section C provides examples of how in-transit (i.e., "pipeline") inventory and buffer inventory are effected by the mode of transportation used to distribute supplies.

3. Section D provides an overview of transportation.

4. Section E presents an example of how logistics (i.e., transportation) is being used as a competitive advantage in the private sector.

5. Finally, Section F briefly summarizes the literature review.

B. FUNCTIONAL CLASSIFICATIONS OF INVENTORY

The objective of inventory management is "to have items available to maintain flow of goods to customers while minimizing the investment required to achieve this service."

(Fogarty, Blackstone, and Hoffman, 1991) When making critical inventory management decisions such as how much inventory to carry, when reorder, and what mode of distribution to use, there are four classifications of inventory that are relevant. Magee, Copacino, and Rosenfield (1985) use the terms cycle stock, seasonal/smoothing stock, process stock and safety stock. Leenders, Fearon, and England (1980) classify inventory as[1]: 1) cycle inventory, 2) anticipation inventory, 3) transit inventory, and 4) buffer inventory. These classifications are given different names by different individuals, but the concepts behind the names remain fairly consistent. Since both models are essentially the same, the terms used in the Leenders model are chosen to describe the different functions of inventory.

Cycle inventory is the result of an organization purchasing an item in a larger quantity than is needed for immediate purposes. (Magee, Copacino, and Rosenfield, 1985) According to Fogarty, Blackstone, and Hoffman (1991), cycle inventory represents "the purchase of goods in a quantity sufficient to meet relatively stable demand during an extended period." This is effected by "how much is ordered", rather than "how the order is delivered". Therefore, this is not directly effected by the ETS program.

Secondly, anticipation inventory is carried in order to meet expected changes in customer demand and/or supplier delivery. This implies that some items have seasonal trends that can be forecasted and anticipated. For the most part, the Marine Corps supply system does not exhibit any seasonal trends, so anticipation inventory is not really applicable. Forecasting seasonal trends in the Marine Corps supply system can be the subject of future research, but is not the focus of this study.

Transit inventory, also referred to as "pipeline inventory", represents the materiel that is being moved from the supplier to the requesting organization. A significant amount of inventory can be in-transit for organizations that use slow and/or unreliable modes of transportation to distribute supplies. This is basically wasted capital that is tied up in inventory that is not even yet available for use by the requesting unit.

This also relates to the concept of lead time. According to Magee, Copacino, and Rosenfield (1985), "the longer the lead time for a particular stage of a process, the more important inventories become, and with relatively short lead time it may not be crucial to carry the inventory." In addition, factors such as the speed of the transportation mode, speed of paperwork processing, and flexibility of the transportation system also have an impact on the amount of inventory needed. (Magee, Copacino, and Rosenfield, 1985) Finally, Magee, Copacino, and Rosenfield (1985) state, "If the flow of material from seller to buyer is rapid, prompt when ordered, and highly reliable, the buyer can reduce investment in inventory." This is exactly the intent of the ETS program.

Finally, buffer inventory is carried because of the probabilistic nature of inventory management. Specifically, there are usually fluctuations in customer demand and/or supplier delivery that can not be anticipated. The amount of buffer inventory is a function of the desired service level the supplier wants to provide the customer. An example of an approach to determining the "appropriate" amount of buffer inventory is as follows, equation 2.1[2]:

$$B = K\sqrt{UL * Q} \quad (2.1)$$

where;

B = buffer inventory
K = service level factor (see Table 2.1)
U = usage
L = lead time
Q = order lot size

Service Level Factor - K Table

Desired Service Level	Factor
50%	0
85%	1.04
90%	1.28
95%	1.65
99.9%	4

Table 2-1.

From this example, it can be shown that a reduction in lead time (L) will result in a reduction of buffer inventory. As already discussed, the ETS program attempts to reduce lead time by shipping all supply requisitions via premium transportation (i.e., air). Therefore, the ETS program helps reduce the amount of buffer inventory carried at the RIPs. Section C provides examples of how transit inventory and buffer inventory are effected by the mode of transportation used to distribute supplies.

C. TRANSIT INVENTORY AND BUFFER INVENTORY EXAMPLES

This section quantifies some of the information provided in Section B. First, an example of how transit inventory is effected by the mode of transportation is provided. Fogarty, Blackstone, and Hoffman (1991) provide the following formula, equation 2.2, for determining the cost of transit inventory:

$$\text{(2.2)} \qquad TRIC = K * D * C * T$$

where;

TRIC = transit inventory cost
K = transportation carrying cost, based on the cost of capital, pilferage, etc. This does not represent the cost of shipment
D = demand per period
C = unit cost
T = transit time

Based on the equation above, the following information is provided. If:

K = 10% per year
D = 2 units per day
C = $40/unit
T = 7 days

Then;

TRIC = (.10/year) * (2 units/day) * ($40/unit) * (7 days) = $56/year

However, if transit time (T) is reduced to one day and everything else remains constant, then;

TRIC = (.10/year) * (2 units/day) * ($40/unit) * (1 day) = $8/year

This is a small example, but it demonstrates how a faster mode of transportation reduces transit inventory. In addition, this example shows only one item, but the Marine Corps RIPs carry over 1,000 different items. A slight reduction in transit inventory cost for many items may result in significant savings.

Next, an example of how buffer inventory is effected by the mode of transportation is provided. Equation 2.1 will be used for this example. If:

K = 90% desired service level = K factor 1.28 (see Table 2.1)
U = 2 units/day
L = 7 days
Q = 10 units

Then;

$$B = 1.28\sqrt{(2units/day) * (7days) * (10units)} = 1.28\ (11.83\ \text{units}) = 15.15\ \text{units}$$

However, if leadtime (L) is reduced to one day and everything else remains constant, then;

$$B = 1.28\sqrt{(2units/day) * (1day) * (10units)} = 1.28\ (4.47\ \text{units}) = 5.72\ \text{units}$$

Once again, this is only a small example, but it demonstrates how a faster mode of transportation reduces the amount of buffer inventory. The following section provides an overview of transportation.

D. TRANSPORTATION OVERVIEW

This section provides a brief introduction, discusses factors and trade offs to consider in choosing a mode of transportation, and finally, highlights some advantages of air transportation. To begin, the mode of transportation chosen to distribute supplies represents one of the most important decisions the logistician must make. According to Ballou (1992), "Transportation is a key decision area within the logistics mix. Except for the cost of the purchased goods, transportation absorbs, on average, a higher proportion of logistics costs than any other logistics activity." In light of that statement, it is imperative that the logistician make an informed decision when choosing a mode of transportation to distribute and/or receive supplies. Therefore, several factors must be considered when choosing the mode of transportation.

Based on an analysis of seven different surveys, Ballou (1992) highlights three factors that weigh heavily in choosing a mode of transportation: 1) cost, 2) transit time and variability, and 3) loss or damage. When considering the cost of transportation, several factors, not just the cost of shipment, must be examined. Magee, Copacino, and

Rosenfield (1985) point out that "Transportation rates and other direct costs, such as handling and packaging, are not the only costs to be considered. There are indirect costs, such as extra stock investment and lost sales due to unreliable service." In addition, other surveys have shown that average delivery time and delivery time variability rank as the most important factors for managers in "corporate America". (Ballou, 1992)

The most important "loss" to consider is customers who are lost due to dissatisfaction with unreliable service. Marine Corps organizations, such as an infantry battalion, have very little flexibility in choosing suppliers. However, customer service is still an important consideration. For instance, delayed shipments may result in higher inventory costs due to stockouts or backorders. (Ballou, 1992) The prudent logistician should choose the mode of transportation that provides the best balance between all three of the factors discussed above.

In choosing the best balance between the factors, there are certain trade offs that must be considered. To the customer, better transportation service (i.e., faster and more reliable) means that lower inventory levels can be maintained. (Ballou, 1992) A shipper using a slower, less reliable mode of transportation will compensate the customer by charging a lower rate. However, this also results in more inventory being carried in stock and in the pipeline. On the other hand, "air freight must charge higher rates than other modes of transportation, which results in a trade off between performance and premium costs." (Ballou, 1992) Some benefits of using air transportation are discussed next.

To begin with, air is the fastest mode of transportation available for intermediate to long range shipments. In addition, package delivery services, such as Federal Express, are the fastest mode for transporting small shipments over 200 miles. (Magee, Copacino, and Rosenfield, 1985) Secondly, the speed of air transportation also helps reduce costs of other logistic components. Specifically, the amount of material in stock and in the pipeline is reduced, thus reducing the inventory costs. (Magee, Copacino, and Rosenfield, 1985)

Next, less protective packaging is required when using air transportation. Air shippers provide relatively delicate physical handling of shipments, as compared to other modes of transportation, as part of the premium service. Therefore, air shipment results in less physical damage to goods. (Ballou, 1992) Finally, air shippers can "trace" a shipment with relative ease. Lost or delayed shipments are never desirable; however, the logistician that does not plan for this inevitable situation is setting himself/herself up for failure. "Information on the exact location of a shipment normally can be obtained with little difficulty." (Leenders, Fearon, and England, 1980) This provides more flexibility for the customer. The following section provides a "real world" example of how an organization is using transportation as a competitive advantage.

E. TRANSPORTATION AS A COMPETITIVE ADVANTAGE

This section presents one example that was highlighted in an article by Henkoff (1994). The intent is to demonstrate that logistics management is not a concept merely applicable to academia. Logistics, and specifically transportation, is considered one of the most important factors for the success of many businesses. The organization that is discussed is National Semiconductor, a producer of computer microchips.

National Semiconductor incurred several years of losses in the early 1990's. As a result, they conducted an in-depth analysis of the organization to identify potential problem areas. What they found was that their product was delivered to customers within 45 days 95% of the time, and the remaining 5% took as long as 90 days. (Henkoff, 1994) With computer technology progressing quickly, this performance was unacceptable if they wished to be successful. Further review revealed that they had inventory stockpiled all over the place to compensate for long and/or highly variable delivery schedules. According to Patrick Brockett, president of the National Semiconductor international business group, "We had buffer stocks all along the (supply) line. The whole system was awash in inventory." (Henkoff, 1994)

They attacked the problem by cutting buffer stocks and hiring Federal Express (FedEx) to manage their transportation and distribution. The results from the first two years were impressive. National Semiconductor reduced distribution costs by 2.5% and increased sales by 34% (i.e., $584 million). In addition, they reduced delivery time by 47%, and now they move their product to the customer within four days. Their success is an example of how an awareness of the link between transportation and inventory can result in reduced costs and provide a competitive advantage.

F. CONCLUSION

This chapter demonstrated that the amount of inventory carried and the mode of transportation used to distribute that inventory are inescapably connected. The introduction highlighted the fact that the military understood this connection nearly forty years ago, but the aviation was not fast enough or reliable enough to institute a program similar to ETS.

Section B looked at the inventory portion of this two-part link. It was shown that transit inventory and buffer inventory are directly effected by the mode of transportation. Section C presented some quantitative examples of how faster transportation can result in less inventory. Section D looked at the transportation portion of the "link". Factors to consider when choosing a mode of transportation were discussed. In addition, some of the benefits of air transportation were highlighted. Finally, Section E presented a practical example of how an organization used the link between air transportation and inventory to gain an advantage in a highly competitive industry.

The shortcomings identified in the PACE study no longer present a barrier. The ETS program can be successful for the Marine Corps. The next chapter reviews the requisitioning objective (RO). RO is used as a measure of inventory in this research and is important in the analysis of the ETS program.

ENDNOTES

[1] Leenders, Fearon, and England also say that inventory serves a "decoupling" function, which allows for the separation of dependent production centers. This is more applicable to manufacturing organizations and not the Marine Corps, therefore, it is not included in this literature review.

[2] Taken from a Cost Accounting lecture by Professor Gordon Louvau on August 5, 1996.

III. REQUISITIONING OBJECTIVE

A. INTRODUCTION

Requisitioning objective (RO) is the maximum amount of an item a unit is authorized to carry on hand and on order at any given time (DoD 4140.1-R). The Department of Defense Materiel Management Regulation (1993) Chapter 3 provides general guidance to the military in establishing a RO formula. The components of the RO formula, for reparable items, are 1) the order and ship requirement, 2) The repair cycle requirement and 3) safety level.

Before proceeding, it should be re-emphasized that this research is only reviewing the requisitioning objective for reparable items, but not consumable items. This is an important distinction because reparable items have two procurement sources, while consumable items only have one source. That is, if a unit submits a request to the Supply Battalion for a reparable item, then the Supply Battalion can look to two sources to fill the request.

First, the Supply Battalion can turn to the supporting maintenance activity, the General Support Maintenance Company (GSM), to see if they have a replacement item repaired and ready for issue. Next, if no unit(s) are ready for issue or the unit(s) in maintenance are deemed "unreparable", then the Supply Battalion forwards the request to the wholesale level supply activity.

In a broad sense, the order and ship requirement (OSR) looks at requisitions filled through the supply channel, and the repair cycle requirement (RCR) looks at requisitions filled through the maintenance channel. Finally, the safety level is an additional stockage level to hopefully provide a "buffer" against a potential stock-out. Each of the components, OSR, RCR, and safety level, is covered in detail in the following sections.

B. ORDER AND SHIP REQUIREMENT

"The order and ship requirement is the average monthly number of units that are on order from the source of supply" (Naval Audit Service, 1996). The order and ship requirement can be further synthesized into the following, equation 3.1:

$$[(MFR - RR) \times OST] / 30 \text{ days} \quad (3.1)$$

where;

MFR = Maintenance Failure Rate
RR = Repair Rate
OST = Order and Ship Time

The maintenance failure rate is the demand per month for reparable items (NAS, 1996). This is represented by the number of equipment repair orders (EROs) opened during the period. The assumption is that the supporting maintenance activity initiates an ERO because they have been given a broken reparable item by a requesting unit. Therefore, there is a demand to have that item repaired. The repair rate is the number of an item returned, repaired and ready for use, by the supporting maintenance activity to the Reparables Issue Point (RIP) (Naval Audit Service, 1996). This is represented by the number of equipment repair orders (EROs) closed during the period. The assumption here is that the ERO is not closed until the required repair(s) are completed. Finally, order and shipping time is "the average number of days it takes the RIP to order and receive replenishment from the source of supply", such as a DLA supply depot (NAS, 1996).

The maintenance failure rate (MFR) less the repair rate (RR) is also known as the washout rate (NAS, 1996). A "washed out" item is one that could not be repaired locally. Therefore, the wash out rate is the number of items that must be requisitioned through the supply vice maintenance channel. This figure is important because, as stated in Section A, the OSR portion of the RO formula accounts for requisitions filled through the supply channel. Therefore, the wash out rate multiplied by the order and ship time provides the total number of days it took the RIP to order and receive replenishment from the source of supply, over the entire period (e.g., one year). Dividing this figure by thirty days provides an approximate monthly average for the number of units on order from the source of supply. The next section examines the maintenance portion of the RO formula.

C. REPAIR CYCLE REQUIREMENT

The repair cycle requirement is the average monthly number of units that are being repaired by the supporting intermediate level maintenance activity (NAS, 1996). The repair cycle requirement can be further synthesized into the following, equation 3.2:

(3.2) (RR X RCT) / 30 days

where;

RCT = Repair Cycle Time
RR = Repair Rate

The repair cycle time is the average number of days it takes to repair an item (NAS, 1996). This is calculated by taking the total number of calendar days a type of item is in maintenance during the past year and dividing by the number of repairs in the past year. The repair rate is explained in Section B. An example of how the components of the RCR formula interact is provided, as follows.

If three repairs take ten days to complete and one repair takes thirty days to complete, then the RCT is as follows:

[(3 repairs X 10 days) + (1 repair X 30 days)] / 4 repairs
= 60 days / 4 repairs = 15 days/repair

By using a weighted average, this helps reduce some of the effect of outliers. For example, the RCT would have been overstated if computed as follows:

10 days + 30 days / 2 observations = 40 days / 2 observations
= 20 days/repair

Finally, to complete the example, if four units are repaired during the period and it takes an average of fifteen days per repair, then:

(4 repairs X 15 days/repair) / 30 days = 60 days / 30 days
= 2 units/month

This shows that on average, two units are being repaired during the month. To reiterate, the RCR portion of the RO formula accounts for requisitions filled through the maintenance channel. The next section examines the measure taken to avoid a stock-out; the safety level.

D. SAFETY LEVEL (SL)

The safety level is "the quantity of materiel required to be on hand to permit continued operation in the event of a minor interruption of normal replenishment or a fluctuation in demand" (DoD 4140.1-R). The Department of Defense Materiel Management Regulation (1993) does not provide specific guidance for formulating safety level for retail level RIPs, as highlighted in the Naval Audit Service report (1996). Therefore, the formula recommended in the report (NAS, 1996) is now being used. The safety level is computed as the lower of lead time demand (LTD) or two standard deviations of LTD. However, since the Marine Corps currently has insufficient historical data in order to compute standard deviation for LTD, lead time demand alone is used to compute safety level until sufficient historical data has been collected (NAS, 1996). The lead time demand is the quantity of materiel required to sustain operations while waiting to receive supply replenishment (NAS, 1996). Lead time demand can be represented as the following, equation 3.3:

$$LTD = OSR + RCR \tag{3.3}$$

where;

OSR = Order and ship requirement
RCR = Repair cycle requirement

This approach to safety level is somewhat simple, but nonetheless it is currently being used. Finally, Sections B through D can be summarized in the following, equation 3.4:

$$RO = OSR + RCR + SL \tag{3.4}$$

where;

$OSR = [(MFR - RR) \times OST] / 30$ days
$RCR = (RR \times RCT) / 30$ days
$SL = LTD = OSR + RCR$

E. SUMMARY

This chapter provided an overview of the requisitioning objective formula used by the Marine Corps at retail level RIPs. In addition, the three components of the RO were also defined and reviewed. The requisitioning objective is an important inventory measure because it represents the amount of capital tied up in inventory, not including cost of holding the inventory and the cost of ordering the inventory. In the next chapter, a spreadsheet model of the requisitioning objective is presented. A simulation is conducted in order to view the affect of "premium transportation" on the RO stockage and determine if the ETS program is cost effective.

IV. SIMULATION MODEL

A. INTRODUCTION

As discussed in Chapter I, the purpose of this research is to investigate the merits/ shortcomings of the ETS program through the use of computer simulation. Computer simulation is a fairly easy and inexpensive method of using historical data to look into the future. The simulation model in this research is built around the requisitioning objective formula discussed in Chapter III. This chapter discusses how the simulation was formulated and conducted. Section B describes simulation in general. Section C highlights the methodology behind this research. Section D discusses the supply and maintenance data. Section E explains the step-by-step process used during the simulation. Finally, Section F provides a summary.

B. WHAT IS A SIMULATION?

According to Clark, Hindelang, and Pritchard (1989), "simulation is the imitation of a real-world system by using a mathematical model which captures the critical operating characteristics of the system as it moves through time encountering random events." There are four characteristics of simulation. First, simulation is a representation of a real-world system. "The model abstracts from the system its important features, thus simplifying it and making it easier to manipulate."[1] Next, simulation is a controlled experiment, which means the experiment takes place in a controlled environment (e.g., a computer program) rather than a real world setting (e.g., 1st FSSG). Third, simulation is a problem solving tool, but not an end.[1] That is, this tool provides insight into the future, but analysis is necessary to transform the data into useful information. Finally, simulation involves the manipulation of variables, which allows researchers to evaluate the effect of different policies/scenarios over time.[1]

There are three different types of variables that may be involved in a simulation. State variables represent the "state" of the system at any point in time. "State variables must be given an initial value, but the simulation model will generate new values for state variables according to their relationship with other variables."[1] Decision variables take on new values in the model as the result of decisions made, or policies created, by decision makers. Finally, environmental variables are variables that are beyond the control of decision makers, but still have a significant impact on the model. In a simulation the different variables will interact with one another to generate an outcome, which the researcher can analyze and use as the basis for a future decision. The different types of variables are related to the current research in Section D.

C. METHODOLOGY

A spreadsheet model is generated using Lotus 1-2-3. An "add-in" computer program, Crystal Ball, is used to run the simulation. One year of historical data for twenty-six supply items are be used to define the probabilistic assumptions (i.e., distribution) of all the applicable variables.

Before proceeding, recall the order ship time (OST) portion of the order & ship requirement is comprised of six time segments for shipments within CONUS. The time segments, highlighted in Appendix B, are listed below:

1. Requisition submission

2. Passing action

3. Inventory control point (ICP) availability determination

4. Depot/storage site processing

5. Transportation hold and CONUS in-transit to CONUS requisitioner

6. Receipt by requisitioner

Time segment #5 is directly effected by the mode of shipment. Marine Corps Order 4400.16G (see Appendix B) establishes time frame requirements for each segment, and overall, that the vendor must meet when processing requisitions. The requirements are different for high, medium, and low priority requisitions. Current time standards are shown in Table B-1, and newly proposed time standards are in Table C-1.

The first simulation manipulates the OST data to reflect air shipment under current UMMIPS time standards. This is referred to as "scenario #1" from this point forward. This is done by changing segment #5 to one day (i.e., vice the current thirteen day requirement for low priority requisitions), because vendors have 24 hours to deliver under the proposed ETS program. For example, assume the overall OST for a low priority item is 31 days, with the transportation hold and in-transit segment as 13 days. If next day air transportation is used, then the OST is 19 days, with one day for the transportation hold and in-transit segment. The second simulation manipulates the OST data to reflect air shipment under proposed new time frame requirements, as outlined in Table C-1. This is referred to as "scenario #2" from this point forward.

This provides the RO under two different scenarios. In Chapter V, the incremental inventory value is compared to the incremental transportation cost to determine if the ETS program is cost effective under the different scenarios.

D. EXPLAINING THE DATA

1. Classifying the Variables

Recall from Section B that a simulation model may be comprised of three different types of variables: state, decision, and environmental. This section "labels" the components of the RO model, which is shown in Appendix G.

Repair rate (RR), order and shipping requirement (OSR), repair cycle time (RCT), repair cycle requirement (RCR), safety level (SL), and requisitioning objective (RO) are all state variables. These variables take on different values during the simulation based on their relationship with other variables. Maintenance failure rate (MFR) and order and shipping time (OST) are environmental variables because the demand for an item or the delivery of that item from the supplier are largely out of the hands of the "decision makers" at 1st FSSG. There is a "fine line" between the classification of the different variables, and others may classify the variables a little bit differently. This section should not be considered the "best" classification; rather, it is merely intended to highlight the researcher's perspective of the model.

2. Supply Data[2]

The supply data contains the OST times for the twenty-six items included in the simulation. For example, 1st FSSG had nine wholesale requisitions during fiscal year 1996 for item #1. The requisitions took the following number of days from the date of order to the date of receipt: 107, 6, 5, 35,30, 28, 31, 30, and 15 days. In Appendix E, the column labeled "HISTORICAL OST" represents the historical OST data.

The column labeled "OST #1" represents the OST data that are used to run the simulation for scenario #1. These numbers are derived by subtracting twelve days from the numbers in column "HISTORICAL OST". The twelve days was taken from the last column of Table B-1, which shows that the transportation hold and in-transit time standard is thirteen days. Since the ETS program allows one day for in-transit, twelve days are subtracted from that time standard. This data is used to "define the assumption" for OST for scenario #1. This is explained further in the "Step-By-Step Procedures" section.

The column labeled "OST #2" represents the OST data that are used to run the simulation for scenario #2. These numbers are derived by subtracting eight days from the numbers in column "HISTORICAL OST". The eight days was taken from the last column of Table C-1, which shows that the transportation hold and in-transit time standard is nine days. Since the ETS program allows one day for in-transit, eight days is subtracted from that time standard. This data is used to "define the assumption" for OST for scenario #2. This is explained further in the "Step-By-Step Procedures" section.

The column labeled "HISTORICAL MEAN OST" represents the arithmetic mean OST based on the historical data. The mean OSTs are then plugged into the RO model under the "OST" column (see Appendix G). For example, item #1 had a total of 287 days that requisitions were outstanding. These days are then divided by the number of requisitions during the year. Therefore; the historical mean OST is 287 days / 9 requisitions, which equals approximately 32 days per requisition. The columns labeled "MEAN OST #1" and "MEAN OST #2" are computed similarly, but are based on the data from columns "OST #1" and "OST #2", respectively.

3. Maintenance Data[2]

The maintenance data is from the Marine Corps Integrated Maintenance Management System (MIMMS). The data are arranged by month for fiscal year 1996, with each item having four rows of corresponding data: "EROs Opened", "Qty Repaired", "Total Days", and "RCT". The "EROs Opened" row is a count of all equipment repair orders opened on a specific item (i.e., NSN) for each of the months indicated. This is based on the "Date-Received-In-Shop" (DRIS) of the ERO (i.e., MIMMS uses a DRIS data field to indicate when maintenance is initiated). The "EROs Opened" row corresponds to the maintenance failure rate (MFR) in the RO model.

The "QTY Repaired" row is a count of all EROs closed for a specific item. This is based on the MIMMS data field "ERO-Close-Status", with a code of 15 indicating that the item is repaired. This row corresponds to the repair rate (RR) in the RO model.
The "Total Days" row indicates how many days EROs are opened on a specific item. This is derived as the number of days between the "Date-Received-In-Shop" and the "Date-Closed". Finally, the "RCT" row is the repair cycle time for each item. This is computed by taking total days and dividing it by the repair rate. This row corresponds to the repair cycle time in the RO model.

E. RUNNING THE SIMULATION

1. Assumptions

In order to provide a framework for the simulation, the following assumptions are made:

A. That the RO model described in Chapter III is an accurate reflection of how requisitioning objective is calculated for a RIP.

B. That the supply requisitions are low priority (i.e., Force Activity Designator III).

C. That the requisitions are being filled by Defense Depot Albany, Georgia (DDAG) for 1st FSSG.

D. That subtracting off part of time segment #5 (i.e., as shown in Tables B-1 and C-1) from historical OST will provide order and shipping times that are comparable to those that are experienced with the ETS program. In addition, the other time segments remain constant.

2. Limitations

The study has two limitations. First, the supply and maintenance data used only provides one year of historical data. Several years of historical data will provide more accurate results, but due to time and personnel constraints the study had to be limited to include only one year of data. Second, only twenty-six items are included in the simulations. Therefore, the results have only limited applicability to the twenty-six items, and can not be used to extrapolate what will occur on a larger scale (e.g., the entire RIP, SMU, Marine Corps, etc). Once again, it is necessary to restrict the size of this study due to time and personnel constraints.

3. Step-By-Step Procedures

The step-by-step procedures used to run the simulations are provided to serve as a basis for future research. The step-by-step procedures used to formulate the spreadsheet model are not covered. This is intended to assist future researchers set up and run a similar simulation model. This model is set up using a Lotus 1-2-3 spreadsheet, and the simulation is run using "Crystal Ball" add-in program.

Before starting the simulation, the add-in program must be loaded to the spreadsheet. In order to do this, click on the "Tools" command at the top menu bar, which produces a drop down menu. Next, at the bottom of this menu click on "add-in". Assuming that the simulation program "Crystal Ball" is loaded to the computer, click on "CB" and then "Load". This adds Crystal Ball to the spreadsheet.

The next step is to define the probabilistic distributions of the data within the spreadsheet. Since it is not realistic to assume that the data have a traditional "normal" distribution (i.e., bell curve), a "custom" distribution is assumed. In order to do this, click on the "Cell" command at the top menu bar, which produces a drop down menu. Next, at the top of this menu click on "Define Assumptions", which produces a menu of probability distributions to choose from. Choose "Custom Distribution" and click on "O.K.". Next, the historical data must be input.

For example, in order to define the OST distribution for item #1 under scenario #1, first look at the supply data provided in Appendix E. Next, input the data in the space provided. Type in 95 and then press the enter button. Then type in 1 and press the enter button. Continue this procedure until all of the OST data for item #1 under scenario #1 are input, and then click on "O.K.".

Once the probability distribution is successfully input for OST item #1, that cell on the spreadsheet will change color. This is merely a guide for users so that they can visualize which spreadsheet cells have a probability distribution defined. Each data element in the spreadsheet model that is based on historical supply or maintenance data must be "defined" in the same manner as described above.

The next step is to "define the forecast" cell(s) within the simulation model. That is, the purpose of the model is to determine how the RO stockage levels change in response to different scenarios (i.e., what happens when OST is reduced to one day). Therefore, the spreadsheet cells that contain the RO for the different items serves as the forecast cells. In order to do this, first highlight the cell(s) that are designated as "forecast" cells. Next, click on "Cell" at the top menu bar. From the drop down menu choose the "Define Forecast" command, and a new command box appears. In this box, click on "O.K." to define the forecast cells. Once the forecast cells are successfully designated, those cells change color. In order to distinguish between the two, forecast cells are a different color than the cells with probability distributions.

At this point the simulation is set up and ready to run. At the top menu bar click on the "Run" command. Next, click on "Run Preferences" in order to choose the number of simulation trials to run and the type of simulation. This simulation was set for 5,000 trials using a Monte Carlo simulation. Click on "O.K." to set these preferences. Once again, click on the "Run" command at the top menu bar, and then click on the "Run" command on the drop down menu. This starts the simulation. The numbers within the "Assumption" and "Forecast" cells continue to change until 5,000 trials (i.e., iterations) have been generated. The simulation stops once the maximum number of trials is reached. This concludes the simulation process.

4. Simulation Summary

Appendix D is a list of supply items used for the simulation(s). Appendix E represents fiscal year 1996 supply data from I Marine Expeditionary Force. Appendix F represents fiscal year 1996 maintenance data from I Marine Expeditionary Force. Finally, Appendix G contains the results of the requisitioning objective model used for the simulation.

F. SUMMARY

This chapter discussed simulation in general terms, and the formulation and conduct of simulation in this research specifically. Section B described the concept behind the simulation technique. Section C discussed the specific methodology used for this research. Section D explained the data input into the simulation model. Finally, Section E described the process used to run the simulation. The next chapter discusses and analyzes the results of the simulations.

ENDNOTES

[1] Characteristics and components of simulation were taken from notes from a course taught by Professor Shu Liao entitled "Decision, Cost, and Policy Analysis". Material was presented in November 1996.

[2] The supply and maintenance data were compiled by Mr. Michael Carroll, Maintenance Data Analysis Center (Code 804), Marine Corps Logistics Base Albany, GA. The data were provided during the month of April 1997.

V. ANALYSIS

A. INTRODUCTION

This chapter discusses and analyzes the results of the simulations. The analysis centers around the question, "Is it cheaper to carry more inventory and pay less for standard surface transportation services, or is it more cost effective to carry less inventory and pay more for premium transportation services?" This question is answered by comparing the cost of inventory to the cost of transportation under the different scenarios.

In Section B, the assumptions and limitations of the cost of inventory computations in Appendix H are discussed. Next, in Section C, the assumptions and limitations of the cost of transportation computations in Appendix K are discussed. Section D provides an analysis by comparing the cost of inventory to the cost of transportation. Finally, Section E presents the conclusion.

B. COST OF INVENTORY

The cost of inventory is computed as shown in Appendix H. The assumptions and limitations are presented below.

1. Assumptions

A. That the safety stockage level is the minimum quantity of an item that can be carried on hand to meet customer demand. That is, a stockage level below the safety level will adversely effect customer service, and as a result impact unit readiness. Regardless of mode of transportation or other stocking related decisions, the safety level is considered a "must have". Therefore, it is not appropriate to consider stockage levels below the safety level.

B. That, based on assumption "A", the sum of OSR and RCR is considered the relevant stockage level in the computation of the total cost of inventory. That is, since the safety level is the minimum quantity that can be carried without adversely effecting customer service, any quantity above this level (i.e., OSR and RCR) are considered additional inventory carried to meet demand. Therefore, the sum of OSR and RCR, multiplied by the unit price for an item is used as the measure of the total cost of inventory. (See column "T/P" of Appendix H) It should be noted that the numbers for each component of the RO model (i.e., OSR, RCR, and SL) are rounded to the nearest whole number since it is not feasible to carry a fraction of an item in inventory.

C. That the variable cost of holding inventory is computed in accordance with the Department of Defense Materiel Management Regulation (DoD 4140.1-R). The total holding cost percentage used is 21.44% of the total cost of inventory.[1] The variable holding cost of inventory is considered the most relevant inventory measure in the analysis because it represents the cost of holding extra inventory. The four components of variable holding cost are explained below in assumptions D - G.

D. That the investment cost percentage is a fixed 10% charge.[1] (See column "INV COST" of Appendix H)

E. That the inventory loss due to obsolescence or forecast error cost percentage is 1.40%.[1] (See column "OBSOL" of Appendix H)

F. That the inventory loss due to reasons other than obsolescence cost percentage is 9.04%.[1] (See column "OTHER" of Appendix H)

G. That the storage cost percentage is a fixed 1% charge.[1] (See column "STORAGE" of Appendix H)

H. That the cost of ordering is not considered in the analysis because the mode of shipment does not impact the work load of ordering personnel. That is, it is assumed that there are always a sufficient amount of personnel to handle the ordering activities.

2. Limitations

The analysis of the variable cost of inventory is limited by the fact that the percentage factors described above are from a study conducted in 1988. Therefore, the analysis in Appendix H really calculates the 1988 vice 1997 incremental cost of inventory. Although this data is severely out dated it is the only data available for this analysis. This limitation should be addressed in future research.

C. COST OF TRANSPORTATION

The cost of transportation is computed as shown in Appendix K. The computations are based upon the "incremental cost of premium transportation" using the rate difference between premium air shipment and normal surface shipment. The assumptions and limitations are presented below.

1. Assumptions

A. That the OSR quantity represents the quantity of an item that requires shipment from the wholesale supply activity. The OSR is rounded to the nearest whole number since it is not feasible to ship a fraction of an item. The RCR is not relevant to this portion of the analysis because RCR represents the quantity of an item repaired by the maintenance activity. Therefore, these items do not require shipment.

B. That the air transportation rates, listed in Appendix I, are based on Federal Express (FedEx) and Burlington Air Express rates.[2] The rates listed up to 150 pounds are provided by FedEx. The rates between 200 pounds and 3,000 pounds are provided by Burlington Air Express.

C. That the surface transportation rates, listed in Appendix J, are based on Roadway Package Service (RPS) and Consolidated Freightway rates.[2] The rates listed up to 150 pounds are provided by RPS. The rates between 200 pounds and 3,000 pounds are provided by Consolidated Freightway.

D. That the difference between air shipment rates and surface shipment rates represents the incremental cost of premium transportation. This figure multiplied by the OSR represents the additional charge for using premium transportation.

E. That the first destination transportation charge is part of the vendor contract, and therefore irrelevant to the analysis in this research. However, second destination transportation charges for medium and low priority shipments must be paid for by the Marine Corps. (See Table 1-2)

F. That the cubic dimensions of the twenty-six items used in this study are not a factor in the cost of transportation. However, it should be noted that if future analysis includes items of "outsized" cubic dimensions, then "cube" will effect the transportation rates. This will vary based on the carrier.

2. Limitations

The analysis of the incremental cost of premium transportation service is limited by the fact that the surface transportation rates are based on a California point of origin to a Georgia point of destination, vice Georgia (i.e., Albany) to California (i.e., Camp Pendleton). Although the point of origin and point of destination are merely reversed, the rates are still different. Due to inflexible time constraints to complete this study and the fact that the Georgia to California rates are not readily available, the California to Georgia rates are used. Therefore, the incremental cost of premium transportation may be somewhat off, but the concept behind the analysis still remains valid.

D. ANALYSIS

Appendix L compares the incremental cost of holding inventory to the incremental cost of premium transportation. The analysis draws a conclusion as to whether the Enhanced Transportation Service program deserves further consideration or be eliminated as a "Precision Logistics" initiative.

1. Scenario #1

Based on the results of the simulation run for scenario #1, the cost of carrying extra inventory is much more than the cost of premium transportation service.

Specifically, to carry additional inventory it will cost $402,101.06 more than the premium transportation service provided under ETS.

2. Scenario #2

A comparison of premium transportation costs alone for scenario #1 ($2,826.85) and scenario #2 ($3,963.77) would reveal that transportation costs under scenario #2 are $1,136.92 more than for scenario #1. The analysis taken by itself may lead to the conclusion ETS is more cost effective under scenario #1 conditions. However, when comparing the cost of carrying extra inventory to the cost of premium transportation service the opposite conclusion can be drawn. That is, to carry additional inventory it will cost $407,609.81 more than the premium transportation service. This means that although premium transportation service costs more under scenario #2 (i.e., as compared to scenario #1), it is more cost effective because less inventory has to be carried on hand; and hence, a savings for the incremental cost of inventory.

3. Final Analysis

These comparisons lead to the conclusion that the ETS Program does deserve further consideration as a "Precision Logistics" initiative. Moreover, the more stringent time standards proposed under scenario #2 are more cost effective than the current UMMIPS time standards.

E. CONCLUSION

This chapter provided assumptions and limitations, and then an analysis of the simulation runs. Section B discussed the highlights of the cost of inventory computations as shown in Appendix H. Next, Section C provided insight into the cost of transportation computations as shown in Appendix K. Finally, Section D brought everything together by comparing the cost of inventory to the cost of transportation. This was done by comparing the results shown in Appendix H to the results shown in Appendix K. The analysis is shown in Appendix L. The next chapter re-addresses the original research questions and discusses the direction of future research.

ENDNOTES

[1] The variable cost of holding inventory percentage factors were provided by Master Sergeant Thomas Campbell, IRM 740, and Master Sergeant John Robinson, ILSD 840, Marine Corps Logistics Base Albany, Georgia. The data were provided on April 16, 1997. The factors are from a study conducted in 1988. The methodology used in the 1988 study for the computation of the four components is as follows:

1) Investment cost percentage was a fixed 10% charge
2) Inventory loss due to obsolescence or forecast error cost percentage was 1.40%. It was computed as the total "D7J" issues to the Defense Reutilization Management Office (DRMO) divided by the lesser of average dollar value of inventory or requisitioning objective.
3) Inventory loss due to reasons other than obsolescence cost percentage was 9.04%. This was computed as the net total, if negative, of all D8_ and D9_ transactions divided by the average dollar value of inventory. It was computed as zero if the net total of all D8_ and D9_ transactions were positive or zero.
4) Storage cost percentage was a fixed 1% charge.

[2] Air and surface rates were provided by Master Sergeant John Robinson, ILSD 840, Marine Corps Logistics Base Albany, Georgia and Ms. Betty Mitchell, Transportation Office, Marine Corps Logistics Base Barstow, California during April 1997.

VI. CONCLUSION

A. INTRODUCTION

The previous chapter provided an analysis of the simulation results. This chapter relates the analysis back to the original research questions posed in Chapter I, and provides a foundation for future research of the Enhanced Transportation Service program. It should be stressed that the results of this study can not be generalized to other situations. That is, assumptions surrounding the simulations place the RO model inside a "small box". This is a drawback to this technique since it limits the applicability of the results. However, it is also necessary to make these assumptions since it is not possible to entirely simulate reality, because there are too many environmental variables. The simulation is still a valuable tool because it allows researchers to "what if" different scenarios. The results of the study are used to answer the original research questions. The next section addresses these questions.

B. RESEARCH QUESTIONS

1. Primary

Recall from Chapter I that the ETS program funds for the air shipment of all requisitions. Moreover, air transportation is the fastest mode of shipment, but it is also the most expensive as well. The purpose of the ETS program is to decrease OST, resulting in a decrease in customer stockage levels. Based on that background, the primary research question was "Does the benefit derived from reduced stockage levels outweigh the additional cost of air shipment?" Based on the analysis conducted in Chapter V, the ETS program does appear to be a viable option for reducing OST in a cost effective manner. Once again, this is not intended to be the basis for the final decision on the matter; rather, it is a starting point for future research. Therefore, it is recommended that further research of the ETS program should be conducted. This is addressed again in Section C.

2. Secondary

The primary research question examined the cost effectiveness of the ETS program under the present UMMIPS time standards outlined in Appendix B. Appendix C outlines new UMMIPS time standards that are currently under review. Based on the analysis conducted in Chapter V, it does appear that the new time standards make the ETS program even more cost effective, as compared to the results obtained under the current time standards. Section C discusses specific recommendations for future research.

C. RECOMMENDATIONS

1. Broaden the Scope of Research

The scope of the research can be broadened in two ways. First, run the simulation without as many assumptions, since the assumptions restrict the applicability of the results. The assumptions highlighted in Chapter V place the simulation in a "small box". Limiting the amount of assumptions is synonymous with placing the simulation into a "larger box". This may assist in making the simulation results more applicable in a general sense. Second, continue the simulation, but use different assumptions. As discussed earlier, the use of simulation provides a technique to "what if" many different situations. Place the simulation in a "different box" and see if the results are similar or different.

2. Re-address the Limitations

At the beginning of a study it is not always possible to foresee all of the potential shortcomings. However, in this instance there is the benefit of "hindsight". Therefore, future research should eliminate the limitations highlighted in Chapters IV and V. The simulation model is a "work-in-progress"; and something that is constantly being updated, revised, and improved. This study is only the first step. Future research must take what has been accomplished here, and improve upon it.

3. Re-evaluate the Safety Level Computation

The safety level computation discussed in Chapter III is very inaccurate. This formula was used because it was recommended in the Naval Audit Service report (1996), but it can be improved upon. There are many different methods for calculating safety stock, as can be found in any book on inventory management. Books on the American Production and Inventory Control Society (APICS) reading list provide a good starting point for researching a more appropriate safety level formula. Whichever formula is chosen, it should have a service level factor component similar to that found in equation 2.1. There is not necessarily one best way to calculate safety stock, but there are many that are an improvement over the formula used in this study.

D. SUMMARY

This study intended to provide a cost-benefit analysis of the proposed Enhanced Transportation Service (ETS) program. To this end, Chapter I presented background material to familiarize the reader with the Marine Corps supply system and the proposed ETS program. Next, Chapter II provided a review of current literature on the subject of inventory management. Chapter III described the components of the requisitioning objective model. Chapter IV presented background information on simulations in general, and a specific review of how the simulation in this research was conducted. Finally, Chapter V provided an analysis of the results obtained during the data gathering. As discussed earlier in this chapter, this study was intended to be a starting point in the analysis of the ETS program. In conclusion, the ETS program does warrant further research.

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GLOSSARY

Consumer Level of Supply - "An inventory held only by the final element in an established supply distribution system for the sole purpose of internal consumption." (DoD 4140.1-R)

CONUS - Continental United States

Defense Automated Addressing System (DAAS) - A computer system used at the wholesale level supply activity (DLA) to track requisitions.

Defense Logistics Agency (DLA) - The wholesale level supply activity

Equipment Repair Order Shopping List (EROSL) - Document used to initiate a supply requisition.

First Destination Transportation (FDT) - "That transportation required to effect the delivery of materiel from a procurement source to the first point of use or storage for subsequent distribution within the supply system. The procurement source is any supplier outside the DoD supply system and DoD industrial activity which fabricates new material." (DoD 4500.32-R Vol. II)

FMF - Fleet Marine Force

Force Service Support Group (FSSG) - Unit that provides support for a Marine Expeditionary Force (MEF). The supply battalion is a unit within the FSSG.

Intermediate Supply - "Any level of inventory between the consumer and wholesale level of inventory, and is considered a retail level." (DoD 4140.1-R)

Material Release Order - "Prepared by the source of supply as a result of processing requisitions against inventory records and determining that material is available. MROs are directives to storage sites for release and shipment of material from stock." (DoD 4140.1-R)

Prepositioned War Reserve Materiel Stocks (PWRMS) - A safety stock of supplies maintained on hand, and not to be issued, in case of activation for war.

Reparable Item - "An item of supply subject to economical repair and for which the repair is considered in satisfying computed requirements at any inventory level." (DoD 4140.1-R)

Reparable Issue Point (RIP) - The section within the supply battalion where parts for reparable items are issued to requesting units.

Required Delivery Date - "A three position field on the requisition document that is used to identify the level of service (in terms of time) that a customer requires of the logistics system. The RDD specifies the allotted times that each element of the logistics system has to satisfy the service level required by the customer. The logistic management systems use the RDD to determine the service level times that must be met or exceeded and allocate their resources accordingly." (DoD 4140.1-R)

Requisitioning Objective - "The maximum quantity of material to be maintained on hand and on order to sustain current operations and core war reserves. It will consist of the sum of stocks represented by the operating level, safety level, repair cycle and the order and shipping time." (DoD 4140.1-R)

Retail-Level Supply - "Those secondary items stored within DoD intermediate and consumer levels of supply. These include supply levels down to Marine Expeditionary Force (MEF) and base supply." (DoD 4140.1-R) The supply battalion manages retail-level supply for the MEF.

Second Destination Transportation (SDT) - "That transportation required to effect movement of Marine Corps materiel from, to, or between Marine Corps activities and other Service/Agency activities worldwide, except as provided by first destination transportation." (DoD 4500.32-R Vol. II)

SASSY - Supported Activities Supply Support System

TMO - Traffic Management Office

Wholesale Supply - "The highest level of organized DoD supply, and as such, procures, repairs and maintains stocks to resupply the retail levels of supply." (DoD 4140.1-R)

APPENDIX A

Uniform Materiel Movement and Issue Priority System (UMMIPS)

The following are excerpts taken directly from the Marine Corps Order 4400.16G. The author has reorganized the presentation of the information, but this does not represent any original work by the author.

A. Background

1. The Uniform Materiel Movement and Issue Priority System provides the basis for indicating the relative importance of requisitions and other materiel movement transactions through a series of two-digit codes known as priority designators. UMMIPS provides 15 priority designators which are determined by combinations of five force/activity designators (F/AD's I through V) and three urgency of need designators (A through C).

2. The F/AD is assigned by higher authority to requisitioning units. An organizations F/AD assignment is permanent until its mission or status is changed. Overall authority for assigning and reviewing F/AD's is vested in the Joint Chiefs of Staff (JCS/J-4). The JCS has delegated to the Commandant of the Marine Corps (CMC) the authority to assign and regulate the use of F/AD's II through V with the Marine Corps. A force/activity is:

a. A unit, organization, or installation performing a function or mission.

b. A body of troops, ships or aircraft, or a combination thereof.

c. A function, mission, project or program.

3. The urgency of need designator is determined by the requisitioning activity

B. Force/Activity Designator I Assignment Criteria

1. United States forces in combat and other forces or JCS activities designated by the Secretary of Defense on the recommendation of the JCS. The F/AD I will not normally be used in peacetime, except as follows:

a. Programs which have been approved for top national priority by the President.

b. There is a declared emergency.

c. Units or projects which have been specifically designated by the Secretary of Defense on the recommendation of the JCS.

C. Force/Activity Designator II Assignment Criteria

1. The FMF combat-ready forces deployed to or operating from areas outside the 50 states and adjacent waters.

2. The FMF CONUS forces being maintained in a state of combat readiness for immediate (within 24 hours) employment or deployment.

3. Programs and projects vital to defense or national objectives which are of comparable importance to U.S. forces specified in paragraphs C1 and C2 above.

4. Specified combat-ready and direct combat support forces of foreign countries with comparable importance to U.S. forces specified in paragraphs C1 and C2.

5. Specific identifiable Federal agency programs which are vital to defense or national objectives and are so designated by the Secretary of Defense.

D. Force/Activity Designator III Assignment Criteria

1. All FMF forces within and outside CONUS not included under F/AD II.

2. Programs and projects which are of comparable importance with that contained in paragraph D1.

3. CONUS industrial maintenance and repair activities (i.e., Repair Divisions, MCLB's, Albany and Barstow) providing direct logistics support for forces in a state of combat readiness.

4. Ships detachments afloat.

5. Specified combat-ready and direct combat support forces for foreign countries with comparable importance to that contained in paragraph D1.

6. Specific identifiable Federal agency programs designated by the Secretary of Defense.

E. Force/Activity Designator IV Assignment Criteria

1. The FMF Reserve units.

2. Training bases, FMF supporting establishments, and security forces.

3. Programs and projects which are of comparable importance with that contained in paragraph E1.

4. Specified combat-ready and direct combat support forces of foreign countries with comparable importance to that contained in paragraph E1.

5. Federal agency programs which contribute to planned improvement of defense or national objectives and are so designated by the Secretary of Defense.

F. Force/Activity Designator V Assignment Criteria

1. All other Active and Reserve forces or activities, including staff, administrative, and base/post supply-type activities.

2. Programs and projects not otherwise designated.

3. Forces of foreign countries not otherwise designated.

G. Urgency of Need Designator "A" Criteria

1. Item(s) required for immediate end use without which the force/activity concerned is unable to perform assigned operational missions, or such condition will occur within 15 days in CONUS and 20 days overseas.

2. Item(s) required for immediate installation on, or repair of mission-essential materiel and without which the requiring force/activity is unable to perform assigned operational missions.

3. Item(s) required for immediate end use for installation on, or repair of direct support equipment (ground support, firefighting, test equipment, etc.) necessary for the operation of mission-essential materiel.

4. Item(s) required for immediate end use in replacement, or repair of mission-essential training materiel and without which the force/activity is unable to perform assigned training missions.

5. Item(s) required for immediate end use to eliminate an existing work stoppage at industrial/production activities manufacturing, modifying, or maintaining mission-essential materiel.

6. Item(s) required for immediate end use to eliminate an existing work stoppage on a production line performing repair and maintenance of unserviceable intensive management/critical items.

7. Item(s) required for immediate end use to effect replacement or repair of essential physical facilities of an industrial/production activity and without which the activity is unable to perform assigned missions.

H. Urgency of Need Designator "B" Criteria

1. Item(s) required for immediate end use and without which the capability of the force/activity to perform assigned operational missions is impaired. Materiel requirements of this nature directly affect the capability of the force/activity to perform its mission; it can temporarily accomplish assigned missions and tasks but with effectiveness below an acceptable level of readiness.

2. Item(s) required for immediate installation on or repair of mission-essential materiel and without which the capability of the force/activityto perform assigned operational missions is impaired. Materiel requirements of this nature directly affect the capability of the force/activity to perform its mission; it can temporarily accomplish assigned missions and tasks but with effectiveness below an acceptable level of readiness.

3. Item(s) required for immediate end use for installation on or repair of auxiliary equipment.

4. Item(s) required for immediate end use in replacement or repair of mission-essential or auxiliary training equipment and without which the capability of the force/activity to perform assigned missions is impaired.

5. Item(s) required for immediate end use to effect replacement or repair of essential physical facilities of an industrial/production activity and without which the capability of the activity to perform assigned missions is impaired.

6. Item(s) required to preclude an anticipated work stoppage at industrial/production activities manufacturing, modifying, or maintaining mission-essential materiel.

7. Item(s) required to preclude an <u>anticipated</u> work stoppage on a production line performing repair and maintenance of unserviceable intensive management/critical items.

8. Item(s) required for the immediate replacement of the safety level quantity of mission-essential items where the last item has already been issued out of stock to end use.

9. Item(s) required for prepositioned war reserve materiel stocks (PWRMS) only when the shortage would, in the commander's judgment, justify reporting a composite readiness rating lower than the ratings for equipment/supplies on hand or equipment readiness.

I. Urgency of Need Designator "C" Criteria

1. Item(s) required for on-schedule repair/maintenance/manufacture or replacement of all equipment.

2. Item(s) required for replenishment of stock to meet authorized stockage objectives.

3. Item(s) required for PWRMS when the shortage does not significantly degrade readiness (such as might be the result from routine recomputation of requirements, etc.).

4. Material required for purposes not specifically covered by any other urgency of need designator.

UMMIPS Priority Designator Matrix

Force Activity/Designator	Urgency of Need Designator "A"	Urgency of Need Designator "B"	Urgency of Need Designator "C"
I	1	4	11
II	2	5	12
III	3	6	13
IV	7	9	14
V	8	10	15

Table A-1.

APPENDIX B

UMMIPS Time Standards

The following are excerpts taken directly from the Marine Corps Order 4400.16G. The author has reorganized the presentation of the information, but this does not represent any original work by the author.

A. Time Segments

1. Requisition submission - This segment extends from the date of the requisition to the date of receipt by the initial wholesale supply source (e.g., ICP or stock point) which maintains asset availability records for the purpose of filling materiel demands or ordering other supply action.

2. Passing action - This segment extends from the date the initial supply source receives the requisition until the date of receipt by the ultimate supply source (e.g., appropriate ICP).

3. ICP availability determination - This time segment extends from the date the requisition is received by the ultimate supply source to the date a material release/issue instruction is transmitted to the depot/storage site. This segment includes time required by supply source data entry keypunching of requisitions manually prepared by the requisitioner.

4. Depot/storage site processing - This segment extends from the date that the material release/issue instruction is transmitted to the depot/storage site until the date that material is made available to the transportation officer. This segment includes packaging and packing time as well as holding time for the purpose of shipment planning in the shipping activity.

5. Transportation hold and in-transit - This segment extends from the date the materiel is made available to the transportation officer until the date of receipt by the CONUS requisitioning installation.

6. Receipt takeup by requisitioner - This segment extends from the date of receipt of the materiel at the destination until the date that the materiel receipt is recorded on the requisitioner's inventory records.

Current UMMIPS Time Standards (in Calendar Days)

Time Segment	Priority 01 - 03	Priority 04 - 08	Priority 09 - 15
A. Requisition submission	1	1	2
B. Passing action	1	1	2
C. Inventory Control Point availability determination	1	1	3
D. Depot/storage site processing	1	2	8
E. Transportation hold and In-transit	3*	6*	13
F. Receipt take-up by requisitioner	1	1	3
TOTAL ORDER SHIP TIME	8	12	31

Table B-1.

* Time standards for priority designators 09 through 15 apply when cargo is diverted to surface movement

Note: Table B-1 does not include time standards for requisitions from units outside CONUS.

APPENDIX C

Newly Proposed UMMIPS Time Standards

Time standards are defined as the maximum amount of time (in days) that should elapse during any given time segment for items that are in stock. Table C-1 does not include time standards for requisitions from units outside CONUS.

Proposed UMMIPS Time Standards

Time Segment	Priority Designator 01 - 03 Transportation Priority 1	Priority Designator 04 -15* Transportation Priority 2	Priority Designator 04 - 15** Transportation Priority 3
A. Requisition submission	.5	.5	1
B. Inventory Control Point processing time	.5	.5	1
C. Storage site (or base) processing, packaging, or transportation hold time	1	1	3
D. In-transit time	1	1 - 4 (Note 1)	1 - 9 (Note 1)
E. Receipt take up time	.5	1	2
TOTAL ORDER SHIP TIME	3.5	4 - 7	8 - 16

Table C-1.

* Priority designator 04 - 15 and a RDD less than 8 days
** Priority designator 04 - 15 and a RDD of 8 - 16 days, or no RDD at all

Note 1 - CONUS in-transit time - Use DTR standards or Guaranteed Traffic (GT) standards, whichever are more stringent.

APPENDIX D - SUPPLY ITEMS USED IN SIMULATION

ITEM	NSN	NOMEN	UNIT PRICE	UNIT WEIGHT (LBS)	UNIT CUBE
1	1025-01-090-5680	EQUILIBRATOR ASSEMB	$6,091.00	235	3.712
2	1240-01-038-0531	TELESCOPE,PANORAMIC	$7,938.00	24	2.326
3	1240-01-170-1646	HEAD ASSEMBLY	$5,825.00	24.5	0
4	1440-00-196-0038	TUBE,GUIDED MISSILE	$604.00	31	4.04
5	1440-00-462-2553	DAMPER,AZIMUTH	$2,655.00	17	28
6	1450-01-171-1656	CONDITIONER,POWER	$522.00	26	2.3
7	2350-01-199-6319	PANEL,INSTRUMENT,MO	$3,577.92	10	0.3
8	2520-00-450-7502	SHAFT ASSEMBLY,FINA	$348.59	20	2.5
9	2520-01-117-3010	TRANSMISSION WITH C	$11,814.00	1020	33.347
10	2520-01-132-5989	TORQUE CONVERTER	$9,100.00	440	12
11	2520-01-134-3891	TRANSMISSION AND CO	$111,961.87	2875	120
12	2520-01-178-7149	TRANSMISSION,HYDRAU	$12,352.00	1198	48
13	2530-01-125-0461	STEER UNIT,HYDRASTA	$31,593.19	230	0.8
14	2815-01-108-5384	CRANKSHAFT,ENGINE	$1,619.00	261	7.92
15	5820-00-892-0623	RECEIVER-TRANSMITTE	$10,345.00	0.1	0.001
16	5855-01-096-0871	VIEWER,NIGHT VISION	$5,378.00	23	0.938
17	5895-01-298-1397	PANEL,INDICATOR	$6,539.18	2	0.1
18	5895-01-307-5491	SYNTHESIZER,ELECTRI	$6,037.32	2	0.07
19	5998-01-026-1206	CIRCUIT CARD ASSEMB	$710.63	0.1	0
20	5998-01-260-2527	CIRCUIT CARD ASSEMB	$2,924.45	25	2
21	5998-01-327-2071	CIRCUIT CARD ASSEMB	$125.00	0.4	0
22	5998-01-358-1187	CIRCUIT CARD ASSEMB	$3,108.47	1	0.115
23	5999-01-102-9320	CIRCUIT CARD ASSEMB	$526.00	0.9	0
24	5999-01-109-9374	CIRCUIT CARD ASSEMB	$253.00	1	0
25	5999-01-240-1249	CIRCUIT CARD ASSEMB	$611.00	0.8	0
26	6130-01-027-2839	POWER SUPPLY	$2,256.59	10	0.03

APPENDIX E - SUPPLY DATA

Item	NSN	ORDER DATE	RECEIPT DATE	HISTORICAL OST	HISTORICAL MEAN OST	OST #1	MEAN OST #1	OST #2	MEAN OST #2
1	1025-01-090-5680	6085	6192	107	32	95	22	99	25
	1025-01-090-5680	6087	6093	6		1		1	
	1025-01-090-5680	6088	6093	5		1		1	
	1025-01-090-5680	6100	6135	35		23		27	
	1025-01-090-5680	6107	6137	30		18		22	
	1025-01-090-5680	6115	6143	28		16		20	
	1025-01-090-5680	6135	6166	31		19		23	
	1025-01-090-5680	6136	6166	30		18		22	
	1025-01-090-5680	6177	6192	15		3		7	
2	1240-01-038-0531	6067	6124	57	57	45	45	49	49
3	1240-01-170-1646	5292	5320	28	23	16	11	20	15
	1240-01-170-1646	5305	5331	26		14		18	
	1240-01-170-1646	5352	6010	23		11		15	
	1240-01-170-1646	6234	6249	15		3		7	
4	1440-00-196-0038	6025	6043	18	36	6	24	10	28
	1440-00-196-0038	6036	6072	36		24		28	
	1440-00-196-0038	6058	6143	85		73		77	
	1440-00-196-0038	6078	6113	35		23		27	
	1440-00-196-0038	6123	6143	20		8		12	
	1440-00-196-0038	6269	6290	21		9		13	
5	1440-00-462-2553	6158	6198	40	86	28	74	32	78
	1440-00-462-2553	6206	6338	132		120		124	
6	1450-01-171-1656	5305	6009	69	46	57	34	61	38
	1450-01-171-1656	6260	6282	22		10		14	
7	2350-01-199-6319	6080	6124	44	44	32	32	36	36
8	2520-00-450-7502	5275	6184	274	89	262	78	266	81
	2520-00-450-7502	5282	5320	38		26		30	
	2520-00-450-7502	5282	6184	267		255		259	
	2520-00-450-7502	6066	6206	140		128		132	
	2520-00-450-7502	6066	6206	140		128		132	
	2520-00-450-7502	6067	6215	148		136		140	
	2520-00-450-7502	6134	6215	81		69		73	
	2520-00-450-7502	6143	6215	72		60		64	
	2520-00-450-7502	6169	6299	130		118		122	
	2520-00-450-7502	6171	6249	78		66		70	
	2520-00-450-7502	6177	6215	38		26		30	
	2520-00-450-7502	6197	6219	22		10		14	
	2520-00-450-7502	6219	6299	80		68		72	
	2520-00-450-7502	6226	6299	73		61		65	
	2520-00-450-7502	6232	6299	67		55		59	
	2520-00-450-7502	6260	6270	10		1		2	
	2520-00-450-7502	6268	6276	8		1		1	
	2520-00-450-7502	6268	6285	17		5		9	
	2520-00-450-7502	6268	6276	8		1		1	
9	2520-01-117-3010	5275	6123	213	74	201	62	205	66
	2520-01-117-3010	5282	6123	206		194		198	
	2520-01-117-3010	5331	5362	31		19		23	
	2520-01-117-3010	5363	6039	41		29		33	
	2520-01-117-3010	6008	6058	50		38		42	
	2520-01-117-3010	6106	6151	45		33		37	
	2520-01-117-3010	6108	6145	37		25		29	
	2520-01-117-3010	6151	6206	55		43		47	
	2520-01-117-3010	6198	6234	36		24		28	
	2520-01-117-3010	6261	6283	22		10		14	

APPENDIX E - SUPPLY DATA

Item	NSN	ORDER DATE	RECEIPT DATE	HISTORICAL OST	HISTORICAL MEAN OST	OST #1	MEAN OST #1	OST #2	MEAN OST #2
10	2520-01-132-5989	6022	6040	18	36	6	24	10	28
	2520-01-132-5989	6022	6039	17		5		9	
	2520-01-132-5989	6072	6095	23		11		15	
	2520-01-132-5989	6073	6155	82		70		74	
	2520-01-132-5989	6177	6192	15		3		7	
	2520-01-132-5989	6179	6228	49		37		41	
	2520-01-132-5989	6190	6228	38		26		30	
	2520-01-132-5989	6255	6299	44		32		36	
11	2520-01-134-3891	5305	6274	334	167	322	155	326	159
	2520-01-134-3891	6131	6228	97		85		89	
	2520-01-134-3891	6268	6337	69		57		61	
12	2520-01-178-7149	5304	6011	72	57	60	45	64	49
	2520-01-178-7149	5317	6059	107		95		99	
	2520-01-178-7149	6080	6137	57		45		49	
	2520-01-178-7149	6080	6137	57		45		49	
	2520-01-178-7149	6094	6137	43		31		35	
	2520-01-178-7149	6113	6145	32		20		24	
	2520-01-178-7149	6253	6283	30		18		22	
13	2530-01-125-0461	6008	7069	426	238	414	226	418	230
	2530-01-125-0461	6214	7069	220		208		212	
	2530-01-125-0461	6241	6310	69		57		61	
14	2815-01-108-5384	6018	6250	232	163	220	151	224	155
	2815-01-108-5384	6018	6145	127		115		119	
	2815-01-108-5384	6018	6061	43		31		35	
	2815-01-108-5384	6067	7085	383		371		375	
	2815-01-108-5384	5282	6054	137		125		129	
	2815-01-108-5384	5292	6166	239		227		231	
	2815-01-108-5384	5304	6162	223		211		215	
	2815-01-108-5384	5307	6155	213		201		205	
	2815-01-108-5384	5318	6158	205		193		197	
	2815-01-108-5384	6018	6284	266		254		258	
	2815-01-108-5384	6018	6270	252		240		244	
	2815-01-108-5384	6018	6025	7		1		1	
	2815-01-108-5384	6023	6158	135		123		127	
	2815-01-108-5384	6067	7079	377		365		369	
	2815-01-108-5384	6077	6158	81		69		73	
	2815-01-108-5384	6077	6166	89		77		81	
	2815-01-108-5384	6109	6166	57		45		49	
	2815-01-108-5384	6109	6166	57		45		49	
	2815-01-108-5384	6136	7041	270		258		262	
	2815-01-108-5384	6194	6212	18		6		10	
	2815-01-108-5384	6197	6213	16		4		8	
15	5820-00-892-0623	5283	5312	29	25	17	13	21	17
	5820-00-892-0623	5298	5318	20		8		12	
	5820-00-892-0623	5305	5331	26		14		18	
16	5855-01-096-0871	6086	6095	9	26	1	15	1	18
	5855-01-096-0871	6089	6115	26		14		18	
	5855-01-096-0871	6089	6115	26		14		18	
	5855-01-096-0871	6123	6145	22		10		14	
	5855-01-096-0871	6123	6143	20		8		12	
	5855-01-096-0871	6127	6179	52		40		44	
17	5895-01-298-1397	5333	5356	23	52	11	40	15	44
	5895-01-298-1397	5338	6009	36		24		28	
	5895-01-298-1397	6029	6046	17		5		9	
	5895-01-298-1397	6071	6201	130		118		122	
	5895-01-298-1397	6138	6249	111		99		103	
	5895-01-298-1397	6183	6253	70		58		62	
	5895-01-298-1397	6256	6271	15		3		7	
	5895-01-298-1397	6260	6276	16		4		8	
18	5895-01-307-5491	6029	6039	10	18	1	7	2	10
	5895-01-307-5491	6109	6134	25		13		17	

APPENDIX E - SUPPLY DATA

Item	NSN	ORDER DATE	RECEIPT DATE	HISTORICAL OST	HISTORICAL MEAN OST	OST #1	MEAN OST #1	OST #2	MEAN OST #2
19	5998-01-026-1206	6260	6271	11	11	1	1	3	3
20	5998-01-260-2527	6268	6319	51	51	39	39	43	43
21	5998-01-327-2071	5331	6068	102	92	90	80	94	84
	5998-01-327-2071	6040	6074	34		22		26	
	5998-01-327-2071	5352	6128	141		129		133	
22	5998-01-358-1187	6177	6193	16	15	4	3	8	7
	5998-01-358-1187	6208	6222	14		2		6	
23	5999-01-102-9320	6043	6285	242	100	230	88	234	92
	5999-01-102-9320	6142	6285	143		131		135	
	5999-01-102-9320	6193	6285	92		80		84	
	5999-01-102-9320	6208	6285	77		65		69	
	5999-01-102-9320	6213	6344	131		119		123	
	5999-01-102-9320	6220	6285	65		53		57	
	5999-01-102-9320	6260	6285	25		13		17	
	5999-01-102-9320	6262	6285	23		11		15	
24	5999-01-109-9374	6087	6093	6	91	1	79	1	83
	5999-01-109-9374	6022	6127	105		93		97	
	5999-01-109-9374	6040	6072	32		20		24	
	5999-01-109-9374	6078	6124	46		34		38	
	5999-01-109-9374	6143	6344	201		189		193	
	5999-01-109-9374	6143	6274	131		119		123	
	5999-01-109-9374	6151	6274	123		111		115	
	5999-01-109-9374	6155	6274	119		107		111	
	5999-01-109-9374	6232	6285	53		41		45	
25	5999-01-240-1249	5318	6249	296	316	284	304	288	308
	5999-01-240-1249	5319	6298	344		332		336	
	5999-01-240-1249	5352	6298	311		299		303	
	5999-01-240-1249	6010	6323	313		301		305	
26	6130-01-027-2839	5341	6045	69	44	57	32	61	36
	6130-01-027-2839	5352	6040	53		41		45	
	6130-01-027-2839	6067	6088	21		9		13	
	6130-01-027-2839	6130	6213	83		71		75	
	6130-01-027-2839	6226	6253	27		15		19	
	6130-01-027-2839	6229	6253	24		12		16	
	6130-01-027-2839	6233	6253	20		8		12	
	6130-01-027-2839	6255	6344	89		77		81	
	6130-01-027-2839	6260	6271	11		1		3	

ITEM	NSN		OCT 95	NOV 95	DEC 95	JAN 96	FEB 96	MAR 96	APR 96	MAY 96	JUN 96	JUL 96	AUG 96	SEP 96	TOT
1	1025-01-090-5680	EROs Opened	1	0	0	0	0	1	3	2	0	0	1	0	8
	1025-01-090-5680	QTY Repaired	0	1	0	0	0	0	0	0	1	0	0	1	3
	1025-01-090-5680	Total Days	0	8	0	0	0	0	0	121	84	0	0	39	252
		RCT													84
2	1240-01-038-0531	EROs Opened	3	7	5	7	7	15	6	9	8	6	3	7	83
	1240-01-038-0531	QTY Repaired	4	5	2	8	2	3	7	13	14	8	2	11	79
	1240-01-038-0531	Total Days	221	271	101	156	121	214	416	683	729	428	136	322	3798
		RCT													48
3	1240-01-170-1646	EROs Opened	4	1	1	2	1	1	4	0	2	0	3	1	20
	1240-01-170-1646	QTY Repaired	1	2	0	1	1	0	2	3	0	0	1	5	16
	1240-01-170-1646	Total Days	313	85	104	197	12	0	70	55	0	123	214	310	1483
		RCT													93
4	1440-00-196-0038	EROs Opened	2	0	4	1	0	1	2	2	0	1	2	0	15
	1440-00-196-0038	QTY Repaired	1	0	0	0	0	0	0	0	0	0	1	0	2
	1440-00-196-0038	Total Days	192	0	0	144	36	17	0	36	22	0	137	64	648
		RCT													324
5	1440-00-462-2553	EROs Opened	0	0	0	0	0	0	0	2	0	1	0	0	3
	1440-00-462-2553	QTY Repaired	0	0	0	0	0	0	0	1	0	0	0	0	1
	1440-00-462-2553	Total Days	0	0	0	0	0	0	0	3	20	0	25	0	48
		RCT													48
6	1450-01-171-1656	EROs Opened	1	0	0	0	0	2	1	0	2	0	1	1	8
	1450-01-171-1656	QTY Repaired	0	1	0	0	0	0	1	0	1	1	1	1	6
	1450-01-171-1656	Total Days	0	28	0	0	0	183	10	49	16	21	123	19	449
		RCT													75
7	2350-01-199-6319	EROs Opened	6	2	1	2	7	11	1	2	6	1	11	4	54
	2350-01-199-6319	QTY Repaired	3	2	1	6	4	6	1	4	7	1	5	6	46
	2350-01-199-6319	Total Days	605	52	70	471	42	202	6	136	505	40	34	81	2244
		RCT													49
8	2520-00-450-7502	EROs Opened	6	3	3	2	10	3	0	0	4	3	5	0	39
	2520-00-450-7502	QTY Repaired	0	12	0	7	1	3	0	0	0	0	1	0	24
	2520-00-450-7502	Total Days	82	1421	670	1005	186	369	431	369	0	199	108	0	4840
		RCT													202
9	2520-01-117-3010	EROs Opened	7	6	4	5	6	5	8	5	9	4	3	3	65
	2520-01-117-3010	QTY Repaired	3	12	3	3	3	6	6	2	4	5	1	8	56
	2520-01-117-3010	Total Days	890	1353	232	432	58	231	695	217	215	174	724	454	5675
		RCT													101
10	2520-01-132-5989	EROs Opened	0	0	0	3	0	1	0	1	1	1	1	1	9
	2520-01-132-5989	QTY Repaired	0	0	0	0	0	1	0	0	0	1	0	0	2
	2520-01-132-5989	Total Days	396	0	0	21	14	21	0	0	0	70	81	20	623
		RCT													312
11	2520-01-134-3891	EROs Opened	7	6	3	6	6	2	2	1	4	4	0	1	42
	2520-01-134-3891	QTY Repaired	3	5	4	4	6	7	0	1	1	6	4	1	42
	2520-01-134-3891	Total Days	398	90	248	225	339	358	0	7	8	538	239	108	2558
		RCT													61
12	2520-01-178-7149	EROs Opened	0	2	1	1	1	2	2	2	0	0	1	0	12
	2520-01-178-7149	QTY Repaired	0	0	1	1	4	0	1	0	0	0	2	1	10
	2520-01-178-7149	Total Days	0	0	27	364	1634	0	91	363	69	0	234	185	2967
		RCT													297
13	2530-01-125-0461	EROs Opened	1	2	1	0	2	1	0	1	4	0	1	0	13
	2530-01-125-0461	QTY Repaired	0	0	4	0	0	0	0	0	0	0	0	0	4
	2530-01-125-0461	Total Days	297	170	575	329	93	0	0	0	0	0	173	851	2488
		RCT													622

ITEM	NSN		OCT 95	NOV 95	DEC 95	JAN 96	FEB 96	MAR 96	APR 96	MAY 96	JUN 96	JUL 96	AUG 96	SEP 96	TOT
14	2815-01-108-5384	EROs Opened	3	4	1	2	0	0	3	0	0	0	0	0	13
	2815-01-108-5384	QTY Repaired	0	0	0	0	0	0	1	0	0	0	0	0	1
	2815-01-108-5384	Total Days	0	365	206	0	125	0	928	42	45	0	0	0	1711
		RCT													1711
15	5820-00-892-0623	EROs Opened	2	2	1	1	1	12	0	2	17	5	3	0	46
	5820-00-892-0623	QTY Repaired	7	3	2	0	2	7	2	0	4	11	5	1	44
	5820-00-892-0623	Total Days	576	142	184	0	88	62	223	0	44	392	172	78	1961
		RCT													45
16	5855-01-096-0871	EROs Opened	1	14	22	1	2	5	0	2	3	0	3	1	54
	5855-01-096-0871	QTY Repaired	3	3	5	10	0	4	15	2	2	0	1	1	46
	5855-01-096-0871	Total Days	302	24	284	1035	0	357	2372	1610	53	34	33	4	6108
		RCT													133
17	5895-01-298-1397	EROs Opened	1	2	0	2	0	1	0	0	0	1	0	1	8
	5895-01-298-1397	QTY Repaired	0	0	1	2	0	0	0	0	0	0	0	0	3
	5895-01-298-1397	Total Days	0	0	44	117	0	156	0	0	0	14	0	15	346
		RCT													115
18	5895-01-307-5491	EROs Opened	0	0	0	1	0	0	1	1	0	0	0	0	3
	5895-01-307-5491	QTY Repaired	0	0	0	0	0	0	0	0	0	1	0	0	1
	5895-01-307-5491	Total Days	0	0	0	0	0	65	0	27	0	68	0	0	160
		RCT													160
19	5998-01-026-1206	EROs Opened	2	0	0	0	1	1	3	4	1	1	0	1	14
	5998-01-026-1206	QTY Repaired	0	1	2	0	0	0	0	5	3	0	2	1	14
	5998-01-026-1206	Total Days	0	49	102	0	0	0	0	263	78	0	104	63	659
		RCT													47
20	5998-01-260-2527	EROs Opened	0	0	0	2	0	2	2	0	1	0	0	0	7
	5998-01-260-2527	QTY Repaired	0	0	0	0	0	0	0	1	0	1	0	0	2
	5998-01-260-2527	Total Days	0	0	0	0	0	0	237	46	0	13	0	0	296
		RCT													148
21	5998-01-327-2071	EROs Opened	0	3	0	1	1	0	0	1	0	0	3	0	9
	5998-01-327-2071	QTY Repaired	0	0	1	1	0	0	0	0	0	0	0	0	2
	5998-01-327-2071	Total Days	0	0	36	88	20	0	0	12	0	0	0	57	213
		RCT													107
22	5998-01-358-1187	EROs Opened	0	5	6	6	2	6	3	3	0	1	1	0	33
	5998-01-358-1187	QTY Repaired	0	3	0	1	7	7	9	1	0	2	0	1	31
	5998-01-358-1187	Total Days	177	249	420	63	528	520	770	62	77	104	802	141	3913
		RCT													126
23	5999-01-102-9320	EROs Opened	0	0	0	0	1	0	0	1	0	3	1	1	7
	5999-01-102-9320	QTY Repaired	1	0	0	0	0	0	0	0	0	0	0	0	1
	5999-01-102-9320	Total Days	48	0	0	0	22	0	0	0	29	17	31	42	189
		RCT													189
24	5999-01-109-9374	EROs Opened	0	1	0	0	1	1	0	4	0	3	1	0	11
	5999-01-109-9374	QTY Repaired	0	0	0	0	0	0	0	0	1	0	0	0	1
	5999-01-109-9374	Total Days	0	0	0	0	110	18	0	0	97	0	119	0	344
		RCT													344
25	5999-01-240-1249	EROs Opened	2	0	2	4	1	2	0	0	0	0	0	0	11
	5999-01-240-1249	QTY Repaired	0	0	0	0	0	1	0	0	0	0	0	0	1
	5999-01-240-1249	Total Days	0	0	79	77	113	68	0	0	0	0	0	0	337
		RCT													337
26	6130-01-027-2839	EROs Opened	1	1	0	2	0	0	2	1	0	0	3	1	11
	6130-01-027-2839	QTY Repaired	0	1	2	0	0	0	0	1	0	1	0	0	5
	6130-01-027-2839	Total Days	0	32	163	0	0	145	0	42	0	70	63	14	529
		RCT													106

APPENDIX G

Requisitioning Objective Models

APPENDIX G - REQUISITIONING OBJECTIVE MODEL
STATUS QUO

OSR = [(MFR - RR) X OST] / 30 days

RCR = (RR X RCT) / 30 days

SL = OSR + RCR

RO = OSR + RCR +SL

Item	MFR	RR	OST	**OSR**	RR	RCT	**RCR**	**SL**	**RO**
1	8	3	32	5	3	84	8	14	27
2	83	79	57	8	79	48	126	134	268
3	20	16	23	3	16	93	50	53	105
4	15	2	36	16	2	324	22	37	74
5	3	1	86	6	1	48	2	7	15
6	8	6	46	3	6	75	15	18	36
7	54	46	44	12	46	49	75	87	174
8	39	24	89	45	24	202	162	206	412
9	65	56	74	22	56	101	189	211	421
10	9	2	36	8	2	312	21	29	58
11	42	42	167	0	42	61	85	85	171
12	12	10	57	4	10	297	99	103	206
13	13	4	238	71	4	622	83	154	309
14	13	1	163	65	1	1711	57	122	244
15	46	44	25	2	44	45	66	68	135
16	54	46	26	7	46	133	204	211	422
17	8	3	52	9	3	115	12	20	40
18	3	1	18	1	1	160	5	7	13
19	14	14	11	0	14	47	22	22	44
20	7	2	51	9	2	148	10	18	37
21	9	2	92	21	2	107	7	29	57
22	33	31	15	1	31	126	130	131	262
23	7	1	100	20	1	189	6	26	53
24	11	1	91	30	1	344	11	42	83
25	11	1	316	105	1	337	11	117	233
26	11	5	44	9	5	106	18	26	53

MFR = Maintenance Failure Rate
RR = Repair Rate
OST = Order and Shipping Time
OSR = Order and Shipping Requirement

RR = Repair Rate
RCT = Repair Cycle Time
RCR = Repair Cycle Requirement

SL = Safety Level

RO = Requisitioning Objective

Table G-1.

APPENDIX G - REQUISITIONING OBJECTIVE MODEL
CURRENT UMMIPS TIME STANDARDS SCENARIO (5,000 TRIALS)
SCENARIO #1

OSR = [(MFR - RR) X OST] / 30 days

RCR = (RR X RCT) / 30 days

SL = OSR + RCR

RO = OSR + RCR +SL

Item	MFR	RR	OST	OSR
1	1	0	22	0
2	7	7	45	0
3	2	1	11	0
4	1	0	24	1
5	0	0	73	0
6	1	1	34	0
7	4	4	32	1
8	3	2	79	3
9	5	5	62	2
10	1	0	24	0
11	4	4	156	0
12	1	1	45	0
13	1	0	228	6
14	1	0	152	5
15	4	4	13	0
16	5	4	14	0
17	1	0	41	1
18	0	0	7	0
19	1	1	1	0
20	1	0	39	1
21	1	0	80	2
22	3	3	3	0
23	1	0	87	1
24	1	0	81	2
25	1	0	304	9
26	1	0	32	1

MFR = Maintenance Failure Rate
RR = Repair Rate
OST = Order and Shipping Time
OSR = Order and Shipping Requirement

RR	RCT	RCR
0	84	1
7	48	11
1	93	4
0	324	2
0	48	0
0	75	1
4	49	6
2	202	13
5	101	15
0	312	2
3	61	7
1	297	8
0	622	7
0	1711	5
4	45	5
4	133	17
0	115	1
0	160	0
1	47	2
0	148	1
0	107	1
3	126	11
0	189	1
0	344	1
0	337	1
0	106	1

RR = Repair Rate
RCT = Repair Cycle Time
RCR = Repair Cycle Requirement

SL
1
11
4
3
1
1
7
16
17
2
7
9
12
10
6
18
1
0
2
1
2
11
2
3
9
2

SL = Safety Level

RO
2
22
8
5
1
3
14
33
34
5
15
17
25
21
11
35
3
1
4
3
4
22
4
7
19
4

RO = Requisitioning Objective

Table G-2.

APPENDIX G - REQUISITIONING OBJECTIVE MODEL
NEW UMMIPS TIME STANDARDS SCENARIO (5,000 TRIALS)
SCENARIO #2

OSR = [(MFR - RR) X OST] / 30 days

RCR = (RR X RCT) / 30 days

SL = OSR + RCR

RO = OSR + RCR +SL

Item	MFR	RR	OST	OSR
1	1	0	25	0
2	7	7	49	0
3	2	1	15	0
4	1	0	28	1
5	0	0	76	0
6	1	1	38	0
7	5	4	36	1
8	3	2	80	4
9	5	5	66	2
10	1	0	27	1
11	4	3	160	0
12	1	1	49	0
13	1	0	231	6
14	1	0	156	5
15	4	4	17	0
16	4	4	18	0
17	1	0	44	1
18	0	0	10	0
19	1	1	3	0
20	1	0	43	1
21	1	0	85	2
22	3	3	7	0
23	1	0	92	1
24	1	0	83	2
25	1	0	308	8
26	1	0	36	1

RR	RCT	RCR
0	84	1
7	48	11
1	93	4
0	324	2
0	48	0
1	75	1
4	49	6
2	202	13
5	101	16
0	312	2
3	61	7
1	297	8
0	622	7
0	1711	5
4	45	6
4	133	17
0	115	1
0	160	0
1	47	2
0	148	1
0	107	1
3	126	11
0	189	1
0	344	1
0	337	1
0	106	1

SL
1
11
4
3
1
1
7
17
17
2
7
8
12
10
6
17
2
1
2
1
2
11
2
3
9
2

RO
2
22
9
6
1
3
14
33
35
5
14
17
25
20
11
35
3
1
4
3
4
22
4
6
19
4

MFR = Maintenance Failure Rate
RR = Repair Rate
OST = Order and Shipping Time
OSR = Order and Shipping Requirement

RR = Repair Rate
RCT = Repair Cycle Time
RCR = Repair Cycle Requirement

SL = Safety Level

RO = Requisitioning Objective

Table G-3.

APPENDIX H

Incremental Cost of Inventory Analysis

APPENDIX H
SCENARIO #1

COST OF INVENTORY / INCREMENTAL COST OF INVENTORY

Item	SR + RCR	U/P	T/P	Inv Cost	Obsol	Other	Storage	Holding Cost
1	1	$6,091.00	$6,091.00	$609.10	$85.27	$550.63	$60.91	$1,305.91
2	11	$7,938.00	$87,318.00	$8,731.80	$1,222.45	$7,893.55	$873.18	$18,720.98
3	4	$5,825.00	$23,300.00	$2,330.00	$326.20	$2,106.32	$233.00	$4,995.52
4	3	$604.00	$1,812.00	$181.20	$25.37	$163.80	$18.12	$388.49
5	0	$2,655.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
6	1	$522.00	$522.00	$52.20	$7.31	$47.19	$5.22	$111.92
7	7	$3,577.92	$25,045.44	$2,504.54	$350.64	$2,264.11	$250.45	$5,369.74
8	16	$348.59	$5,577.44	$557.74	$78.08	$504.20	$55.77	$1,195.80
9	17	$11,814.00	$200,838.00	$20,083.80	$2,811.73	$18,155.76	$2,008.38	$43,059.67
10	2	$9,100.00	$18,200.00	$1,820.00	$254.80	$1,645.28	$182.00	$3,902.08
11	7	$111,961.87	$783,733.09	$78,373.31	$10,972.26	$70,849.47	$7,837.33	$168,032.37
12	8	$12,352.00	$98,816.00	$9,881.60	$1,383.42	$8,932.97	$988.16	$21,186.15
13	13	$31,593.19	$410,711.47	$41,071.15	$5,749.96	$37,128.32	$4,107.11	$88,056.54
14	10	$1,619.00	$16,190.00	$1,619.00	$226.66	$1,463.58	$161.90	$3,471.14
15	5	$10,345.00	$51,725.00	$5,172.50	$724.15	$4,675.94	$517.25	$11,089.84
16	17	$5,378.00	$91,426.00	$9,142.60	$1,279.96	$8,264.91	$914.26	$19,601.73
17	2	$6,539.18	$13,078.36	$1,307.84	$183.10	$1,182.28	$130.78	$2,804.00
18	0	$6,037.32	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
19	2	$710.63	$1,421.26	$142.13	$19.90	$128.48	$14.21	$304.72
20	2	$2,924.45	$5,848.90	$584.89	$81.88	$528.74	$58.49	$1,254.00
21	3	$125.00	$375.00	$37.50	$5.25	$33.90	$3.75	$80.40
22	11	$3,108.47	$34,193.17	$3,419.32	$478.70	$3,091.06	$341.93	$7,331.02
23	2	$526.00	$1,052.00	$105.20	$14.73	$95.10	$10.52	$225.55
24	3	$253.00	$759.00	$75.90	$10.63	$68.61	$7.59	$162.73
25	10	$611.00	$6,110.00	$611.00	$85.54	$552.34	$61.10	$1,309.98
26	2	$2,256.59	$4,513.18	$451.32	$63.18	$407.99	$45.13	$967.63
			$1,888,656.31					$404,927.91

Table H-1.

APPENDIX H
SCENARIO #2

COST OF INVENTORY

Item	SR + RCR	U/P	T/P
1	1	$6,091.00	$6,091.00
2	11	$7,938.00	$87,318.00
3	4	$5,825.00	$23,300.00
4	3	$604.00	$1,812.00
5	0	$2,655.00	$0.00
6	1	$522.00	$522.00
7	7	$3,577.92	$25,045.44
8	17	$348.59	$5,926.03
9	18	$11,814.00	$212,652.00
10	3	$9,100.00	$27,300.00
11	7	$111,961.87	$783,733.09
12	8	$12,352.00	$98,816.00
13	13	$31,593.19	$410,711.47
14	10	$1,619.00	$16,190.00
15	6	$10,345.00	$62,070.00
16	17	$5,378.00	$91,426.00
17	2	$6,539.18	$13,078.36
18	0	$6,037.32	$0.00
19	2	$710.63	$1,421.26
20	2	$2,924.45	$5,848.90
21	3	$125.00	$375.00
22	11	$3,108.47	$34,193.17
23	2	$526.00	$1,052.00
24	3	$253.00	$759.00
25	9	$611.00	$5,499.00
26	2	$2,256.59	$4,513.18
			$1,919,652.90

INCREMENTAL COST OF INVENTORY

Inv Cost	Obsol	Other	Storage	Holding Cost
$609.10	$85.27	$550.63	$60.91	$1,305.91
$8,731.80	$1,222.45	$7,893.55	$873.18	$18,720.98
$2,330.00	$326.20	$2,106.32	$233.00	$4,995.52
$181.20	$25.37	$163.80	$18.12	$388.49
$0.00	$0.00	$0.00	$0.00	$0.00
$52.20	$7.31	$47.19	$5.22	$111.92
$2,504.54	$350.64	$2,264.11	$250.45	$5,369.74
$592.60	$82.96	$535.71	$59.26	$1,270.54
$21,265.20	$2,977.13	$19,223.74	$2,126.52	$45,592.59
$2,730.00	$382.20	$2,467.92	$273.00	$5,853.12
$78,373.31	$10,972.26	$70,849.47	$7,837.33	$168,032.37
$9,881.60	$1,383.42	$8,932.97	$988.16	$21,186.15
$41,071.15	$5,749.96	$37,128.32	$4,107.11	$88,056.54
$1,619.00	$226.66	$1,463.58	$161.90	$3,471.14
$6,207.00	$868.98	$5,611.13	$620.70	$13,307.81
$9,142.60	$1,279.96	$8,264.91	$914.26	$19,601.73
$1,307.84	$183.10	$1,182.28	$130.78	$2,804.00
$0.00	$0.00	$0.00	$0.00	$0.00
$142.13	$19.90	$128.48	$14.21	$304.72
$584.89	$81.88	$528.74	$58.49	$1,254.00
$37.50	$5.25	$33.90	$3.75	$80.40
$3,419.32	$478.70	$3,091.06	$341.93	$7,331.02
$105.20	$14.73	$95.10	$10.52	$225.55
$75.90	$10.63	$68.61	$7.59	$162.73
$549.90	$76.99	$497.11	$54.99	$1,178.99
$451.32	$63.18	$407.99	$45.13	$967.63
				$411,573.58

Table H-2.

APPENDIX I
AIR TRANSPORTATION RATES

Weight (lbs.)	Unit Shipping Cost
0	$3.45
1	$3.50
2	$3.57
3	$3.62
4	$3.67
5	$4.17
6	$4.92
7	$5.67
8	$6.42
9	$7.17
10	$7.92
11	$8.52
12	$9.12
13	$9.72
14	$10.32
15	$10.92
16	$11.57
17	$12.42
18	$13.17
19	$13.92
20	$14.57
21	$15.42
22	$16.17
23	$16.92
24	$17.67
25	$18.42
26	$19.17
27	$19.92
28	$20.67
29	$21.42
30	$22.17
31	$22.88
32	$23.67
33	$24.42
34	$25.17
35	$25.92
36	$26.57
37	$27.42
38	$28.17
39	$28.92
40	$29.57
41	$30.42
42	$31.17
43	$31.92
44	$32.67

APPENDIX I
AIR TRANSPORTATION RATES

Weight (lbs.)	Unit Shipping Cost
45	$33.42
46	$34.17
47	$34.92
48	$35.67
49	$36.42
50	$37.17
51	$37.92
52	$38.67
53	$39.42
54	$40.17
55	$40.92
56	$41.57
57	$42.42
58	$43.17
59	$43.92
60	$44.57
61	$45.42
62	$46.17
63	$46.92
64	$47.67
65	$48.42
66	$49.17
67	$49.92
68	$50.67
69	$51.42
70	$52.17
71	$52.92
72	$53.67
73	$54.42
74	$55.17
75	$55.67
76	$56.17
77	$56.57
78	$57.17
79	$57.67
80	$58.17
81	$58.67
82	$59.17
83	$59.67
84	$60.17
85	$60.67
86	$61.17
87	$61.67
88	$62.17
89	$62.67

APPENDIX I
AIR TRANSPORTATION RATES

Weight (lbs.)	Unit Shipping Cost
90	$63.12
91	$63.57
92	$64.02
93	$64.47
94	$64.92
95	$65.37
96	$65.82
97	$66.27
98	$66.55
99	$67.00
100	$67.00
101	$67.75
102	$68.50
103	$69.25
104	$70.00
105	$70.75
106	$71.60
107	$72.25
108	$73.00
109	$73.75
110	$74.50
111	$75.25
112	$76.00
113	$76.75
114	$77.50
115	$78.25
116	$79.00
117	$79.75
118	$80.50
119	$81.25
120	$82.00
121	$82.75
122	$83.50
123	$84.25
124	$85.00
125	$85.75
126	$88.50
127	$87.25
128	$88.00
129	$88.75
130	$89.50
131	$90.25
132	$91.00
133	$91.75
134	$92.50

APPENDIX I
AIR TRANSPORTATION RATES

Weight (lbs.)	Unit Shipping Cost
135	$93.25
136	$94.00
137	$94.75
138	$95.50
139	$96.25
140	$97.00
141	$97.75
142	$98.50
143	$99.25
144	$100.00
145	$100.75
146	$101.50
147	$102.25
148	$103.00
149	$103.75
150	$104.50
200	$172.00
300	$258.00
400	$344.00
500	$415.00
600	$498.00
700	$581.00
800	$664.00
900	$747.00
1000	$820.00
1100	$902.00
1200	$984.00
1300	$1,066.00
1400	$1,148.00
1500	$1,230.00
1600	$1,312.00
1700	$1,394.00
1800	$1,476.00
1900	$1,558.00
2000	$1,640.00
2100	$1,722.00
2200	$1,804.00
2300	$1,886.00
2400	$1,968.00
2500	$2,025.00
2600	$2,106.00
2700	$2,187.00
2800	$2,268.00
2900	$2,349.00
3000	$2,430.00

APPENDIX J
GROUND TRANSPORTATION RATES

Weight (lbs.)	Unit Shipping Cost
0	$1.73
1	$1.73
2	$1.84
3	$1.99
4	$2.19
5	$2.19
6	$2.36
7	$2.37
8	$2.50
9	$2.50
10	$2.63
11	$2.63
12	$2.80
13	$4.84
14	$5.14
15	$5.45
16	$5.75
17	$6.06
18	$6.16
19	$6.65
20	$6.95
21	$7.34
22	$7.55
23	$7.86
24	$8.17
25	$8.45
26	$8.76
27	$9.07
28	$9.36
29	$9.66
30	$10.01
31	$10.33
32	$10.66
33	$10.88
34	$11.33
35	$11.64
36	$11.95
37	$12.26
38	$12.57
39	$12.96
40	$13.17
41	$13.49
42	$13.78
43	$14.10
44	$14.40

APPENDIX J
GROUND TRANSPORTATION RATES

Weight (lbs.)	Unit Shipping Cost
45	$14.71
46	$15.01
47	$15.32
48	$15.62
49	$15.93
50	$16.23
51	$16.32
52	$16.39
53	$16.46
54	$16.54
55	$16.61
56	$16.69
57	$16.77
58	$16.84
59	$16.92
60	$17.01
61	$17.07
62	$17.14
63	$17.23
64	$17.28
65	$17.37
66	$17.46
67	$17.53
68	$17.56
69	$17.66
70	$17.76
71	$27.74
72	$27.85
73	$27.95
74	$28.08
75	$28.21
76	$28.32
77	$28.44
78	$28.57
79	$28.68
80	$28.81
81	$28.91
82	$29.02
83	$29.15
84	$29.27
85	$29.38
86	$29.52
87	$29.63
88	$29.73
89	$29.87

APPENDIX J
GROUND TRANSPORTATION RATES

Weight (lbs.)	Unit Shipping Cost
90	$29.98
91	$30.08
92	$30.21
93	$30.33
94	$30.46
95	$30.57
96	$30.69
97	$30.79
98	$30.94
99	$31.04
100	$32.55
101	$32.70
102	$32.96
103	$33.23
104	$33.48
105	$33.76
106	$34.02
107	$34.28
108	$34.54
109	$34.81
110	$35.08
111	$35.34
112	$35.60
113	$35.87
114	$36.13
115	$36.40
116	$36.66
117	$36.83
118	$37.15
119	$37.44
120	$37.71
121	$37.96
122	$38.22
123	$38.48
124	$38.74
125	$39.00
126	$39.26
127	$39.52
128	$39.78
129	$40.04
130	$40.30
131	$40.56
132	$40.82
133	$41.08
134	$41.34

APPENDIX J
GROUND TRANSPORTATION RATES

Weight (lbs.)	Unit Shipping Cost
135	$41.60
136	$41.86
137	$42.12
138	$42.38
139	$42.54
140	$42.80
141	$43.16
142	$43.42
143	$43.66
144	$43.84
145	$44.20
146	$44.48
147	$44.72
148	$44.98
149	$45.00
150	$45.00
200	$45.02
300	$67.53
400	$90.04
500	$85.80
600	$102.96
700	$120.12
800	$137.28
900	$154.44
1000	$145.90
1100	$160.49
1200	$175.08
1300	$189.67
1400	$204.26
1500	$218.85
1600	$233.44
1700	$248.03
1800	$262.62
1900	$277.21
2000	$253.20
2100	$265.86
2200	$278.52
2300	$291.18
2400	$303.84
2500	$316.50
2600	$329.16
2700	$341.82
2800	$354.48
2900	$367.14
3000	$379.80

APPENDIX K

Incremental Cost of Premium Transportation Analysis

APPENDIX K
SCENARIO #1

COST OF PREMIUM TRANSPORTATION

Item	OSR	Weight (lbs.)	Unit Shipping Cost	Total Shipping Cost
1	0	235	$172.00	$0.00
2	0	24	$17.67	$0.00
3	0	25	$17.67	$0.00
4	1	31	$22.88	$22.88
5	0	17	$12.42	$0.00
6	0	26	$19.17	$0.00
7	1	10	$7.92	$7.92
8	3	20	$14.57	$43.71
9	2	1020	$820.00	$1,640.00
10	0	440	$344.00	$0.00
11	0	2875	$2,268.00	$0.00
12	0	1198	$902.00	$0.00
13	6	230	$172.00	$1,032.00
14	5	261	$172.00	$860.00
15	0	0	$3.45	$0.00
16	0	23	$16.92	$0.00
17	1	2	$3.57	$3.57
18	0	2	$3.57	$0.00
19	0	0	$3.45	$0.00
20	1	25	$18.42	$18.42
21	2	0	$3.45	$6.90
22	0	1	$3.50	$0.00
23	1	1	$3.45	$3.45
24	2	1	$3.50	$7.00
25	9	1	$3.45	$31.05
26	1	10	$7.92	$7.92
			Total Cost:	$3,684.82

INCREMENTAL COST OF PREMIUM TRANSPORTATION

Air Shipping Cost	Ground Unit Shipping Cost	Difference	OSR	Incremental Shipping Cost
$172.00	$45.02	$126.98	0	$0.00
$17.67	$8.17	$9.50	0	$0.00
$17.67	$8.17	$9.50	0	$0.00
$22.88	$10.33	$12.55	1	$12.55
$12.42	$6.06	$6.36	0	$0.00
$19.17	$8.76	$10.41	0	$0.00
$7.92	$2.63	$5.29	1	$5.29
$14.57	$6.95	$7.62	3	$22.86
$820.00	$145.90	$674.10	2	$1,348.20
$344.00	$90.04	$253.96	0	$0.00
$2,268.00	$354.48	$1,913.52	0	$0.00
$902.00	$160.49	$741.51	0	$0.00
$172.00	$45.02	$126.98	6	$761.88
$172.00	$45.02	$126.98	5	$634.90
$3.45	$1.73	$1.72	0	$0.00
$16.92	$7.86	$9.06	0	$0.00
$3.57	$1.84	$1.73	1	$1.73
$3.57	$1.84	$1.73	0	$0.00
$3.45	$1.73	$1.72	0	$0.00
$18.42	$8.45	$9.97	1	$9.97
$3.45	$1.73	$1.72	2	$3.44
$3.50	$1.73	$1.77	0	$0.00
$3.45	$1.73	$1.72	1	$1.72
$3.50	$1.73	$1.77	2	$3.54
$3.45	$1.73	$1.72	9	$15.48
$7.92	$2.63	$5.29	1	$5.29
				$2,826.85

Table K-1.

APPENDIX K
SCENARIO #2

COST OF PREMIUM TRANSPORTATION

Item	OSR	Weight (lbs.)	Unit Shipping Cost	Total Shipping Cost
1	0	235	$172.00	$0.00
2	0	24	$17.67	$0.00
3	0	24.5	$17.67	$0.00
4	1	31	$22.88	$22.88
5	0	17	$12.42	$0.00
6	0	26	$19.17	$0.00
7	1	10	$7.92	$7.92
8	4	20	$14.57	$58.28
9	2	1020	$820.00	$1,640.00
10	1	440	$344.00	$344.00
11	0	2875	$2,025.00	$0.00
12	0	1198	$820.00	$0.00
13	6	230	$172.00	$1,032.00
14	5	261	$172.00	$860.00
15	0	0.1	$3.45	$0.00
16	0	23	$16.92	$0.00
17	1	2	$3.57	$3.57
18	0	2	$3.57	$0.00
19	0	0.1	$3.45	$0.00
20	1	25	$18.42	$18.42
21	2	0.4	$3.45	$6.90
22	0	1	$3.50	$0.00
23	1	0.9	$3.45	$3.45
24	2	1	$3.50	$7.00
25	8	0.8	$3.45	$27.60
26	1	10	$7.92	$7.92
			Total Cost:	$4,039.94

INCREMENTAL COST OF PREMIUM TRANSPORTATION

Air Shipping Cost	Ground Unit Shipping Cost	Difference	OSR	Incremental Shipping Cost
$172.00	$0.00	$172.00	0	$0.00
$17.67	$8.17	$9.50	0	$0.00
$17.67	$8.17	$9.50	0	$0.00
$22.88	$10.33	$12.55	1	$12.55
$12.42	$6.06	$6.36	0	$0.00
$19.17	$8.76	$10.41	0	$0.00
$7.92	$2.63	$5.29	1	$5.29
$14.57	$6.95	$7.62	4	$30.48
$820.00	$0.00	$820.00	2	$1,640.00
$344.00	$0.00	$344.00	1	$344.00
$2,025.00	$0.00	$2,025.00	0	$0.00
$820.00	$0.00	$820.00	0	$0.00
$172.00	$0.00	$172.00	6	$1,032.00
$172.00	$0.00	$172.00	5	$860.00
$3.45	$1.73	$1.72	0	$0.00
$16.92	$7.86	$9.06	0	$0.00
$3.57	$1.84	$1.73	1	$1.73
$3.57	$1.84	$1.73	0	$0.00
$3.45	$1.73	$1.72	0	$0.00
$18.42	$8.45	$9.97	1	$9.97
$3.45	$1.73	$1.72	2	$3.44
$3.50	$1.73	$1.77	0	$0.00
$3.45	$1.73	$1.72	1	$1.72
$3.50	$1.73	$1.77	2	$3.54
$3.45	$1.73	$1.72	8	$13.76
$7.92	$2.63	$5.29	1	$5.29
				$3,963.77

Table K-2.

APPENDIX L
COST OF INVENTORY VS. COST OF TRANSPORTATION
SCENARIO #1

Item	Incremental Holding Cost	Incremental Transpo Cost	Difference
1	$1,305.91	$0.00	$1,305.91
2	$18,720.98	$0.00	$18,720.98
3	$4,995.52	$0.00	$4,995.52
4	$388.49	$12.55	$375.94
5	$0.00	$0.00	$0.00
6	$111.92	$0.00	$111.92
7	$5,369.74	$5.29	$5,364.45
8	$1,195.80	$22.86	$1,172.94
9	$43,059.67	$1,348.20	$41,711.47
10	$3,902.08	$0.00	$3,902.08
11	$168,032.37	$0.00	$168,032.37
12	$21,186.15	$0.00	$21,186.15
13	$88,056.54	$761.88	$87,294.66
14	$3,471.14	$634.90	$2,836.24
15	$11,089.84	$0.00	$11,089.84
16	$19,601.73	$0.00	$19,601.73
17	$2,804.00	$1.73	$2,802.27
18	$0.00	$0.00	$0.00
19	$304.72	$0.00	$304.72
20	$1,254.00	$9.97	$1,244.03
21	$80.40	$3.44	$76.96
22	$7,331.02	$0.00	$7,331.02
23	$225.55	$1.72	$223.83
24	$162.73	$3.54	$159.19
25	$1,309.98	$15.48	$1,294.50
26	$967.63	$5.29	$962.34

Total Cost: $402,101.06

APPENDIX L
COST OF INVENTORY VS. COST OF TRANSPORTATION
SCENARIO #2

Item	Incremental Holding Cost	Incremental Transpo Cost	Difference
1	$1,305.91	$0.00	$1,305.91
2	$18,720.98	$0.00	$18,720.98
3	$4,995.52	$0.00	$4,995.52
4	$388.49	$12.55	$375.94
5	$0.00	$0.00	$0.00
6	$111.92	$0.00	$111.92
7	$5,369.74	$5.29	$5,364.45
8	$1,270.54	$30.48	$1,240.06
9	$45,592.59	$1,640.00	$43,952.59
10	$5,853.12	$344.00	$5,509.12
11	$168,032.37	$0.00	$168,032.37
12	$21,186.15	$0.00	$21,186.15
13	$88,056.54	$1,032.00	$87,024.54
14	$3,471.14	$860.00	$2,611.14
15	$13,307.81	$0.00	$13,307.81
16	$19,601.73	$0.00	$19,601.73
17	$2,804.00	$1.73	$2,802.27
18	$0.00	$0.00	$0.00
19	$304.72	$0.00	$304.72
20	$1,254.00	$9.97	$1,244.03
21	$80.40	$3.44	$76.96
22	$7,331.02	$0.00	$7,331.02
23	$225.55	$1.72	$223.83
24	$162.73	$3.54	$159.19
25	$1,178.99	$13.76	$1,165.23
26	$967.63	$5.29	$962.34

Total Cost: $407,609.81

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