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INVENTORY MANAGEMENT ANALYSIS OF SPECTACLE FRAMES AT THE NAVAL OPHTHALMIC SUPPORT AND TRAINING ACTIVITY

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THESIS

INVENTORY MANAGEMENT ANALYSIS OF SPECTACLE FRAMES AT THE NAVAL OPHTHALMIC SUPPORT AND TRAINING ACTIVITY

by

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December 2019

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The Defense Health Agency (DHA) has challenged each of its subordinate organizations through several initiatives to reduce costs while delivering world-class medical care. As a step toward the DHA's cost-saving initiative, this thesis analyzes the current inventory management and recommends suitable inventory models for DHA's largest eyewear production organization, Naval Ophthalmic Support and Training Activity (NOSTRA). This unique organization carries the most extensive inventories of lenses and spectacle frames. NOSTRA provides eyewear to all service branches, retirees, and other eligible personnel. This project evaluates 141 spectacle frame types across two fiscal years, 2017 and 2018. The analysis reveals that NOSTRA uses a combination of the periodic review and continuous review models. NOSTRA also uses three separate information technology systems, which makes it challenging to accurately forecast demand and track inventory.

The findings indicate that NOSTRA can benefit from inventory management models and substantially reduce its inventory and cost. The results of this analysis recommend that NOSTRA incorporate the economic order quantity model and ABC analysis, and utilize the joint ordering strategy. Furthermore, management can extend the frame-of-choice replacement policy to the end of the suppliers' contract year to capture more potential savings.

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LIST OF ACRONYMS AND ABBREVIATIONS

DHA	Defense Health Agency
DLA	Defense Logistics Agency
DMLSS	Defense Medical Logistics Standard Support
DOD	Department of Defense
DoN	Department of the Navy
EOQ	Economic Order Quantity
FOC	Frame of Choice
FY	Fiscal Year
MHS	Military Health System
MMD	Material Management Department
MTF	Military Treatment Facility
NDAA	National Defense Authorization Act
NOSTRA	Naval Ophthalmic Support and Training Activity
OFE	Optical Fabrication Enterprise
OMB	Office of Management and Budget
ROP	Re-Order Point
SKU	Stock-Keeping Unit
SRTS	Spectacle Request Transmission System
SS	Safety Stock

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—LT Shawn Dean, LT Nasim Hawashem, and LCDR William Agbo

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—LT Nasim Hawashem

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I. INTRODUCTION

The passage of the National Defense Authorization Act (NDAA) of Fiscal Year (FY) 2017 brings major changes within the military health system (MHS). The government aims to reduce inventory and cost, along with other goals such as consolidating the military health care system administration and management under the Defense Health Agency (DHA; National Defense Authorization Act [NDAA], 2017). The DHA serves as a "joint, integrated Combat Support Agency that enables the Army, Navy, and Air Force medical services to provide a medically ready force to Combatant Commands in both peacetime and wartime" (Defense Health Agency [DHA], n.d.). The agency's four goals are to "increase readiness, better health, better care, and lower cost" (DHA, n.d.). These objectives are defined in Figure 1.

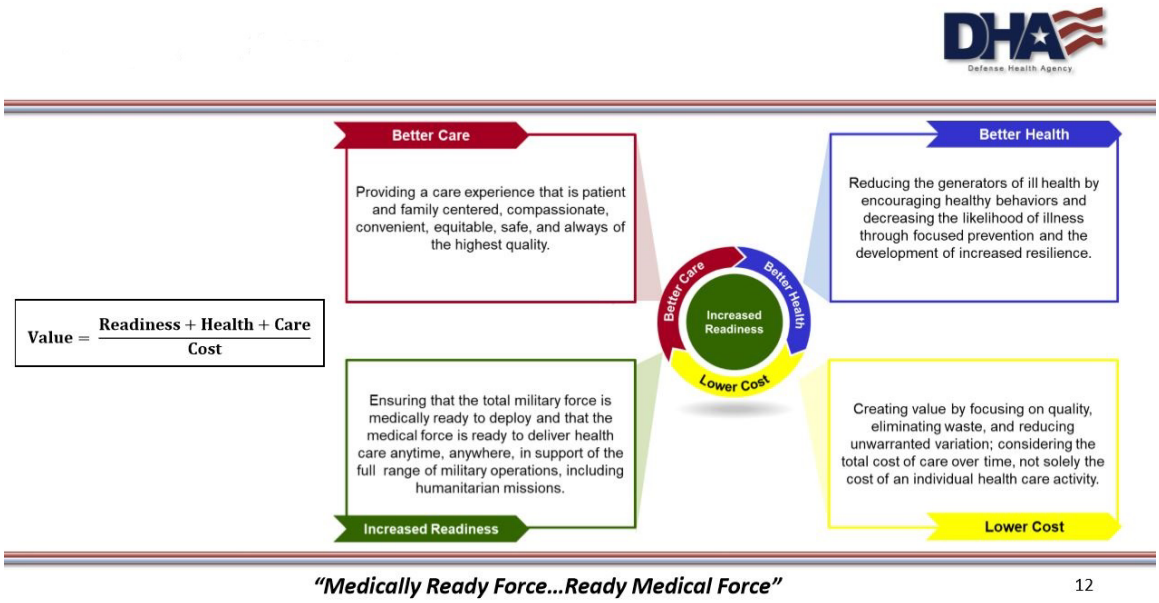

Figure 1. DHA Quadruple Aim Performance Process. Source: DHA (n.d.).

As described in Figure 1, the DHA wants to lower costs by "eliminating waste, reducing unwarranted variation, and considering the total cost of care over time" (DHA, 2019). In part, the DHA will improve operational cohesion and financial coherence through

standardization of processes and achievement of economies of scale, maximized commonality, and increased fidelity to methodologies used in the workplace (Kurta, 2017). These are not minor tasks considering that the military health service system takes care of 9.4 million beneficiaries as of FY 2018 in 997 DHA locations (Kurta, 2017). Motivated by the DHA's lower-cost goal, this thesis evaluates and recommends an inventory management strategy and policy to reduce inventory and cost at the DHA's largest optical fabrication organization, Naval Ophthalmic Support and Training Activity (NOSTRA).

A. PURPOSE STATEMENT

The Department of Defense's (DOD) political concerns, imposed mandates, and numerous reports highlight an urgency to reduce costs and improve supply chain management practices. This thesis is a step toward aligning multiple levels of governmental goals and mandates. In doing so, it presents an analysis of the current inventory management practices at NOSTRA. This organization carries an extensive inventory of lenses and spectacle frames. It provides eyewear to all service branches, retirees, and other eligible personnel. Drawing on NOSTRA's resemblance to production and retail organizations, this thesis leverages inventory management models to suggest ways to enhance its mission. A thesis by Gavan and Fowler (2019) evaluated NOSTRA's in-shop inventory management and suggested using the two-bin Kanban system to manage inventory at the bench level. This thesis takes their research further by expanding the inventory of selected items across two fiscal years, incorporating holding cost, and including more inventory models to optimize inventory at the organizational level. The purpose of this thesis is to evaluate NOSTRA's current inventory management methods and to suggest suitable models that can be integrated into its daily operations to optimize inventory and reduce cost.

B. BACKGROUND

Adequate vision is one of the primary requirements for military service members. In order to avoid alienating the part of the population that may be willing to join the all-volunteer force, the Army, Navy, and Air Force established service-specific corrective guidelines for using spectacles for less than optimal visual acuity.

Since World War II, the Navy has provided ocular care for Sailors and Marines (Naval Ophthalmic Support and Training Activity [NOSTRA], n.d.). With no ophthalmic program to meet the "critical need for prescription eyewear," the Navy contracted civilian fabrication laboratories to satisfy the requirement (NOSTRA, n.d.). Because of high demand for prescription eyewear, the Navy established the military ophthalmic program as directed in the Navy Appropriations Act of 1942 (NOSTRA, n.d.). The initial program provided prescription eyewear for Navy and Marine Corps personnel serving overseas. The optical units' basic functions limited the effectiveness of the program, because of lens surfacing capabilities. The units fabricated a limited range of prescriptions from pre-finished eyewear using lens edging equipment. As the demand for prescription eyewear and the need for more trained spectacle dispensers continued to rise, the Navy continued to modernize its ophthalmic program (NOSTRA, n.d.). In June 1945, the Navy established an optical school at the U.S. Naval Medical Supply Depot, Brooklyn, NY, to train opticians and dispensers (NOSTRA, n.d.). Four years later, the Navy ophthalmic laboratories with surfacing capabilities were established at the same location (NOSTRA, n.d.). The fabrication laboratories and the training school went through various relocations and name changes until May 6, 1968, when they were co-located at Naval Weapons Station Yorktown, VA, and granted command status as the Naval Ophthalmic Support and Training Activity (NOSTRA, n.d.).

The mission of NOSTRA is to "support readiness of the Armed Forces and beneficiaries by providing timely and efficient worldwide delivery of quality eyewear" (NOSTRA, n.d.). The organization consists of more than 200 military, civilian, and contract personnel, all of whom "take great pride in providing Armed Forces with the sight to fight" (NOSTRA, n.d.). NOSTRA manages the MHS's Optical Fabrication Enterprise (OFE), which is made up of nine Army and 18 Navy laboratories and produces 1.6 million pairs of eyeglasses per year (Ostermaier, 2017).

NOSTRA uses a Frame of Choice (FOC) program administered through the OFE (Department of the Navy [DoN,] 2015). The FOC program allows eligible beneficiaries to pick civilian-style frames at military treatment facilities (MTFs). NOSTRA's FOC policy is

to keep a minimal inventory on-hand because of the short turnaround time (E. B. Walters, personal communication, September 8, 2019). NOSTRA offers eight FOC styles. The FOC program currently rotates styles every three years.

C. OBJECTIVE

The main objective of this thesis is to assist NOSTRA in aligning itself with the cost-reducing goals of the DHA. This will be accomplished through a comprehensive review of its current inventory management strategy and policy. The goal of this thesis is to find the best inventory management models that can reduce inventory and cost at NOSTRA while improving efficiency and customer service. The aim is to utilize the data given by NOSTRA to find inventory models that will fit its business practices and have the least financial impact on operations.

The primary research question is as follows:

What inventory management models are suitable for NOSTRA to optimize its inventory practices? To answer this question, two other secondary questions are incorporated into this thesis:

- How is NOSTRA managing its spectacle frame inventory?
- How many styles of spectacle frames should NOSTRA carry?

D. SUMMARY

This section describes the change of recent legislative actions that has shifted the tri-services' military health care system in a new direction of efficiency and accountability. As a result, the tri-services' military health care system is now under the purview of the DHA for administration and management. Of the DHA's four goals, this thesis focuses on the lower cost aspect. In contributing to the DHA's goal to lower costs, NOSTRA is selected because of its unique history and service in providing eyewear to the armed forces and beneficiaries. The objective of this thesis is to identify suitable inventory management policies and models that can be incorporated into NOSTRA's daily operations. This thesis provides a step towards understanding inventory management in following chapters.

II. LITERATURE REVIEW

This chapter introduces research used in supply chain management to control inventory and briefly discusses common terminology. It intertwines multiple academic disciplines such as applied science (business), social science (organizational behavior), and formal science (mathematics). The inventory models examine the economic order quantity, re-order point (ROP) with safety stock (SS), periodic review system, continuous review system, ABC analysis, and joint ordering. The following section expounds on each model purpose, methods, and findings. However, the literature review shows limited research in the field of health care inventory management especially in the optical industry. The later chapters explain the various applications and equations of the models.

A. ECONOMIC ORDER QUANTITY

Nasri, Paknejad, and Affisco (2009) described the Economic Order Quantity (EOQ) model as an inventory control technique that aims to "keep order quantities and production lots to a practical minimum" (p. 403). The EOQ model helps an organization order material in a uniform sequence under several assumptions, such as constant demand, regular availability of supply, and known lead-time. The only variables are order cost and holding cost. The ordering cost is the cost for placing an order. The holding cost is the cost of keeping the physical material on-hand.

While consulting for the Health Insurance National House, Adriana, Alexandru, and Olimpia (2010) applied the EOQ model to determine the amount of "single-use syringes for intravenous and intramuscular injections in different treatments of the patients" (p. 241). The authors used single-use syringe purchase data from 2008 to establish the baseline numbers. Then the authors incorporated the baseline numbers into the Inventory Theory and System module of the WinQSB software to determine the appropriate single-use syringe EOQ. Through the application of the EOQ, the hospital was able to minimize cost and quantity of syringes resulting in a 2% decrease from the status quo. The 2% represented 1,020 syringes that remained otherwise unused, expired, and

discarded. The EOQ model can be expanded to other health care items such as surgical masks, gloves, gowns, pharmaceutical products, and spectacle frames.

However, Chakrabortty, Pal, and Nayak (2013) argued that the EOQ model is not perfect because of the changing dynamic environment of inventory management. A few contributing factors to the complexity of inventory management are change in unit prices, capacity, and seasonal demand. Managers must be aware of these factors in making decisions on how much to order and keep on-hand.

B. RE-ORDER POINT WITH SAFETY STOCK

Ruiz-Torres and Mahmoodi (2010) described the re-order point (ROP) as the level of inventory at a predetermined point to place an order and safety stock as additional items to carry on-hand. Ruiz-Torres and Mahmoodi stated that "the re-order point is a function of the average demand during the expected lead time plus the required safety stock" (p. 2842).

The ROP can viewed as the point where consumption of an item drives the remaining inventory low enough to trigger a new order. The safety stock is kept to provide a buffer against supply lead time disruptions and to avoid a stockout. By using the ROP and safety stock together, management can create policies to determine how much to keep on-hand to satisfy demand. A service level is the percentage of the time that an organization will have the item in stock. Kritchanchai and Meesamut (2015) stated that hospitals hold excessive pharmaceutical products to meet high service levels, which "involve extra costs, such as those for replacing expired and deteriorated items" (p. 11). Kritchanchai and Meesamut (2015) developed a pharmaceutical inventory policy using data from "the Hospital Information System for the period 2009–2012" (p. 11) to reduce cost and increase utilization effectiveness. The authors used the ABC/VED (vital, essential, and desirable) analysis, then tailored the repoint and safety stock policy based on the category. The results from the analysis kept the pharmaceutical products with high consumption and vital need in stock, while using a mix repoint and safety policy for all other categories.

Ruiz-Torres and Mahmoodi (2010) argued that having high service levels can cause overestimation of safety stock and higher inventory carrying cost. According to the authors, "One of the main reasons for the overestimation is that the assumption of normality for the demand during the lead time may be incorrect, and therefore the calculated safety stock resulting in a service level significantly different from what was desired" (p. 2842). Management can change the service level to suit operational and demand needs. Service levels can also impact the number of items maintained by an organization, provide insight to internal process, and affect customer service.

C. PERIODIC REVIEW SYSTEM

Eynan and Kropp (2007) stated that in a "periodic review system an order is placed at fixed intervals, while the quantity ordered varies to accommodate the changing rate of demand" (p. 1135). Eynan and Kropp modeled a "single product periodic review which included variable stockout costs" (p. 1136). Their proposed heuristic approach results in minimizing total costs compared to the sequential approach.

Setyaningsih and Basri (2013) noted that inventory management in hospitals is just as crucial as in any supply chain setting. Numerous items in hospitals are perishable and require an "effective and efficient" system to reduce costs and meet patient needs (Setyaningsih & Basri, 2013, p. 253). In this study, the authors evaluated the effects of an inventory management model on formula and enteral food supply in a hospital. Data collected from January through September 2012 consisted of 11 high value products. The data was furthered filtered by the ABC analysis which narrowed the data to five products. The authors' analysis concluded with a recommendation for a periodic review policy implementation with costs savings across "Anlene by 92%, Pediasure 80%, Hepatosol 47%, Neosure 89%, and Peptamen 80%" (p. 257).

A periodic review system is easy and cheap to implement for limited inventory because a person is manually counting the items. However, a periodic review system is subject to counting inaccuracies and may require a substantial time commitment.

D. CONTINUOUS REVIEW SYSTEM

The continuous review system, also known as the perpetual inventory system, requires real-time tracking of inventory at the point of sale to provide accurate stock levels at any point in time. Typically, a replenishment order is triggered when the inventory level drops to or below a predetermined ROP (Axsäter & Viswanathan, 2012). The authors modeled an installation stock policy with time delay for the supplier using the continuous review inventory system. The results revealed that the potential savings by the time delay policy is low due to untimely information. When the continuous review method is used, an investment in technology must be considered because the level of inventory detail required is tedious when conducted manually. Without timely information that can only be captured by information technology, the continuous review system is ineffective.

However, Bouldin, Holmes, and Garner (2011) argued that a continuous review policy can be used without the need for technology for a small number of items. Hafnika, Farmaciawaty, Adhiutama, and Basri (2016) evaluated a probabilistic inventory model combined with a continuous review policy to analyze excessive inventory levels in the pharmacy department within a hospital. The authors stated that with a probabilistic model, "demand is variable and the lead time is constant" (Hafnika et al., 2016, p. 111). Pharmacy inventory data was collected from January 2015 through May 2016. The authors analyzed 1,164 pharmaceutical line items utilizing several supply inventory management models and techniques such as "continuous review policy, EOQ, ROP, AIL [average inventory level], and ABC classification" (p. 112). It was discovered that by combing the probabilistic inventory model and continuous review policy, the hospital had a "potential to save 56.93% from overstock cost in the pharmacy" (p. 118). The main drawback to the continuous review system is the overhead cost of implementation. Once implementation is complete, it can save valuable personnel time that may be reallocated to other inventory management activities.

E. JOINT ORDERING STRATEGY

Mokhtari (2018) stated, “Joint ordering policy, when managing multiple products, is another extension of basic EOQ” (p. 35). The premise of the joint ordering strategy is to combine items that are ordered separately into one order, usually from the same vendor, to save on transportation, holding cost, and order cost. Mokhtari (2018) stated that joint ordering is ideal for items are that substitutable and complementary. The joint-ordering strategy has many applications across many industries including pharmaceuticals supplies. One item that is generally used in the pharmaceutical field is infusion solutions (Guerrero, Yeung, & Guéret, 2013). Infusion solutions typically have a long shelf life and are non-critical. The authors evaluated the current infusion solution ordering policy by a central warehouse for three pharmacy depots. The goals of the study were to reduce transshipments while maintaining current service level. Although precise historical data was not available, the authors used data from each of the care units over a period of 20 months, approximately between 2010 through 2013 (Guerrero et al., 2013). In this particular analysis, a Markov Chain (linear model) was applied to determine the ROP, demand ratio, and joint optimization for infusion solutions. When the joint-order optimization was applied, it reduced one hospital pharmacy stock-on-hand by 44.9% (Guerrero et al., 2013). “As expected, more expensive products will be ordered more frequently in lower quantities while the cheaper ones will be kept on-hand in larger quantities to avoid ordering more products per week than dictated by the constraints” (Guerrero et al., 2013, p. 106).

Mokhtari (2018) argued that this analysis may have some short comings as it restricts all products to a common inventory cycle. Even though the author modeled products that can be substituted, or complementary, joint ordering may include items frequently used or similar inventory cycled items. The key to a joint ordering strategy is to the determine the optimal lot size that leverages fixed costs while minimizing the inventory ordering and holding costs.

F. ABC ANALYSIS

Rusanescu (2014) described the ABC analysis as "a method of tiered inventory that separates the [vital] critical few from the [useful] trivial many by dividing inventory into categories based on cost per unit and quantity held in stock or turned over a period of time" (p. 18). Each category (A, B, and C) is represented by the level of importance:

> "A" items are very important, "B" items are important, and "C" items are marginally important. "A" category items generally represent approximately 15%–20% of an overall inventory by item but represent 80% of value of an inventory." "B" category items represent 30%–35% of inventory items by item type, and about 15% of the value. "C" category items represent 50% of actual items but only 5% of the inventory value. (Rusanescu, 2014, p. 18)

Given this scenario, management can use the ABC analysis to implement inventory controls and identify areas of improvement. For example, Mahatme, Dakhale, Hiware, Shinde, and Salve (2012) stated that hospital supply systems are seeking ways to manage limited budgets while ensuring adequate stock. The authors used the ABC analysis to create a Visual Essential Desirable (VED) matrix to set priority purchases for pharmaceutical medications. The authors aggregated data from 2010–2011 hospital expenditure in their analysis. This resulted in "24 of 165 drugs from 'A' category consuming about 70% of the drug budget" (p. 117). Also, the "B" and "C" categories consisted of the 141 remaining pharmaceutical medications and accounted for 30% of the budget.

The "A" category may require detailed forecasting and monitoring because of the high volume of demand and order frequency, perhaps automatic tracking. Any changes in this category will make the most impact on cost and customer service. In contrast, items listed in the "C" category may require little attention and monitored less frequently.

Keskin and Ozkan (2013) argued that

> it has been generally recognized that the traditional ABC analysis has a serious drawback that may inhibit the effectiveness of the procedure in some situations. Using one criterion only may create problems of significant financial loss "C" category items with long lead time or "A" category items prone to obsolescence may incur financial losses due to a possible interruption of production and/or huge inventory levels. (p. 1)

G. SUPPLY CHAIN MANAGEMENT TERMINOLOGY

Commercial and military industries may use different supply chain terminology. This thesis includes a short list of supply chain management terminology in Appendix B to help readers understand the meanings of terms that may be used by the commercial industry but have different or similar meanings in the DOD. The list of terms is not all-inclusive nor exhaustive. The Council of Supply Chain Management Professionals is one of the leading commercial organizations that uses research and knowledge management to educate supply chain managers worldwide (Council of Supply Chain Management Professionals [CSCMP], 2019). This organization maintains and shares a wealth of information that the commercial industry uses to form common term understanding. Likewise, the DOD issues the Supply Chain Materiel Management Policy under DOD Instruction Manual 4140.01 Volumes 1–11 (Defense Logistics Agency, n.d.). The purpose of these manuals is to standardize terminology and procedures across the DOD.

H. SUMMARY

This chapter provides academic research to control inventory and list several common terms used in supply chain management. EOQ manages when and how much to order over a specified period. ROP with safety stock provides a level of protection against stockout. Periodic review and continuous review systems are inventory management tools. The key differences are that the periodic review system requires a physical inspection of items at a set time and the continuous review system automates inventory levels in a computer system. The ABC analysis categorizes items based on importance to influence stock and ordering policies. The joint ordering strategy consolidates items into one order to reduce overall cost such as holding and transportation cost. Lastly, the common supply chain terminology acknowledges that terms used in the lexicon of the military and commercial industries can be similar or have different meanings.

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III. PROCESS, METHOD, AND DESIGN

This chapter focuses on how NOSTRA operates, sources of the data used, and specific inventory equations that were used in this research.

A. PROCESS

A joint instruction authorizes NOSTRA to standardize the requirements and process of eyewear for all three services (DoN, 2015). It begins when an eligible DOD beneficiary receives a prescription for eyewear after evaluation by an optometrist or an ophthalmologist in a military treatment facility (MTF) or civilian setting. The prescription enters into the Spectacle Request Transmission System (SRTS) and is assigned a priority code in the manner described in Table 1. The SRTS is a web-based application that serves as the primary means for MTFs to order optical devices from NOSTRA or any of its laboratories (Spectacle Request Transmission System [SRTSweb], 2019). According to the DoN (2015), "Priority codes 1 through 5 are classified as urgent." As such, these types of orders are "usually processed within 24 hours of being received" by the fabrication laboratory (p. 12). Priority codes 6 and 7 are routine and processed as soon as possible at the lab (DoN, 2015). Remote MTFs that do not have SRTS write the prescriptions on either a DOD Form 771 for eyewear prescription or the Department of the Army Form 7655 (DA Form 7655) used to document Armed Forces eye and vision readiness summary (DoN, 2015). The originating facilities mail handwritten prescriptions to NOSTRA. If an eyewear prescription is generated in a civilian treatment facility, then the patient carries a document (DD Form 771 or DA Form 7655) to the MTF for entry into SRTS for fulfillment by NOSTRA. The MTF updates the patient's vision readiness status with this document.

Table 1. Spectacle Priority System. Source: DoN (2015).

Category	Priority Code	SRTS Code	Description
Urgent (U)	1	R	Readiness: Orders for those deploying within 30 days of the order.
U	2	P	Downed Pilot: A pilot who has a significant change in vision that will, without spectacles, result in immediate grounding and degrade combat readiness and effectiveness of the unit to which assigned.
U	3	T	Trainee: Spectacles and insert orders for personnel undergoing basic, ROTC, or Academy training.
U	4	W	Wounded Warrior: Used for eligible wounded personnel suffering from traumatic brain injury.
U	5	V	Very important persons: Used for ranks O-7 and above.
Routine (R)	6	S	Standard Issue: Standard issue frames that are not for an above reason.
R	7	F	Frame of Choice: Frame of Choice orders that are not for Wounded Warriors or Active Duty VIPs.

MTFs "input and manage their optical orders through SRTS on the clinic end, while the optical laboratories receive their orders from the clinics on the lab end…. In those labs with an electronic Lab Management System, SRTS interfaces directly with the Lab Management System to speed the order fabrication process" (DoN, 2015, p. 13). NOSTRA receives spectacle requests through several demand channels including SRTS, emails, telephone calls, and other optical laboratories. Most orders will end up in SRTS through the requesting facility or put in by NOSTRA's customer service section. Once the requests are transmitted to NOSTRA, an optician retrieves and sorts the requests according to the SRTS priority codes and determines which of the two sections within the lab each order needs to go to processing (E. B. Walters, personal communication, April, 22, 2019). The two main sections of the lab are Finish Side and the Surface Side. Finish Side consists of all the common lens prescriptions also known as off-the-shelf lenses. These common lenses do not need further modification other than being cut to fit the selected frame styles. The

Surface Side handles complex prescription orders that require grinding down raw lenses to the prescribed curvature before cutting to fit respective selected frame styles. Figure 2 provides an example of the spectacle machine that is used to cut, drill, and polish lenses. Next, a tray containing the lens moves onto a production line where the lens is mounted into a frame and inspected for quality assurance.

Figure 2. NOSTRA's Spectacle Machine. Source: E. B. Walters (personal communication, April 22, 2019).

After the final stage, the finished spectacles are shipped to the address accompanying the request. Figure 3 depicts the flow process for a typical prescription. The manual states:

> Delivery of spectacles to the patient generally occurs in one of three options: (1) Spectacles are sent to the clinic after fabrication, checked into SRTS, and then the patient is notified that they are available for dispensing at the clinic. (2) Spectacles are sent to the clinic after fabrication, checked into SRTS, and then mailed to the patient. (3) Spectacles are mailed directly to the patient from the optical lab after fabrication. (DoN, 2015, p. 14)

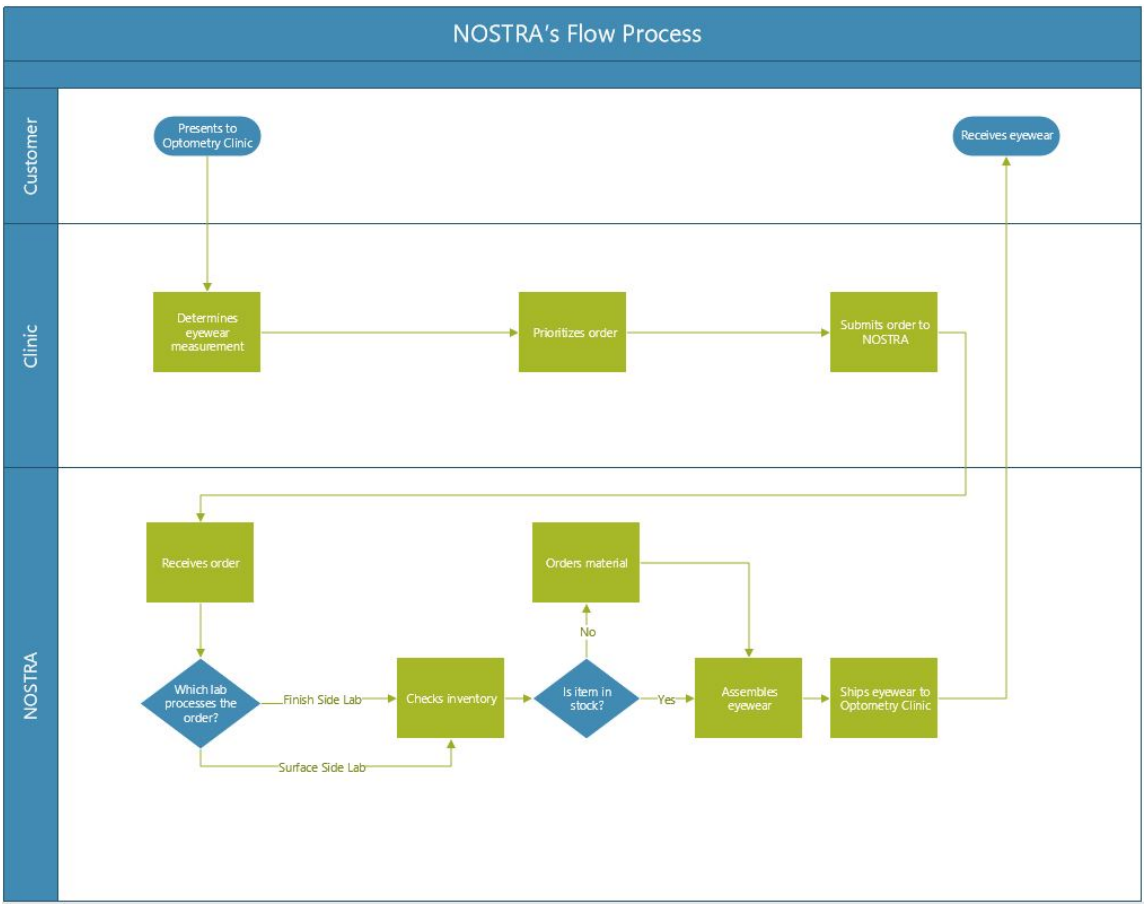

Figure 3. NOSTRA Process Flowchart. Source: E. B. Walters (personal communication, April 22, 2019).

NOSTRA uses a combination of the periodic review system and continuous review system to manage inventory (E. B. Walters, personal communication, April 22, 2019). NOSTRA carries approximately 3,000-line items and maintains a 98%–99% fill rate with a four-day lead time in replenishing its inventory (E. B. Walters, personal communication, September 8, 2019). NOSTRA receives on average 2,200 jobs per day and there are between 8,000 and 10,000 jobs in progress (E. B. Walters, personal communication, September 8, 2019). NOSTRA uses the two-bin Kanban system to store some inventory in barcode labeled bins on the floor and in the warehouse sections (overflow of material). Figure 4 is an example of the two-bin Kanban shelving system.

Figure 4. NOSTRA's Two-Bin Kanban Shelving System. Source: E. B. Walters (personal communications, April 22, 2019).

Using the periodic review system, twice a day, three material handlers inspect bins on the floor and warehouse sections carrying barcode scanners. One material handler is responsible for the lens area. Another material handler is responsible for the spectacle frames area. The third material handler is responsible for the Finish Side, which has both lens and spectacle frames in separate bins. If the top bin is empty, the material handler takes the empty bin out and places the bottom full bin in its place. The material handler will take the empty bins to the warehouse section and replenish the empty bins. If an item is not either on the floor or warehouse section, the material handler will scan the empty bin's barcode label, which generates a demand. Each bin has a set amount of inventory it can hold. Once the periodic review is completed, the material handler will dock the scanner and transmit the item request to the supply technician. The supply technician will receive the item request from the material handler through email and review it for accuracy. The supply technician will place an order in the Defense Medical Logistics Standard Support (DMLSS), information system used to order medical items. The Defense Logistics Agency (DLA) utilizes the electronic catalog to negotiate prices through contractors that can fulfill NOSTRA's demand. DLA uses two main contractors as suppliers for NOSTRA. Vendors

deliver items to NOSTRA's receiving section and staff store the items in the appropriate locations.

NOSTRA also uses the continuous review system on items categorized as fast-movers, similar to "A" category. These items will be automatically ordered in DMLSS if a ROP is pre-established. The supply technicians will set the ROP based on information provided by the material handler supervisor.

The SRTS, DMLSS, and the scanner system are all independent of each other. Furthermore, by having these three separate information systems, it makes the inventory management process difficult for both the material handlers and management to accurately track, store, and order items. Aside from the information systems challenge, NOSTRA encounters humanitarian missions and local pier-side orders, which are usually unplanned. These requisitions are filled with material in the warehouse section and replenished later in routine orders.

B. DATA SOURCE

The following section covers the different sources of data used in this analysis. The demand and procedural data originated from NOSTRA's DMLSS and SRTS. The essential equations introduced in this section are commonly used throughout the supply chain community.

1. Demand Data

NOSTRA utilizes both the DMLSS and SRTS to manage its supply and demand. As mentioned in the previous section, DMLSS and SRTS are separate systems and do not communicate directly with each other. Incoming orders are received by SRTS and cannot be linked to a decision to resupply in DMLSS. Due to this non-traceability, this thesis utilizes the DMLSS order data only. These DMLSS records contain item description, document number, item identification, purchasers (supply technicians), date and time posted, quantity ordered, and total price. The time period observes FYs 2017 and 2018. This thesis focuses on spectacle frame orders. Spectacle frame orders are made up of five

descriptive items, frame color, frame type, eye size, bridge width, and temple length as shown in Figure 5 (All About Vision, n.d.).

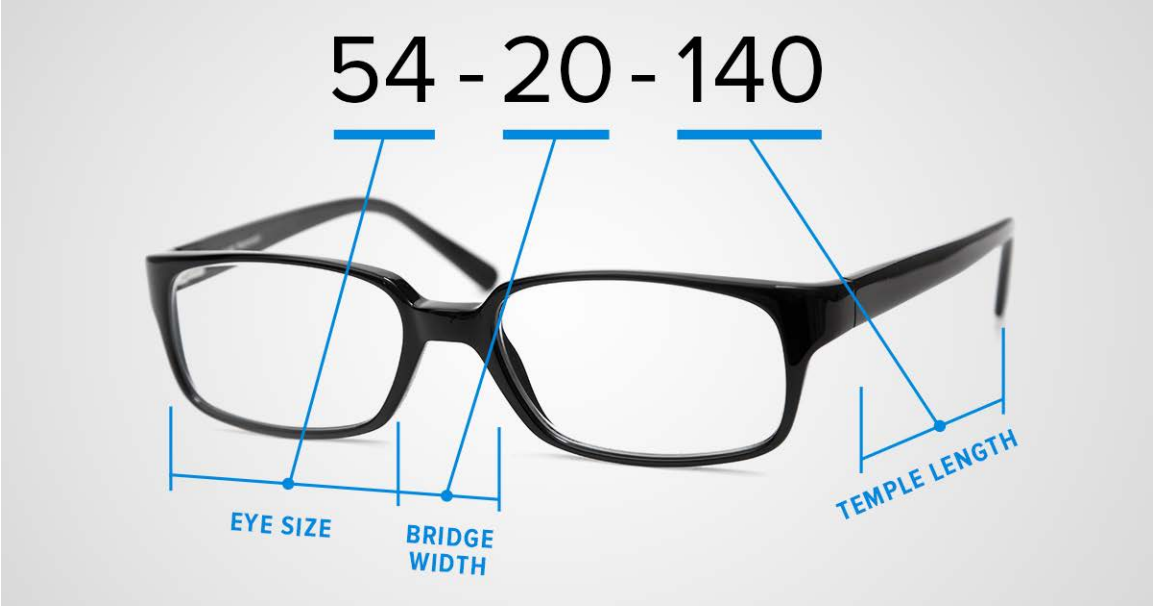

Figure 5. Eyeglass Spectacle Frame Measurements. Source: All About Vision (n.d.).

2. Procedural Data

The procedural data for this study includes prescription requisition data (demand) from the MTFs and spectacle frame orders (supply) to NOSTRA's suppliers. These data sets were provided by NOSTRA's Materiel Management Department and it includes:

- FY 2017 NOSTRA Prescription Requisition Data and Spectacle Frame Orders
- FY 2018 NOSTRA Prescription Requisition Data and Spectacle Frame Orders

This thesis takes both FYs spectacle frame order data, which include approximately 300 styles. The spectacle frame styles similar across both FYs comprise only 141 items for this study.

3. Essential Equations

The essential equations are foundational tools that can be employed to help managers identify key inventory parameters such as supply stock levels and ROPs. Such parameters are necessary for improving the supply chain process but cannot be easily discerned from the raw inventory data.

a. Economic Order Quantity

The EOQ is the ideal order quantity a company should purchase for its inventory. The primary purpose of the EOQ is to reduce holding costs and order costs related to inventory. The EOQ model determines the optimal lot size under these conditions: Holding costs, H, is calculated as a product of the interest rate, i, and the unit cost, C. The interest rate is synonymous with the opportunity cost of holding inventory.

The EOQ model equation is

D = annual demand

S = order cost per lot

H = holding cost

$$EOQ = \sqrt{\frac{2DS}{H}}$$

b. Re-order Point with Safety Stock

The ROP method is a combination of two factors. The first factor is the demand during lead time and the second factor is the amount of safety stock needed. Safety stock, or SS, is the additional stock needed to reduce the chance of running out of items, or stockout. The basic formula for ROP is to multiply the average lead time by the average item daily usage. The ROP with SS equation is as follows.

$$ROP = d * L + (Z * \sqrt{L} * \sigma)$$

d = demand per day

L = lead time in days

Z = number of standard deviations from the mean

σ = standard deviation of demand

c. Periodic Review

The periodic review system is when an inventory is taken at a scheduled time, for example, weekly or monthly. If an item is below the predetermined inventory level, an order is placed to bring the inventory level back to desired amount. According to Apras, "The periodic method is generally used for slower moving items" (Apras, 2011, p. 5). Compared to the continuous review system, the periodic review system is easier and less costly to implement (Chopra & Meindl, 2016).

The base stock, S, equation in the periodic review system is as follows.

$$S = D * (T + L) + Z * \sqrt{(T + L\sigma_D)}$$

D = average demand period

T = review interval

L = average lead time for replenishment

Z = desired service level

σ_D= standard deviation of demand per period

d. Continuous Review

The continuous review system is that in which the inventory is reviewed constantly, and consumed inventory is replenished in real-time. Chopra and Meindl (2016) stated that this system "requires technology that monitors the level of available inventory" (p. 354). As the inventory amount reaches a predetermined level or ROP, the continuous review system automatically places an order. A well-designed continuous review system allows

managers to actively monitor inventory and replenish orders appropriately. Furthermore, there must be a balance between the information technology and business policies. Thus, the continuous review system "is typically utilized for fast moving items or when very inexpensive processes exist for checking the state of the inventory" (Apras, 2011, p. 5).

The demand during lead time, D_L, equation in the continuous review system is as follows.

$$D_L = D * L$$

e. Joint Ordering

Joint ordering consists of pooling like items to reduce overall costs, including costs such as transportation, fixed cost, and order costs. Aggregating replenishment "across products, retailers, or suppliers in a single order allows for a reduction in lot size for individual products because fixed ordering and transportation costs are now spread across multiple products, retailers, or suppliers" (Chopra & Meindl, 2016, p. 290). One method of utilizing this strategy is by combining several orders from distributors onto a single truck, thus reducing transportation costs (Chopra & Meindl, 2016). The joint ordering equations consist of three main components which are the total order cost, S^*, optimal order quantity, n^*, and the order quantity for each item, Q_i, within the joint order.

The joint ordering equations are as follows.

$$S^* = S + s_1 + s_2 + \cdots + s_n$$

$$n^* = \sqrt{\frac{D_1 h C_1 + D_2 h C_2 + \cdots D_n h C_n}{2S^*}}$$

$$Q_i = \frac{D_i}{n^*}$$

Q_i = joint order quantity for item i

S^*= total order cost

S = common order cost

s = item-specific order cost

D_i= annual demand for item i

n^*= optimal number of orders per year

h = holding cost

C = unit cost

C. SUMMARY

The above equations show multiple systems that can benefit an organization in inventory management. A review of the periodic and continuous review systems examined the differences between the two systems and the cost implication of both. For the EOQ model, the reduction of holding and order costs are determined for planning an optimal order size. For the ROP with SS levels, the importance of having an appropriate level of stock is discussed and having a certain stock level to prevent a stockout is crucial for proper inventory management. In the joint ordering strategy, items of similar demand are grouped together to reduce transportation cost and placing an order of optimal size.

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IV. ANALYSIS AND RESULTS

A. ANALYSIS

This chapter collates the spectacle frames data from FYs 2017 and 2018 and evaluates the aggregated data utilizing several inventory management equations and models such as the EOQ, ROP, SS, and joint ordering strategy. Furthermore, the data is grouped into three categories based on percentage contribution to the total budget. This categorization identifies spectacle frames that form the bulk of NOSTRA's business and must be assigned a higher monitoring priority. Following the categorization, the joint ordering strategy was used to highlight the potential cost savings across a category of spectacle frames. Lastly, a sensitivity analysis assesses the various effects of cost estimations on the quantity of spectacle frames.

1. ABC Analysis

The ABC analysis is performed on 141 spectacle frames that are carried by NOSTRA across FYs 2017 and 2018. The "A" category spectacle frames represent 20% of very important [vital few] and account for 80% of the budget. The "B" category spectacle frames represent between 20%–24% of the inventory [useful many] and 15% of the budget. The "C" category spectacle frames represent between 55%–60 % of the inventory and account for 5% of the budget. In FY 2017, there were 28 "A" category, 28 "B" category, and 85 "C" category spectacle frames, whereas in FY 2018, there were 29 "A" category, 34 "B" category, and 78 "C" category spectacle frames. Table 2 and Table 3 provide a short list of the spectacle frames stock-keeping units (SKUs) across the observed fiscal years resulting from the ABC analysis. The tables display each spectacle frame percentage of its contribution towards the total amount spent in descending order for the fiscal year. In Tables 2, the cumulative percent of 80.5 marks the end of "A" category while 95% marks the end of "B" category spectacle frames for FY 2017. In Table 3, the cumulative percent of 80.4 marks the end of "A" category while 95% marks the end of "B" category spectacle frames for FY 2018.

Table 2. List of FY 2017 Spectacle Frame SKUs Ranked by Order Data

ABC Category	Rank	Spectacle Frames (Style, Color, Size)	Percent of Total Amount	Cumulative Percent
A	1	R-5A BLACK 52-20-145	13.22%	13.2%
A	2	KEESLER BLACK/BRONZE 55-15-140	6.03%	19.3%
A	3	R-5A BLACK 50-20-145	5.77%	25.0%
A	4	R-5A BLACK 54-20-145	5.61%	30.6%
A	5	KEESLER BLACK/BRONZE 58-15-145	4.83%	35.5%
A	6	KEESLER BLACK/BRONZE 52-15-140	3.95%	39.4%
A	7	OSAN BLACK 55-15-145	3.93%	43.3%
A	8	OSAN BLACK 53-15-140	3.83%	47.2%
A	9	MUGA BLACK 54-19-145	3.71%	50.9%
…				
A	26	R-5AM, BLACK, 54-22-150	1.18%	78.3%
A	27	AFF-JS EBONY AIRCREW 55-22-130	1.16%	79.5%
A	28	ELLSWORTH GUN METAL/OLIVE 53-18-140	1.05%	80.5%
B	29	OSAN BLACK 53-15-145	1.03%	81.5%
B	30	OSAN BLACK 55-15-140	0.96%	82.5%
B	31	R-5A BLACK 46-16-135	0.95%	83.5%
B	32	WILLOW GUN METAL 50-16-140	0.88%	84.3%
B	33	R-5A BLACK 52-20-140	0.72%	85.1%
B	34	R-5A BLACK 54-22-145	0.72%	85.8%
B	35	R-5A BLACK 50-22-145	0.71%	86.5%
B	36	R-5A BLACK 50-18-145	0.68%	87.2%
…				
B	53	ELITE PEWTER 52-21-145 SKL	0.25%	94.3%
B	54	FGN,GLD,52-20-140,SKL FG28W99G	0.24%	94.5%
B	55	KEESLER BLACK/BRONZE 58-15-140	0.24%	94.8%
B	56	R-5AM, BLACK, 50-24-145	0.23%	95.0%
C	57	R-5AM, BLACK, 54-20-145	0.23%	95.2%
C	58	R-5A BLACK 50-18-140	0.22%	95.5%
C	59	R-5A BLACK 48-18-135	0.20%	95.7%
C	60	R-5A BLACK 48-20-145	0.19%	95.8%
C	61	R-5AM, BLACK, 54-22-145	0.18%	96.0%
C	62	R-5A BLACK 52-18-140	0.18%	96.2%
C	63	R-5A BLACK 52-18-150	0.18%	96.4%
…				
C	141	R-5A TEMPLES BLACK 150MM	0.00%	100%

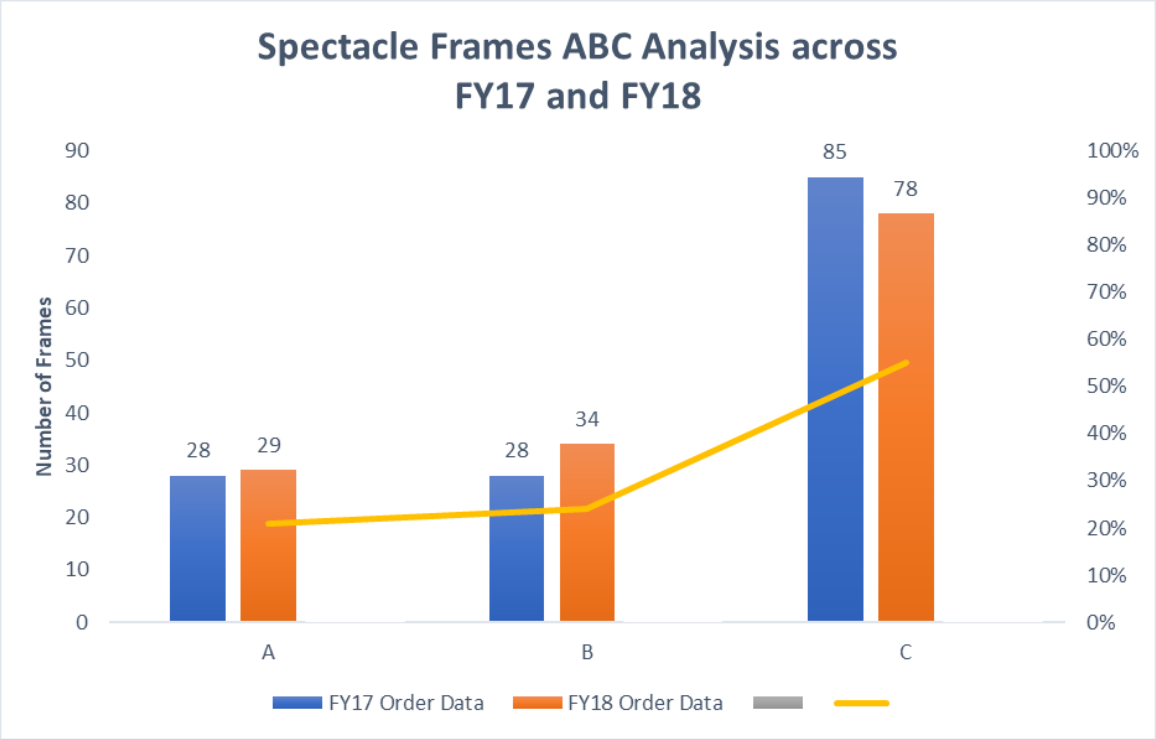
Data retrieved from DMLSS, January 2019

Table 3. List of FY 2018 Spectacle Frame SKUs Ranked by Order Data

ABC Category	Rank	Spectacle Frames (Style, Color, Size)	Percent of Total Amount	Cumulative Percent
A	1	KEESLER BLACK/BRONZE 55-15-140	12.65%	12.7%
A	2	KEESLER BLACK/BRONZE 58-15-145	11.08%	23.7%
A	3	OSAN BLACK 55-15-145	6.06%	29.8%
A	4	MUGA BLACK 54-19-145	5.25%	35.1%
A	5	KEESLER BLACK/BRONZE 52-15-140	4.81%	39.9%
A	6	MUGA BLACK 52-19-140	3.81%	43.7%
A	7	OSAN BLACK 53-15-140	3.71%	47.4%
A	8	COVERT DARK BROWN/LIGHT BROWN 53-19-145	2.99%	50.4%
A	9	KEESLER BLACK/BRONZE 55-15-145	2.58%	53.0%
…				
A	27	R-5A BLACK 50-18-145	0.86%	78.9%
A	28	MUGA BLACK 50-17-140	0.85%	79.8%
A	29	R-5AM, BLACK, 50-20-145	0.68%	80.4%
B	30	LIBERTY RUTHENIUM 54-20-145	0.65%	81.1%
B	31	AVIATOR, CHROME, 52-20,140 BAYONET RO	0.64%	81.7%
B	32	ELITE PEWTER 50-19-145 SKL	0.60%	82.3%
B	33	AFF BLK 55-18-150 SKL	0.60%	82.9%
B	34	THUNDER BLACK 54-17-145	0.58%	83.5%
B	35	R-5A BLACK 50-20-145	0.57%	84.1%
B	36	WILLOW GUN METAL 54-18-145	0.56%	84.6%
B	37	R-5AM, BLACK, 54-20-150	0.56%	85.2%
….				
B	60	R-5AM, BLACK, 54-22-145	0.25%	94.3%
B	61	LIBERTY GOLD 52-20-140	0.23%	94.5%
B	62	WILLOW GUN METAL 52-18-145	0.23%	94.8%
B	63	R-5A BLACK 48-18-135	0.22%	95.0%
C	64	R-5A BLACK 50-24-150	0.22%	95.2%
C	65	OSAN BLACK 55-15-140	0.21%	95.4%
C	66	R-5AM, BLACK, 54-22-150	0.19%	95.6%
C	67	ELLSWORTH GUN METAL/OLIVE 51-18-145	0.18%	95.8%
C	68	R-5A BLACK 52-20-140	0.18%	96.0%
C	69	R-5AM, BLACK, 50-24-150	0.16%	96.1%
C	70	WILLOW GUN METAL 50-16-140	0.15%	96.3%
…				
C	141	R-5A RP BLACK 48-22-135	0.00%	100.0%

Data retrieved from DMLSS, January 2019

Figure 5 compares the 141 spectacle frames across both fiscal years using the ABC analysis. For both fiscal years, "A" category spectacle frames comprise approximately 28 SKUs. It also shows in FY 2018 that "B" category spectacle frames increase by six SKUs. However, in FY 2018, "C" category spectacle frames decrease by seven SKUs. If NOSTRA had leftover inventory of the "C" category spectacle frame SKUs in FY 2017, this explains the decrease in FY 2018.



Data retrieved from DMLSS, October 2019

Figure 6. Spectacle Frame Order by Category

2. Demand Analysis

The models and equations mentioned in the previous chapters require basic information as inputs. The key inputs are demand, orders, unit cost, order cost, service level, and holding cost (referred to as the interest rate). The demand, orders, and unit cost are provided by NOSTRA. The order cost, service level, and holding cost are formulated based on estimations throughout this analysis. There are no administrative, shipping,

distribution, facilities, and other related costs associated with this analysis because it is beyond the scope of this thesis. Furthermore, NOSTRA does not recognize holding cost as a component of its operation cost. To estimate the ordering cost, previous work by Galka (2016) on pharmaceutical inventory management was referenced.

B. ORDERING COST BREAKDOWN

(1) Personnel

Each order NOSTRA places involves personnel and a set of activities. There are four key personnel identified in the ordering process (E. B. Walters, personal communication, September 8, 2019). Two material handlers are federal wage grade 3 step 5, and two supply technicians who are general schedule grade 7 step 5. Employees are paid according to their position and responsibilities. Table 4 shows the supply staff's salary breakdown. Although the data covers FY 2017 and FY 2018, research showed an insignificant difference in previous pay charts, so calendar year 2019 is used for the cost breakdown.

Table 4. NOSTRA Supply Staff Salary Breakdown. Adapted from FederalPay (n.d.-a).

NOSTRA Supply Personnel Salary Breakdown 2019			
Job Type	Salary per Year	Daily Wage	Hourly Wage
Federal Wage 3 Step 5 Material Handlers	$41,706.16	$166.16	$20.77
*General Schedule 7 Step 5 Supply Tech.	$47,759.56	$183.04	$22.88
** salary breakdown; 86.3% of yearly salary is Basic Pay, other 13.7% is locality adjustment*			

(2) Ordering Tasks

The tasks associated with each order can be broken into three activity categories, which are summarized in Table 5.

Walking the floor. Twice a day, two material handlers walk through both the Finish Side and warehouse sections of the facility with barcode scanners and visually inspect the spectacle frame two-bin system. If the first bin is completely empty, the material handlers will replace it with the second full bin of material. On the other hand, if both bins are empty, the material handler will scan the barcode and trigger a replenishment request. This task takes 40 minutes to complete by each of the material handlers.

Building the Order Step 1. Twice a day, two material handlers take the scanners and download the replenishment data onto a spreadsheet. The material handlers send the spreadsheet to the supply technicians through email. This task takes five minutes to complete by each of the material handlers.

Building the Order Step 2. Twice a day, two supply technicians review the spreadsheet for accuracy of replenishment data before placing the order. This task takes five minutes to complete by each of the supply technicians.

Receiving Order. Once a day, two material handlers validate the bill of lading, receive the material in DMLSS, and store the items in the appropriate locations. This task takes 45 minutes to complete by each of the material handlers.

Table 5. Order Cost Breakdown for Spectacle Frames. Adapted from FederalPay (n.d.-b).

Order Cost Breakdown for Frames							
Task	# of Times Performed	# of GS Supply Technicians	# of WG Material Handlers	Task Duration (Minutes)	Total Task Duration (Minutes)	Total Task Duration (Hours)	Cost / Order
Walking the Floor (inventory & scan)	2	n/a	2	40	160	2.7	$ 55.39
Building Order Step 1 (download scanner data)	2	n/a	2	5	20	0.33	$ 6.92
Building Order Step 2 (verify & execute)	2	2	n/a	5	20	0.33	$ 7.63
Receiving Order	1	n/a	2	45	90	1.5	$ 31.16
Total Order Cost							$ 101.09

C. INVENTORY MODEL AND EQUATIONS

1. How Much to Order

The EOQ inventory management method allows for the ideal order quantity to be purchased given the annual demand, order cost, and holding cost (interest rate multiplied by the unit cost). The equation used to determine the EOQ is

$$EOQ = \sqrt{\frac{2DS}{H}}$$

D = annual demand of item

S = order cost

H = holding cost, as percentage of the cost.

This thesis assumes a 15% interest rate because the DOD's rate of inventory investment cost fluctuates between organizations and, in some case, does not consider inventory retention cost (Heivilin, 1993). Heivilin (1993) stated that civilian companies "do not calculate inventory order costs, and they use industry standards for their overall holding cost rate (25 to 30 percent) because the cost to derive these data outweigh the benefits of having the data" (p. 25). The author added that "the formula is not consistent with actual business operations" (Heivilin, 1993, p. 25). The Office of Management and Budget (OMB) provides a nominal interest rate used by government entities for cost analysis. The OMB Circular A-94 (2018) published a nominal 20-year interest rate of 3.5% rate, which is significantly lower than the industry standards. Therefore, for the purpose of this thesis, a 15% interest rate combines the federal interest rate and commercial holding rate to derive a conservative median.

A small sample size of two items is demonstrated in Table 6.

Table 6. EOQ Calculations for FY 2017

Description	Annual Demand (D)	Interest Rate (i)	Unit Cost (C)	Holding Cost (i * C)	Order Cost	EOQ
ELLSWORTH GUN METAL/OLIVE 53-18-140	1,850	0.15	$ 25.75	$ 3.86	$101.09	311
FGN,GLD,52-20-140,STB FG28699G	4,225	0.15	$ 17.75	$ 2.66	$101.09	566

Description and annual demand retrieved from DMLSS, September 2019

For the first item, the ELLSWORTH GUN METAL/OLIVE 53–18-140 spectacle frame has an annual demand of 1,850 units, an interest rate, i, of 15%, item cost, C, of $25.75, and an order cost of $101.09 (see Table 5). The i is multiplied by the C to calculate the holding cost of $3.86. The holding cost is in the denominator of the equation and emphasizes its significant impact on the EOQ. The optimal order quantity for the ELLSWORTH GUN METAL/OLIVE 53–18-140 spectacle frame is 311 units.

$$EOQ = \sqrt{\frac{2\,(1{,}850)(\$101.09)}{\$3.86}} = 311$$

For the second item, the FGN, GLD,52-20-140, STB FG28699G spectacle frame, only the S stays the same. The annual demand, D, is 4,225, and the holding cost, H, is $2.66. Therefore, the EOQ for the FGN, GLD,52-20-140, STB FG28699G spectacle frame is 566 units.

$$EOQ = \sqrt{\frac{2\,(4{,}225)(\$101.09)}{\$2.66}} = 566$$

2. When to Order

The ROP with SS provides an amount of supply to keep on-hand before placing an order. The ROP is the demand multiplied by the average lead time plus the amount of safety stock that is desired. At NOSTRA, there is very little variability in the lead time. For calculation purposes, the ROP and SS are computed separately and then added together. The equation used to determine the ROP with SS is

$$ROP = d * L + (Z * \sqrt{L} * \sigma).$$

Utilizing the same two samples from the EOQ model, the ROP and SS equations are applied to the FY 2017 calculations.

Table 7. ROP and SS Calculations for FY 2017

Description	Standard Deviation of Annual Demand (σ_D)	Daily Demand (during lead time)	Standard Deviation of Daily Demand (σ_d)	ROP	SS
ELLSWORTH GUN METAL/OLIVE 53-18-140	220	28	27	82	54
FGN, GLD, 52-20-140, STB FG28699G	138	65	17	99	34

Description retrieved from DMLSS, May 2019

The lead time at NOSTRA averages four days, mostly due to its dependable suppliers. The standard number of working days in a year is 261 days.

To calculate the daily demand during lead time, the annual demand of ELLSWORTH GUN METAL/OLIVE 53–18-140 spectacle frame (see Table 6) is divided by the number of working days which equals the daily demand. The daily demand is then multiplied by the lead time, resulting in a demand of 28 units per working day.

$$Daily\ Demand\ (during\ lead\ time) = \frac{Annual\ Demand}{Working\ Days\ per\ Year} * Lead\ Time$$

$$Daily\ Demand\ (during\ lead\ time) = \frac{1{,}850}{261} * 4 = 28$$

To calculate the safety stock, the standard deviation of daily demand, σ_d and Z-score are required. The standard deviation of daily demand is calculated by taking the standard deviation of the annual demand, σ_D and multiplying it by the square root of lead time divided by the number of working days. The standard deviation of annual demand is calculated using Microsoft Excel's standard deviation formula, which is the amount of variation between the observed months.

$$\sigma_d = \sigma_D * \sqrt{\frac{Lead\ Time}{Number\ of\ Working\ Days}}$$

$$\sigma_d = 220 * \sqrt{\frac{4}{261}} = 27$$

Another component of the safety stock, SS, is the Z-score. A service level of 95% equates to a 1.96 Z-score, which is then multiplied by the standard deviation of daily demand. This results in a SS amount of 54 units.

$$SS = Z * \sigma_d = 1.96 * 27 = 54$$

The ROP is calculated by adding the daily demand during lead time and to the safety stock to, resulting in 82 units.

$$ROP = Daily\ Demand\ (during\ lead\ time) + SS$$

$$ROP = 28 + 54 = 82$$

Appendix A shows the entire economic order quantities, ROPs, and safety stocks for FYs 2017 and 2018 spectacle frames.

a. Joint Ordering Strategy

Joint ordering strategy combines individual item orders together to reduce variable and fixed costs associated with placing an order such as lot size, transportation, administration, and storage. The joint ordering strategy is to identify the "most frequently ordered products, assuming each product is ordered independently" (Chopra & Meindl, 2016, p. 296). Table 8 will be utilized in the application of the joint ordering strategy.

Calculations in the following tables were performed utilizing Microsoft Excel and will have some minor variations from manual calculations.

Table 8. FY 2017 "A" Category Spectacle Frames

Description	Annual Demand (D)	h	C	Holding Cost (h * C)	D * h	Frame Quantity (Qi)	Annual Holding Cost	Total Cost (EOQ)	Total Cost (Current)
R-5A BLACK 52-20-145	72,897	0.15	$ 8.23	$ 1.23	$ 89,991.35	1400	$ 864.35	$ 4,265.53	$ 10,462.58
KBESLER BLACK/BRONZE 55-15-140	8,850	0.15	$ 30.91	$ 4.64	$ 41,033.03	170	$ 394.12	$ 2,880.31	$ 5,005.05
R-5A BLACK 50-20-145	31,780	0.15	$ 8.23	$ 1.23	$ 39,232.41	610	$ 376.82	$ 2,816.41	$ 7,453.79
R-5A BLACK 54-20-145	30,921	0.15	$ 8.23	$ 1.23	$ 38,171.97	594	$ 366.64	$ 2,778.08	$ 6,001.95
KBESLER BLACK/BRONZE 58-15-145	7,095	0.15	$ 30.91	$ 4.64	$ 32,895.97	136	$ 315.96	$ 2,578.96	$ 5,101.27
KBESLER BLACK/BRONZE 52-15-140	5,803	0.15	$ 30.91	$ 4.64	$ 26,905.61	111	$ 258.42	$ 2,332.35	$ 4,942.67
OSAN BLACK 55-15-145	6,915	0.15	$ 25.75	$ 3.86	$ 26,709.19	133	$ 256.54	$ 2,323.82	$ 4,377.53
OSAN BLACK 53-15-140	6,740	0.15	$ 25.75	$ 3.86	$ 26,033.25	129	$ 250.04	$ 2,294.23	$ 4,838.38
MUGA BLACK 54-19-145	8,174	0.15	$ 20.59	$ 3.09	$ 25,245.40	157	$ 242.48	$ 2,259.25	$ 5,596.02
MUGA BLACK 52-19-140	6,948	0.15	$ 20.59	$ 3.09	$ 21,458.90	133	$ 206.11	$ 2,082.94	$ 4,883.47
THUNDER BLACK 54-17-145	8,601	0.15	$ 14.24	$ 2.14	$ 18,371.74	165	$ 176.46	$ 1,927.29	$ 5,433.42
LIBERTY RUTHENIUM 52-20-140	4,487	0.15	$ 20.59	$ 3.09	$ 13,858.10	86	$ 133.10	$ 1,673.88	$ 3,546.00
R-5AM, BLACK, 50-20-145	9,700	0.15	$ 8.23	$ 1.23	$ 11,974.65	186	$ 115.01	$ 1,555.98	$ 4,388.41
ELITE BLACK 52-21-145 SKL	5,110	0.15	$ 14.91	$ 2.24	$ 11,428.52	98	$ 109.77	$ 1,520.08	$ 4,381.90
FGN,GLD,52-20-140,STB FG28699G	4,225	0.15	$ 17.75	$ 2.66	$ 11,249.06	81	$ 108.05	$ 1,508.10	$ 3,989.50
R-5A BLACK 50-20-140	8,440	0.15	$ 8.23	$ 1.23	$ 10,419.18	162	$ 100.07	$ 1,451.41	$ 2,194.93
WILLOW GUN METAL 54-18-145	3,325	0.15	$ 20.59	$ 3.09	$ 10,269.26	64	$ 98.63	$ 1,440.93	$ 3,013.95
COVERT DARK BROWN/LIGHT BROWN 53-19-145	4,060	0.15	$ 16.67	$ 2.50	$ 10,152.03	78	$ 97.51	$ 1,432.68	$ 2,545.80
WILLOW GUN METAL 52-18-140	2,950	0.15	$ 20.59	$ 3.09	$ 9,111.08	57	$ 87.51	$ 1,357.24	$ 2,523.18
COVERT DARK BROWN/ LIGHT BROWN 51-19-140	3,520	0.15	$ 16.67	$ 2.50	$ 8,801.76	68	$ 84.54	$ 1,334.00	$ 1,809.77
ELLSWORTH GUN METAL/OLIVE 51-18-140	2,225	0.15	$ 25.75	$ 3.86	$ 8,594.06	43	$ 82.54	$ 1,318.17	$ 2,327.55
KINGSVILLE BLACK 55-19-145	3,495	0.15	$ 15.84	$ 2.38	$ 8,304.12	67	$ 79.76	$ 1,295.74	$ 2,505.63
KINGSVILLE BLACK 53-19-140	3,460	0.15	$ 15.84	$ 2.38	$ 8,220.96	66	$ 78.96	$ 1,289.24	$ 2,410.86
THUNDER BLACK 52-17-145	3,846	0.15	$ 14.24	$ 2.14	$ 8,215.06	74	$ 78.90	$ 1,288.78	$ 3,363.29
KBESLER BLACK/BRONZE 55-15-145	1,765	0.15	$ 30.91	$ 4.64	$ 8,183.42	34	$ 78.60	$ 1,286.29	$ 1,789.16
R-5AM, BLACK, 54-22-150	6,498	0.15	$ 8.23	$ 1.23	$ 8,021.78	125	$ 77.05	$ 1,273.53	$ 3,947.03
AFF-JS EBONY AIRCREW 55-22-130	1,455	0.15	$ 36.32	$ 5.45	$ 7,926.84	28	$ 76.14	$ 1,265.97	$ 1,543.39
ELLSWORTH GUN METAL/OLIVE 53-18-140	1,850	0.15	$ 25.75	$ 3.86	$ 7,145.63	36	$ 68.63	$ 1,201.97	$ 1,928.72
Total Count 28					$ 547,924.31		$ 5,262.72	$ 52,033.17	$ 112,305.18

Description and annual demand retrieved from DMLSS, August 2019

In determining the S^* in joint ordering, there are several additional steps involved compared to the EOQ methodology and NOSTRA's current ordering process.

Step 1. The common order cost that is shared among all spectacle frames within a joint order is the Building of Orders Step 2 (see Table 5).

Common Order Cost, $S = \$7.63$ [Building Order Step #2 (verify & execute)]

Step 2. The next step is to determine the related cost across all "A" category items. In reference to Table 5, NOSTRA order cost breakdown is comprised of walking the floor ($55.39), building order step 1 ($6.92), and finally receiving the order ($31.16); all these costs are distributed into the number of items in the "A" category. The resulting values are $1.98, $0.25, and $1.11, respectively as illustrated in the following calculations.

Item-related cost for the 28 "A" category items are:

$$\frac{Item - related\ cost\ of\ "A"\ category\ items}{\#\ of\ items\ categorized\ as\ "A"}$$

a) Walking the Floor (inventory & scanning) = $\frac{\$55.39}{28}$ = \$1.98

b) Building Order Step #1 (downloading scanner data) = $\frac{\$6.92}{28}$ = \$0.25

c) Receiving of Order = $\frac{\$31.16}{28}$ = \$1.11.

The sum of the item-related costs equates to item-specific order cost, s_i, is as follows:

a) Item-specific order cost, $s_i = \$1.98 + \$.25 + \$1.11 = \$3.34$.

Step 3. In determining the total item-specific cost, the item-specific order cost (\$3.34) is multiplied by 28 "A" category items. The total is \$93.47.

a) Total item-specific order cost, $s_1 + s_2 + \cdots s_{28}$ = $\$3.34 * 28 = \$93.47$

Step 4. The following calculation determines that the joint order cost, S^*, is the sum of the building order step #2 (\$7.63) and total item-specific cost (\$93.47). The total equates to \$101.10.

Joint Order Cost, $S^* = S + (s_1 + s_2 + \cdots + s_{28})$ = $\$7.63 + \$93.47 = \$101.10$

Step 5. In the joint ordering strategy, the optimal order frequency must be established to determine the number of joint orders to be placed in a year.

Optimal Order frequency, n^*

$$n^* = \sqrt{\frac{D_1hC_1 + D_2hC_2 + \cdots + D_{28}hC_{28}}{2S^*}}$$

The optimal order frequency for "A" category is determined by first finding the sum of products of the individual item annual demand, holding cost, and unit cost; then divide that value twice the joint order cost, S^*. Finally, the square root of the resulting value yields n^*. The n^* is 52 orders per year for "A" category spectacle frames.

For “A” category items, the total annual demand with holding cost is $547,924.31, as shown in Table 8.

$$n^* = \sqrt{\frac{\$547{,}924.31}{2 * \$101.10}} = 52$$

Step 6. To find the optimal order quantity per frame, Q_i, the following calculation is

$$Q_i = \frac{D_i}{n^*}.$$

The optimal order quantity for R-5A BLACK 52–20-145 spectacle frame is

$$\frac{72{,}897}{52} = 1{,}400.$$

Step 7. To find the annual holding cost, the following calculation is

$$\frac{Q_i}{2} * Holding\ Cost\ .$$

The annual holding cost for R-5A BLACK 52–20-145 spectacle frame is

$$\frac{1{,}400}{2} = 700 * \$1.23 = \$864.35.$$

The annual holding cost for all “A” category spectacle frames annual holding cost is $5,262.72 as shown in Table 8.

Step 8. Next the annual ordering cost must be determined. This is calculated by multiplying the $n^*$and S^*, both which have been previously determined.

$$Annual\ Joint\ Ordreing\ Cost = n^* * S^*$$

For “A” category spectacle frames, this annual joint ordering cost is

$$52 * \$101.10 = \$5{,}262.72.$$

Step 9. Finally, the annual holding and order costs are added together to get the total joint ordering cost of $10,525.44.

$$Total\ Joint\ Ordering\ Cost = Annual\ Holding\ Cost + Annual\ Ordering\ Cost$$

$$Total\ Joint\ Ordering\ Cost = \$5{,}262.72 + \$5{,}262.72 = \$10{,}525.44$$

In conclusion, the joint ordering steps can be applied to "B" category items as well. Now, the total cost under the joint ordering strategy can be compared to NOSTRA's current ordering strategy and the total cost under the EOQ strategy.

Table 9. Comparing Ordering Strategies for FY 2017 "A" Category Spectacle Frames.

Total CURRENT Cost (Category "A" items)	$ 112,305.18
Total EOQ Cost (Category "A" items)	$ 52,033.17
Savings (CURRENT - EOQ)	$ 60,272.01
Total CURRENT Cost (Category "A" items)	$ 112,305.18
Total Joint Ordering Cost (Category "A" items)	$ 10,525.44
Savings (CURRENT - Joint Ordering)	$ 101,779.74
Total EOQ Cost (Category "A" items)	$ 52,033.17
Total Joint Ordering Cost (Category "A" items)	$ 10,525.44
Savings (EOQ - Joint Ordering)	$ 41,507.73

As shown in Table 9, applying the joint ordering strategy instead of the EOQ or NOSTRA's current ordering policy can have substantial savings for the organization. Table 9 illustrates the potential savings for the critical items. NOSTRA could have potentially saved $60,272.01 by utilizing just the EOQ methodology instead of its current method. If NOSTRA had used the joint ordering strategy, a cost savings of $101,779.74 would have been realized. Either of the two strategies would have been more advantageous for NOSTRA and ahead of the DHA's initiatives to reduce cost while delivering world-class medical care.

The same steps involved in determining the joint order cost for "A" category spectacle frames are outlined for FY 2017 "C" category spectacle frames as shown in Table 10.

Table 10. FY 2017 "C" Category Spectacle Frames

Description	Annual Demand (D)	h	C	Holding Cost (h * C)	D * h	Frame Quantity (Qi)	Annual Holding Cost	Total Cost (EOQ)	Total Cost (Current)
R-5AM, BLACK, 54-20-145	1,250	0.15	$ 8.23	$ 1.23	$ 1,543.13	97	$ 59.57	$ 558.56	$ 1,373.54
R-5A BLACK 50-18-140	1,220	0.15	$ 8.23	$ 1.23	$ 1,506.09	94	$ 58.14	$ 551.82	$ 902.86
R-5A BLACK 48-18-135	1,080	0.15	$ 8.23	$ 1.23	$ 1,333.26	83	$ 51.47	$ 519.19	$ 1,172.61
R-5A BLACK 48-20-145	1,020	0.15	$ 8.23	$ 1.23	$ 1,259.19	79	$ 48.61	$ 504.57	$ 2,252.63
R-5AM, BLACK, 54-22-145	993	0.15	$ 8.23	$ 1.23	$ 1,225.86	77	$ 47.32	$ 497.84	$ 977.93
R-5A BLACK 52-18-140	980	0.15	$ 8.23	$ 1.23	$ 1,209.81	76	$ 46.70	$ 494.57	$ 977.04
R-5A BLACK 52-18-150	965	0.15	$ 8.23	$ 1.23	$ 1,191.29	75	$ 45.99	$ 490.77	$ 883.19
R-5AM, BLACK, 50-24-150	930	0.15	$ 8.23	$ 1.23	$ 1,148.09	72	$ 44.32	$ 481.79	$ 789.65
FGN,GLD,52-20-145,SKL FG28Y99G	400	0.15	$17.75	$ 2.66	$ 1,065.00	31	$ 41.11	$ 464.03	$ 537.49
R-5AM, BLACK, 50-20-140	850	0.15	$ 8.23	$ 1.23	$ 1,049.33	66	$ 40.51	$ 460.60	$ 693.99
R-5A RP BLACK 50-22-145	630	0.15	$10.29	$ 1.54	$ 972.41	49	$ 37.54	$ 443.40	$ 602.70
LIBERTY GOLD 52-20-140	300	0.15	$20.59	$ 3.09	$ 926.55	23	$ 35.77	$ 432.82	$ 457.70
WILLOW GUN METAL 50-16-145	300	0.15	$20.59	$ 3.09	$ 926.55	23	$ 35.77	$ 432.82	$ 773.82
R-5A BLACK 54-24-150	700	0.15	$ 8.23	$ 1.23	$ 864.15	54	$ 33.36	$ 417.99	$ 1,545.18
R-5A BLACK 54-24-145	690	0.15	$ 8.23	$ 1.23	$ 851.81	53	$ 32.88	$ 414.99	$ 1,150.73
R-5A RP BLACK 48-22-145	520	0.15	$10.29	$ 1.54	$ 802.62	40	$ 30.98	$ 402.84	$ 858.90
ELITE PEWTER 50-19-135 SKL	335	0.15	$14.91	$ 2.24	$ 749.23	26	$ 28.92	$ 389.21	$ 1,442.04
AFF GLD 55-18-145 SKL	124	0.15	$36.32	$ 5.45	$ 675.55	10	$ 26.08	$ 369.57	$ 415.87
HALFEYE GRAY FADE 50-22-150	615	0.15	$ 5.99	$ 0.90	$ 552.58	47	$ 21.33	$ 334.25	$ 1,534.79
MUGA GOLD 52-19-145	175	0.15	$20.59	$ 3.09	$ 540.49	14	$ 20.86	$ 330.57	$ 651.59
R-5A RP BLACK 50-22-150	340	0.15	$10.29	$ 1.54	$ 524.79	26	$ 20.26	$ 325.74	$ 557.94
ELITE PEWTER 52-21-140 SKL	232	0.15	$14.91	$ 2.24	$ 518.87	18	$ 20.03	$ 323.89	$ 389.75
MUGA BLACK 50-17-140	150	0.15	$20.59	$ 3.09	$ 463.28	12	$ 17.88	$ 306.05	$ 551.79
WILLOW GUN METAL 52-18-145	150	0.15	$20.59	$ 3.09	$ 463.28	12	$ 17.88	$ 306.05	$ 645.16
COVERT DARK BROWN/ LIGHT BROWN 51-19-145	170	0.15	$16.67	$ 2.50	$ 425.09	13	$ 16.41	$ 293.16	$ 641.97
FGN,GLD,55-20-145SKL FG58Y99G	156	0.15	$17.75	$ 2.66	$ 415.35	12	$ 16.03	$ 289.79	$ 372.50
R-5A BLACK 50-20-135	327	0.15	$ 8.23	$ 1.23	$ 403.68	25	$ 15.58	$ 285.69	$ 1,130.36
R-5A BLACK 50-24-150	315	0.15	$ 8.23	$ 1.23	$ 388.87	24	$ 15.01	$ 280.40	$ 452.98
ELLSWORTH GUN METAL/OLIVE 51-18-145	100	0.15	$25.75	$ 3.86	$ 386.25	8	$ 14.91	$ 279.45	$ 452.65
LIBERTY RUTHENIUM 52-20-145	125	0.15	$20.59	$ 3.09	$ 386.06	10	$ 14.90	$ 279.38	$ 544.06
FGN,GLD,58-20-140,STB FG88699G	140	0.15	$17.75	$ 2.66	$ 372.75	11	$ 14.39	$ 274.52	$ 450.96
R-5A BLACK 54-24-155	280	0.15	$ 8.23	$ 1.23	$ 345.66	22	$ 13.34	$ 264.36	$ 360.89
AVIATOR, CHROME, 52-20,140 BAYONET RO	210	0.15	$10.27	$ 1.54	$ 323.51	16	$ 12.49	$ 255.75	$ 283.06
AVIATOR, CHROME, 52-20,145 SKULL RO	210	0.15	$10.27	$ 1.54	$ 323.51	16	$ 12.49	$ 255.75	$ 283.06
AVIATOR, GOLD, 52-20,140 BAYONET RO	210	0.15	$10.27	$ 1.54	$ 323.51	16	$ 12.49	$ 255.75	$ 283.06
MUGA BLACK 54-19-140	100	0.15	$20.59	$ 3.09	$ 308.85	8	$ 11.92	$ 249.89	$ 354.75
R-5A RP BLACK 46-20-140	180	0.15	$10.29	$ 1.54	$ 277.83	14	$ 10.72	$ 237.01	$ 349.58
R-5A BLACK 50-18-135	220	0.15	$ 8.23	$ 1.23	$ 271.59	17	$ 10.48	$ 234.33	$ 727.04
R-5AM, BLACK, 52-20-140	220	0.15	$ 8.23	$ 1.23	$ 271.59	17	$ 10.48	$ 234.33	$ 270.08
AFF BLK 55-18-150 SKL	48	0.15	$36.32	$ 5.45	$ 261.50	4	$ 10.09	$ 229.94	$ 231.84
AFF BLK 58-18-140 SKL	48	0.15	$36.32	$ 5.45	$ 261.50	4	$ 10.09	$ 229.94	$ 628.34
HALF-EYE FADE BROWN 50-22-145	272	0.15	$ 5.99	$ 0.90	$ 244.39	21	$ 9.43	$ 222.29	$ 824.01
R-5A BLACK 52-18-135	190	0.15	$ 8.23	$ 1.23	$ 234.56	15	$ 9.05	$ 217.77	$ 626.10
HALFEYE GRAY FADE 50-22-145	258	0.15	$ 5.99	$ 0.90	$ 231.81	20	$ 8.95	$ 216.49	$ 625.87
LIBERTY RUTHENIUM 50-18-145	75	0.15	$20.59	$ 3.09	$ 231.64	6	$ 8.94	$ 216.41	$ 341.88
LIBERTY RUTHENIUM 54-20-145	75	0.15	$20.59	$ 3.09	$ 231.64	6	$ 8.94	$ 216.41	$ 341.88
MUGA BLACK 50-17-135	75	0.15	$20.59	$ 3.09	$ 231.64	6	$ 8.94	$ 216.41	$ 341.88
MUGA GOLD 50-17-135	75	0.15	$20.59	$ 3.09	$ 231.64	6	$ 8.94	$ 216.41	$ 341.88
MUGA GOLD 50-17-140	75	0.15	$20.59	$ 3.09	$ 231.64	6	$ 8.94	$ 216.41	$ 341.88
WILLOW GUN METAL 54-18-140	75	0.15	$20.59	$ 3.09	$ 231.64	6	$ 8.94	$ 216.41	$ 260.09
ELITE BROWN 50-19-135 SKL	100	0.15	$14.91	$ 2.24	$ 223.65	8	$ 8.63	$ 212.65	$ 527.82
ELITE BROWN 50-19-145 SKL	100	0.15	$14.91	$ 2.24	$ 223.65	8	$ 8.63	$ 212.65	$ 432.32
R-5A BLACK 48-18-145	180	0.15	$ 8.23	$ 1.23	$ 222.21	14	$ 8.58	$ 211.96	$ 822.62
COVERT DARK BROWN/ LIGHT BROWN 53-19-140	70	0.15	$16.67	$ 2.50	$ 175.04	5	$ 6.76	$ 188.12	$ 245.94
HALFEYE FADE BROWN 48-20-145	180	0.15	$ 5.99	$ 0.90	$ 161.73	14	$ 6.24	$ 180.83	$ 424.58
LIBERTY GOLD 50-18-140	50	0.15	$20.59	$ 3.09	$ 154.43	4	$ 5.96	$ 176.70	$ 240.79
MUGA GOLD 52-19-140	50	0.15	$20.59	$ 3.09	$ 154.43	4	$ 5.96	$ 176.70	$ 240.79
MUGA GOLD 54-19-145	50	0.15	$20.59	$ 3.09	$ 154.43	4	$ 5.96	$ 176.70	$ 240.79
R-5A RP BLACK 48-22-140	100	0.15	$10.29	$ 1.54	$ 154.35	8	$ 5.96	$ 176.66	$ 178.27
R-5A BLACK 54-22-160	120	0.15	$ 8.23	$ 1.23	$ 148.14	9	$ 5.72	$ 173.06	$ 239.22
HALF-EYE GRAY FADE 48-20-145	148	0.15	$ 5.99	$ 0.90	$ 132.98	11	$ 5.13	$ 163.97	$ 420.99
THUNDER BLACK 52-17-140	60	0.15	$14.24	$ 2.14	$ 128.16	5	$ 4.95	$ 160.97	$ 234.22
R-5A BLACK 52-20-135	100	0.15	$ 8.23	$ 1.23	$ 123.45	8	$ 4.77	$ 157.99	$ 233.05
KINGSVILLE BLACK 51-17-140	50	0.15	$15.84	$ 2.38	$ 118.80	4	$ 4.59	$ 154.98	$ 231.88
KINGSVILLE BLACK 53-19-145	50	0.15	$15.84	$ 2.38	$ 118.80	4	$ 4.59	$ 154.98	$ 231.88
R-5A RP BLACK 52-24-145	75	0.15	$10.29	$ 1.54	$ 115.76	6	$ 4.47	$ 152.99	$ 158.97
ELITE BLACK 50-19-140 SKL	50	0.15	$14.91	$ 2.24	$ 111.83	4	$ 4.32	$ 150.36	$ 321.91
ELITE BLACK 52-21-135 SKL	50	0.15	$14.91	$ 2.24	$ 111.83	4	$ 4.32	$ 150.36	$ 157.00
ELITE PEWTER 52-21-135 SKL	50	0.15	$14.91	$ 2.24	$ 111.83	4	$ 4.32	$ 150.36	$ 230.14
HALF-EYE FADE BROWN 50-22-150	110	0.15	$ 5.99	$ 0.90	$ 98.84	8	$ 3.82	$ 141.36	$ 226.89
LIBERTY GOLD 50-18-145	25	0.15	$20.59	$ 3.09	$ 77.21	2	$ 2.98	$ 124.94	$ 139.70
LIBERTY GOLD 52-20-145	25	0.15	$20.59	$ 3.09	$ 77.21	2	$ 2.98	$ 124.94	$ 139.70
LIBERTY GOLD 54-20-140	25	0.15	$20.59	$ 3.09	$ 77.21	2	$ 2.98	$ 124.94	$ 139.70
R-5A BLACK 46-20-145	60	0.15	$ 8.23	$ 1.23	$ 74.07	5	$ 2.86	$ 122.38	$ 220.70
R-5A BLACK 50-22-135	60	0.15	$ 8.23	$ 1.23	$ 74.07	5	$ 2.86	$ 122.38	$ 138.13
R-5A RP BLACK 48-22-135	40	0.15	$10.29	$ 1.54	$ 61.74	3	$ 2.38	$ 111.73	$ 131.96
R-5AM, BLACK, 50-24-140	40	0.15	$ 8.23	$ 1.23	$ 49.38	3	$ 1.91	$ 99.92	$ 214.53
R-5A RP BLACK 50-22-155	30	0.15	$10.29	$ 1.54	$ 46.31	2	$ 1.79	$ 96.76	$ 124.24
ELITE BLACK 52-21-140 SKL	20	0.15	$14.91	$ 2.24	$ 44.73	2	$ 1.73	$ 95.10	$ 123.46
R-5A BLACK 48-20-150	35	0.15	$ 8.23	$ 1.23	$ 43.21	3	$ 1.67	$ 93.47	$ 122.70
THUNDER BLACK 54-17-140	20	0.15	$14.24	$ 2.14	$ 42.72	2	$ 1.65	$ 92.94	$ 122.45
R-5A BLACK 50-24-145	30	0.15	$ 8.23	$ 1.23	$ 37.04	2	$ 1.43	$ 86.53	$ 119.61
R-5A BLACK 52-24-145	20	0.15	$ 8.23	$ 1.23	$ 24.69	2	$ 0.95	$ 70.65	$ 113.44
R-5AM, BLACK, 48-20-150	20	0.15	$ 8.23	$ 1.23	$ 24.69	2	$ 0.95	$ 70.65	$ 113.44
R-5A TEMPLES BLACK 150MM	20	0.15	$ 3.73	$ 0.56	$ 11.19	2	$ 0.43	$ 47.57	$ 106.69
Totall Count: 85					$ 33,920.61		$ 1,309.43	$ 21,547.64	$ 42,112.06

Description and annual demand retrieved from DMLSS, August 2019

Step 1. The common order cost, $S = \$7.63$ [Building Order Step #2 (verify & execute)]

Step 2. The next step is to determine the item-related cost across all "C" category items.

The item-related costs of 85 "C" category items are:

a) Walking the Floor (inventory & scanning) = $\frac{\$55.39}{85}$ = \$0.65

b) Building Order Step #1 (downloading scanner data) = $\frac{\$6.92}{85}$ = \$0.08

c) Receiving of Order = $\frac{\$31.16}{85}$ = \$0.37.

The sum of the item-related costs equates to item-specific order cost, s_i, are:

Item-specific order cost, $s_i = \$0.65 + \$0.08 + \$0.37 = \$1.10$.

Step 3. In determining the total item-specific cost, the item-specific order cost (\$1.10) is multiplied by 85 "C" category items. The total is \$93.47.

Step 4. Joint Order Cost, $S^* = S + (s_1 + s_2 + \cdots + s_{85}) = \$7.63 + \$93.47 = \$101.10$

Step 5. Recall that the optimal order frequency, n^* for "C" category is determined by first finding the sum of products of the individual item annual demand, holding cost, and unit cost; then divide that value twice the joint order cost, S^*. Finally, the square root of the resulting value yields n^*. The n^* is 13 orders per year for "C" category spectacle frames.

For "C" category items, the total annual demand with holding cost is \$33,920.61, as shown in Table 10.

$$n* = \sqrt{\frac{\$33{,}920.63}{2*\$101.10}} = 13$$

Step 6. The optimal order quantity for one frame from "C" category R-5A BLACK 54–20-145 spectacle frame is

$$\frac{1{,}250}{13} = 97.$$

Step 7. The annual holding cost for "C" category R-5A BLACK 52–20-145 spectacle frame is

$$\frac{97}{2} = 48.5 * \$1.23 = \$59.57.$$

Step 8. The annual holding cost equals $n^* * S^*$:

$$13 * \$101.10 = \$1{,}309.43.$$

Step 9. Finally, the annual holding and order costs are added together to get the total joint ordering cost of $2,618.86.

$$Total\ Joint\ Ordering\ Cost = \$1{,}309.43 + \$1{,}309.43 = \$2{,}618.86$$

Now, the total cost under the joint ordering strategy can be compared to NOSTRA's current ordering strategy and the total cost under the EOQ policy as shown in Table 11.

Table 11. Comparing Ordering Strategies for FY 2017 “C” Category Spectacle Frames

Total CURRENT Cost ("C" Category items)	$ 42,112.06
Total EOQ Cost ("C" Category items)	$ 21,547.64
Savings (CURRENT - EOQ)	$ 20,564.43
Total CURRENT Cost ("C" Category items)	$ 42,112.06
Total Joint Ordering Cost ("C" Category items)	$ 2,618.86
Savings (CURRENT - Joint Ordering)	$ 39,493.21
Total EOQ Cost ("C" Category items)	$ 21,547.64
Total Joint Ordering Cost ("C" Category items)	$ 2,618.86
Savings (EOQ - Joint Ordering)	$ 18,928.78

NOSTRA could have potentially saved $20,564.43 by adopting the EOQ methodology instead of its current method. If the joint ordering strategy were executed instead of NOSTRA’s current method, the savings would have been $39,493.21. The EOQ and joint ordering strategy are equally superior to NOSTRA’s status quo as demonstrated in Table 11. However, the joint ordering strategy provides a greater cost savings than the EOQ strategy.

Table 12 mimics the same methodology used in Table 8 to determine the joint ordering cost of FY 2018 “A” category spectacle frames joint ordering cost

Table 12. FY 2018 "A" Category Spectacle Frames

Description	Annual Demand (D)	h	C	Holding Cost (h * C)	D * h	Frame Quantity (Qi)	Annual Holding Cost	Total Cost (EOQ)	Total Cost (Current)
KEESLER BLACK/BRONZE 55-15-140	12,850	0.15	$30.91	$ 4.64	$ 59,579.03	297	$ 688.27	$ 3,470.72	$ 6,561.99
KEESLER BLACK/BRONZE 58-15-145	11,253	0.15	$30.91	$ 4.64	$ 52,174.53	260	$ 602.73	$ 3,247.89	$ 5,667.19
OSAN BLACK 55-15-145	7,390	0.15	$25.75	$ 3.86	$ 28,543.88	171	$ 329.74	$ 2,402.31	$ 5,054.97
MUGA BLACK 54-19-145	8,010	0.15	$20.59	$ 3.09	$ 24,738.89	185	$ 285.79	$ 2,236.47	$ 5,301.97
KEESLER BLACK/BRONZE 52-15-140	4,880	0.15	$30.91	$ 4.64	$ 22,626.12	113	$ 261.38	$ 2,138.84	$ 4,046.15
MUGA BLACK 52-19-140	5,810	0.15	$20.59	$ 3.09	$ 17,944.19	134	$ 207.29	$ 1,904.73	$ 5,039.32
OSAN BLACK 53-15-140	4,525	0.15	$25.75	$ 3.86	$ 17,477.81	105	$ 201.91	$ 1,879.82	$ 3,142.67
COVERT DARK BROWN/LIGHT BROWN 53-19-145	5,624	0.15	$16.67	$ 2.50	$ 14,062.81	130	$ 162.46	$ 1,686.20	$ 4,510.46
KEESLER BLACK/BRONZE 55-15-145	2,625	0.15	$30.91	$ 4.64	$ 12,170.81	61	$ 140.60	$ 1,568.67	$ 3,047.90
LIBERTY RUTHENIUM 52-20-140	3,520	0.15	$20.59	$ 3.09	$ 10,871.52	81	$ 125.59	$ 1,482.58	$ 3,024.70
FGN,GLD,52-20-140,STB FG28699G	4,081	0.15	$17.75	$ 2.66	$ 10,865.66	94	$ 125.52	$ 1,482.18	$ 3,500.66
ELITE BLACK 52-21-145 SKL	4,378	0.15	$14.91	$ 2.24	$ 9,791.40	101	$ 113.11	$ 1,407.00	$ 3,581.11
ELLSWORTH GUN METAL/OLIVE 53-18-140	2,530	0.15	$25.75	$ 3.86	$ 9,772.13	58	$ 112.89	$ 1,405.62	$ 3,195.62
ELLSWORTH GUN METAL/OLIVE 51-18-140	2,405	0.15	$25.75	$ 3.86	$ 9,289.31	56	$ 107.31	$ 1,370.45	$ 2,527.05
COVERT DARK BROWN/ LIGHT BROWN 51-19-140	3,620	0.15	$16.67	$ 2.50	$ 9,051.81	84	$ 104.57	$ 1,352.82	$ 2,992.21
LIBERTY GOLD 54-20-145	2,050	0.15	$20.59	$ 3.09	$ 6,331.43	47	$ 73.14	$ 1,131.42	$ 2,558.10
R-5A BLACK 48-20-145	5,115	0.15	$ 8.23	$ 1.23	$ 6,314.47	118	$ 72.95	$ 1,129.90	$ 3,431.70
R-5A BLACK 50-22-145	4,900	0.15	$ 8.23	$ 1.23	$ 6,049.05	113	$ 69.88	$ 1,105.90	$ 4,218.53
R-5A BLACK 50-20-140	4,630	0.15	$ 8.23	$ 1.23	$ 5,715.74	107	$ 66.03	$ 1,075.00	$ 1,796.08
ELITE BLACK 50-19-145 SKL	2,535	0.15	$14.91	$ 2.24	$ 5,669.53	59	$ 65.50	$ 1,070.65	$ 2,544.32
KINGSVILLE BLACK 53-19-140	2,313	0.15	$15.84	$ 2.38	$ 5,495.69	53	$ 63.49	$ 1,054.10	$ 1,972.31
KINGSVILLE BLACK 55-19-145	2,235	0.15	$15.84	$ 2.38	$ 5,310.36	52	$ 61.35	$ 1,036.18	$ 1,874.75
KEESLER BLACK/BRONZE 52-15-145	1,030	0.15	$30.91	$ 4.64	$ 4,775.60	24	$ 55.17	$ 982.62	$ 1,859.02
WILLOW GUN METAL 52-18-140	1,455	0.15	$20.59	$ 3.09	$ 4,493.77	34	$ 51.91	$ 953.19	$ 1,944.48
KINGSVILLE BLACK 51-17-135	1,775	0.15	$15.84	$ 2.38	$ 4,217.40	41	$ 48.72	$ 923.41	$ 2,223.34
MUGA BLACK 52-19-145	1,365	0.15	$20.59	$ 3.09	$ 4,215.80	32	$ 48.70	$ 923.24	$ 2,031.68
R-5A BLACK 50-18-145	3,270	0.15	$ 8.23	$ 1.23	$ 4,036.82	76	$ 46.63	$ 903.42	$ 3,198.95
MUGA BLACK 50-17-140	1,290	0.15	$20.59	$ 3.09	$ 3,984.17	30	$ 46.03	$ 897.51	$ 2,217.79
R-5AM, BLACK, 50-20-145	2,590	0.15	$ 8.23	$ 1.23	$ 3,197.36	60	$ 36.94	$ 804.02	$ 1,812.60
Total Count: 29					$ 378,767.04		$ 4,375.58	$ 43,026.88	$ 94,877.60

Description and annual demand retrieved from DMLSS, August 2019

Step 1. The common order cost, $S = \$7.63$ [Building Order Step #2 (verify & execute)].

Step 2. The next step is to determine the item-related cost across all "A" category items.

The item-related costs of 29 "A" category items are:

a) Walking the Floor (inventory & scanning) = $\frac{\$55.39}{29} = \$1.91$

b) Building Order Step #1 (downloading scanner data) = $\frac{\$6.92}{29} = \$0.24$

c) Receiving of Order = $\frac{\$31.16}{29} = \$1.07$.

The sum of the item-related costs equates to item-specific order cost, s_i, are calculated below.

Item-specific order cost total, $s_i = \$1.91 + \$.24 + \$1.07 = \$3.22$

Step 3. In determining the total item-specific cost, the item-specific order cost ($3.22) is multiplied by 29 "A" category items. The total is $93.47.

Step 4. Joint Order Cost, $S^* = S + (s_1 + s_2 + \cdots + s_{29}) = \$7.63 + \$93.47 = \$101.10$

Step 5. Recall that the optimal order frequency, n^* for "A" category is determined by first finding the sum of products of the individual item annual demand, holding cost, and unit cost; then divide that value twice the joint order cost, S^*. Finally, the square root of the resulting value yields n^*. The n^* is 43 orders per year for "A" category spectacle frames.

$$n* = \sqrt{\frac{\$378{,}767.04}{2 * \$101.10}} = 43$$

For "A" category items, the total annual demand with holding cost is $378,767.04, as shown in Table 12.

Step 6. The optimal order quantity for one frame from "A" category KEESLER BLACK/BRONZE 55–15-140 spectacle frame is

$$\frac{12{,}850}{43} = 299.$$

Step 7. The annual holding cost for "A" category KEESLER BLACK/BRONZE 55–15-140 spectacle frame is

$$\frac{299}{2} = 149.5 * \$4.64 = \$688.27.$$

Step 8. The annual holding cost equals $n^* * S^*$:

$$43 * \$101.10 = \$4{,}375.58.$$

Step 9. Finally, annual holding costs and order costs are added together to get the total joint ordering cost of $8,751.17.

$$Total\ Joint\ Ordering\ Cost = \$4{,}375.58 + \$4{,}375.58 = \$8{,}751.17$$

Now, the total cost under the joint ordering strategy can be compared to NOSTRA's current ordering strategy and the total cost under the EOQ policy as shown in Table 13. NOSTRA could have possibly saved $51,850.72 by applying the EOQ methodology instead of its current process. If the joint ordering strategy were implemented instead of NOSTRA's current method, the savings would have been $86,126.43. The EOQ and joint ordering strategy surpasses NOSTRA's current process as depicted in Table 13. Nevertheless, the joint ordering strategy provides a larger cost savings than the EOQ strategy.

Table 13. Comparing Ordering Strategies for FY 2018 "A" Category Spectacle Frames

Total CURRENT Cost ("A" Category items)	$ 94,877.60
Total EOQ Cost ("A" Category items)	$ 43,026.88
Savings (CURRENT - EOQ)	$ 51,850.72
Total CURRENT Cost ("A" Category items)	$ 94,877.60
Total Joint Ordering Cost ("A" Category items)	$ 8,751.17
Savings (CURRENT - Joint Ordering)	$ 86,126.43
Total EOQ Cost ("A" Category items)	$ 43,026.88
Total Joint Ordering Cost ("A" Category items)	$ 8,751.17
Savings (EOQ - Joint Ordering)	$ 34,275.71

Table 14 mimics the same methodology used in Table 8 to determine the joint ordering cost of FY 2018 "C" category spectacle frames.

Table 14. FY 2018 "C" Category Spectacle Frames

Description	Annual Demand (D)	h	C	Holding Cost (h * C)	D * h	Frame Quantity (Qi)	Annual Holding Cost	Total Cost (EOQ)	Total Cost (Current)
R-5A BLACK 50-24-150	820	0.15	$ 8.23	$ 1.23	$ 1,012.29	76	$ 46.80	$ 452.40	$ 1,158.02
OSAN BLACK 55-15-140	250	0.15	$ 25.75	$ 3.86	$ 965.63	23	$ 44.64	$ 441.85	$ 464.21
R-5AM, BLACK, 54-22-150	715	0.15	$ 8.23	$ 1.23	$ 882.67	66	$ 40.81	$ 422.45	$ 680.11
ELLSWORTH GUN METAL/OLIVE 51-18-145	225	0.15	$ 25.75	$ 3.86	$ 869.06	21	$ 40.18	$ 419.18	$ 769.72
R-5A BLACK 52-20-140	695	0.15	$ 8.23	$ 1.23	$ 857.98	64	$ 39.67	$ 416.50	$ 768.93
R-5AM, BLACK, 50-24-150	600	0.15	$ 8.23	$ 1.23	$ 740.70	55	$ 34.24	$ 386.98	$ 855.03
WILLOW GUN METAL 50-16-140	225	0.15	$ 20.59	$ 3.09	$ 694.91	21	$ 32.13	$ 374.83	$ 757.28
ELITE PEWTER 50-19-135 SKL	305	0.15	$ 14.91	$ 2.24	$ 682.13	28	$ 31.54	$ 371.37	$ 851.37
R-5A BLACK 52-22-145	510	0.15	$ 8.23	$ 1.23	$ 629.60	47	$ 29.11	$ 356.78	$ 1,140.63
LIBERTY GOLD 50-18-140	200	0.15	$ 20.59	$ 3.09	$ 617.70	18	$ 28.56	$ 353.40	$ 481.58
R-5AM, BLACK, 52-20-145	490	0.15	$ 8.23	$ 1.23	$ 604.91	45	$ 27.97	$ 349.72	$ 1,337.46
FRAME, EAB-17, BLACK, 43-18-175	228	0.15	$ 17.52	$ 2.63	$ 599.18	21	$ 27.70	$ 348.06	$ 945.11
THUNDER BLACK 52-17-140	280	0.15	$ 14.24	$ 2.14	$ 598.08	26	$ 27.65	$ 347.74	$ 656.39
ELITE BROWN 50-19-145 SKL	265	0.15	$ 14.91	$ 2.24	$ 592.67	25	$ 27.40	$ 346.16	$ 478.45
WILLOW GUN METAL 50-16-145	175	0.15	$ 20.59	$ 3.09	$ 540.49	16	$ 24.99	$ 330.57	$ 471.93
COVERT DARK BROWN/ LIGHT BROWN 51-19-	210	0.15	$ 16.67	$ 2.50	$ 525.11	19	$ 24.28	$ 325.83	$ 650.31
AFF GLD 55-18-145 SKL	83	0.15	$ 36.32	$ 5.45	$ 452.18	8	$ 20.91	$ 302.36	$ 378.64
R-5AM, BLACK, 52-20-140	360	0.15	$ 8.23	$ 1.23	$ 444.42	33	$ 20.55	$ 299.76	$ 836.51
R-5A BLACK 50-20-135	340	0.15	$ 8.23	$ 1.23	$ 419.73	31	$ 19.41	$ 291.31	$ 547.43
R-5AM, BLACK, 54-20-145	340	0.15	$ 8.23	$ 1.23	$ 419.73	31	$ 19.41	$ 291.31	$ 737.62
KINGSVILLE BLACK 51-17-140	175	0.15	$ 15.84	$ 2.38	$ 415.80	16	$ 19.22	$ 289.94	$ 372.58
KINGSVILLE BLACK 53-19-145	175	0.15	$ 15.84	$ 2.38	$ 415.80	16	$ 19.22	$ 289.94	$ 456.34
ELITE PEWTER 52-21-140 SKL	175	0.15	$ 14.91	$ 2.24	$ 391.39	16	$ 18.09	$ 281.30	$ 368.51
AFF BLK 58-18-140 SKL	64	0.15	$ 36.32	$ 5.45	$ 348.67	6	$ 16.12	$ 265.51	$ 275.43
R-5AM, BLACK, 48-20-145	280	0.15	$ 8.23	$ 1.23	$ 345.66	26	$ 15.98	$ 264.36	$ 830.34
FGN,GLD,55-20-145SKL FG58Y99G	125	0.15	$ 17.75	$ 2.66	$ 332.81	12	$ 15.39	$ 259.40	$ 358.74
AVIATOR, CHROME, 52-20,145 SKULL RO	210	0.15	$ 10.27	$ 1.54	$ 323.51	19	$ 14.96	$ 255.75	$ 283.06
THUNDER BLACK 54-17-140	150	0.15	$ 14.24	$ 2.14	$ 320.40	14	$ 14.81	$ 254.52	$ 356.68
LIBERTY GOLD 50-18-145	100	0.15	$ 20.59	$ 3.09	$ 308.85	9	$ 14.28	$ 249.89	$ 279.40
LIBERTY RUTHENIUM 50-18-145	100	0.15	$ 20.59	$ 3.09	$ 308.85	9	$ 14.28	$ 249.89	$ 354.75
MUGA GOLD 52-19-145	100	0.15	$ 20.59	$ 3.09	$ 308.85	9	$ 14.28	$ 249.89	$ 279.40
MUGA GOLD 54-19-145	100	0.15	$ 20.59	$ 3.09	$ 308.85	9	$ 14.28	$ 249.89	$ 279.40
HALFEYE FADE BROWN 48-20-145	320	0.15	$ 5.99	$ 0.90	$ 287.52	30	$ 13.29	$ 241.11	$ 826.70
ELITE BLACK 52-21-135 SKL	125	0.15	$ 14.91	$ 2.24	$ 279.56	12	$ 12.92	$ 237.75	$ 349.87
COVERT DARK BROWN/ LIGHT BROWN 53-19-	110	0.15	$ 16.67	$ 2.50	$ 275.06	10	$ 12.72	$ 235.82	$ 349.12
HALF-EYE GRAY FADE 48-20-145	270	0.15	$ 5.99	$ 0.90	$ 242.60	25	$ 11.22	$ 221.47	$ 724.97
HALFEYE GRAY FADE 50-22-150	265	0.15	$ 5.99	$ 0.90	$ 238.10	25	$ 11.01	$ 219.41	$ 529.27
R-5A BLACK 48-18-145	190	0.15	$ 8.23	$ 1.23	$ 234.56	18	$ 10.84	$ 217.77	$ 1,022.64
HALF-EYE FADE BROWN 50-22-150	260	0.15	$ 5.99	$ 0.90	$ 233.61	24	$ 10.80	$ 217.33	$ 433.57
R-5A RP BLACK 50-22-150	150	0.15	$ 10.29	$ 1.54	$ 231.53	14	$ 10.70	$ 216.36	$ 341.86
R-5A BLACK 52-18-150	180	0.15	$ 8.23	$ 1.23	$ 222.21	17	$ 10.27	$ 211.96	$ 257.74
R-5A BLACK 54-24-155	170	0.15	$ 8.23	$ 1.23	$ 209.87	16	$ 9.70	$ 205.99	$ 624.04
R-5AM, BLACK, 48-20-150	170	0.15	$ 8.23	$ 1.23	$ 209.87	16	$ 9.70	$ 205.99	$ 338.25
R-5A BLACK 50-18-135	160	0.15	$ 8.23	$ 1.23	$ 197.52	15	$ 9.13	$ 199.84	$ 429.06
R-5A BLACK 46-16-135	155	0.15	$ 8.23	$ 1.23	$ 191.35	14	$ 8.85	$ 196.69	$ 335.17
R-5A RP BLACK 46-20-140	120	0.15	$ 10.29	$ 1.54	$ 185.22	11	$ 8.56	$ 193.52	$ 248.49
R-5AM, BLACK, 52-22-145	150	0.15	$ 8.23	$ 1.23	$ 185.18	14	$ 8.56	$ 193.49	$ 334.14
R-5A BLACK 54-24-150	140	0.15	$ 8.23	$ 1.23	$ 172.83	13	$ 7.99	$ 186.93	$ 332.08
R-5A RP BLACK 52-24-145	110	0.15	$ 10.29	$ 1.54	$ 169.79	10	$ 7.85	$ 185.28	$ 351.57
MUGA BLACK 54-19-140	50	0.15	$ 20.59	$ 3.09	$ 154.43	5	$ 7.14	$ 176.70	$ 240.79
MUGA GOLD 52-19-140	50	0.15	$ 20.59	$ 3.09	$ 154.43	5	$ 7.14	$ 176.70	$ 178.30
WILLOW GUN METAL 54-18-140	50	0.15	$ 20.59	$ 3.09	$ 154.43	5	$ 7.14	$ 176.70	$ 178.30
R-5A BLACK 52-24-145	110	0.15	$ 8.23	$ 1.23	$ 135.80	10	$ 6.28	$ 165.70	$ 421.34
ELITE PEWTER 52-21-135 SKL	60	0.15	$ 14.91	$ 2.24	$ 134.19	6	$ 6.20	$ 164.71	$ 235.73
R-5A RP BLACK 48-22-140	80	0.15	$ 10.29	$ 1.54	$ 123.48	7	$ 5.71	$ 158.01	$ 233.05
R-5A BLACK 50-24-145	100	0.15	$ 8.23	$ 1.23	$ 123.45	9	$ 5.71	$ 157.99	$ 233.05
R-5A BLACK 52-18-135	100	0.15	$ 8.23	$ 1.23	$ 123.45	9	$ 5.71	$ 157.99	$ 162.82
R-5A TEMPLES BLACK 150MM	200	0.15	$ 3.73	$ 0.56	$ 111.90	18	$ 5.17	$ 150.41	$ 916.04
ELITE BLACK 50-19-140 SKL	50	0.15	$ 14.91	$ 2.24	$ 111.83	5	$ 5.17	$ 150.36	$ 157.00
R-5A BLACK 48-20-150	90	0.15	$ 8.23	$ 1.23	$ 111.11	8	$ 5.14	$ 149.88	$ 229.96
R-5A BLACK 52-20-135	90	0.15	$ 8.23	$ 1.23	$ 111.11	8	$ 5.14	$ 149.88	$ 229.96
FGN,GLD,58-20-140,STB FG88699G	41	0.15	$ 17.75	$ 2.66	$ 109.16	4	$ 5.05	$ 148.56	$ 229.47
R-5AM, BLACK, 50-20-140	80	0.15	$ 8.23	$ 1.23	$ 98.76	7	$ 4.57	$ 141.31	$ 319.74
HALFEYE GRAY FADE 50-22-145	100	0.15	$ 5.99	$ 0.90	$ 89.85	9	$ 4.15	$ 134.78	$ 224.65
R-5A BLACK 54-22-145	70	0.15	$ 8.23	$ 1.23	$ 86.42	6	$ 4.00	$ 132.18	$ 223.79
R-5A BLACK 54-22-160	70	0.15	$ 8.23	$ 1.23	$ 86.42	6	$ 4.00	$ 132.18	$ 223.79
LIBERTY GOLD 52-20-145	25	0.15	$ 20.59	$ 3.09	$ 77.21	2	$ 3.57	$ 124.94	$ 139.70
LIBERTY GOLD 54-20-140	25	0.15	$ 20.59	$ 3.09	$ 77.21	2	$ 3.57	$ 124.94	$ 139.70
MUGA BLACK 50-17-135	25	0.15	$ 20.59	$ 3.09	$ 77.21	2	$ 3.57	$ 124.94	$ 139.70
MUGA GOLD 50-17-135	25	0.15	$ 20.59	$ 3.09	$ 77.21	2	$ 3.57	$ 124.94	$ 139.70
ELITE BROWN 50-19-135 SKL	25	0.15	$ 14.91	$ 2.24	$ 55.91	2	$ 2.58	$ 106.32	$ 129.05
R-5A BLACK 54-22-150	40	0.15	$ 8.23	$ 1.23	$ 49.38	4	$ 2.28	$ 99.92	$ 214.53
R-5A RP BLACK 50-22-155	25	0.15	$ 10.29	$ 1.54	$ 38.59	2	$ 1.78	$ 88.33	$ 120.39
R-5A BLACK 50-22-135	25	0.15	$ 8.23	$ 1.23	$ 30.86	2	$ 1.43	$ 78.99	$ 116.52
HALF-EYE FADE BROWN 50-22-145	30	0.15	$ 5.99	$ 0.90	$ 26.96	3	$ 1.25	$ 73.82	$ 114.57
R-5A BLACK 46-20-145	20	0.15	$ 8.23	$ 1.23	$ 24.69	2	$ 1.14	$ 70.65	$ 113.44
R-5AM, BLACK, 50-24-140	20	0.15	$ 8.23	$ 1.23	$ 24.69	2	$ 1.14	$ 70.65	$ 113.44
R-5A RP BLACK 48-22-135	15	0.15	$ 10.29	$ 1.54	$ 23.15	1	$ 1.07	$ 68.42	$ 112.67
Total Count: 78					$ 23,648.20		$ 1,093.32	$ 17,756.46	$ 33,499.01

Description and annual demand retrieved from DMLSS, August 2019

Step 1. The common order cost, $S = \$7.63$ [Building Order Step #2 (verify & execute)].

Step 2. The next step is to determine the item-related cost across all "C" category items.

The item-related costs of 78 "C" category items are:

a) Walking the Floor (inventory & scanning) = $\frac{\$55.39}{78}$ = \$0.71

b) Building Order Step #1 (downloading scanner data) = $\frac{\$6.92}{78}$ = \$0.09

c) Receiving of Order = $\frac{\$31.16}{78}$ = \$0.40.

The sum of the item-related costs equates to item-specific order cost, s_i, are calculated below.

Item-specific order cost total, $s_i = \$0.71 + \$0.09 + \$0.40 = \$1.20$

Step 3. In determining the total item-specific cost, the item-specific order cost ($1.20) is multiplied by 78 "C" category items. The total is $93.47.

Step 4. Joint Order Cost, $S^* = S + (s_1 + s_2 + \cdots + s_{78}) = \$7.63 + \$93.47 = \$101.10$

Step 5. Recall that the optimal order frequency, n^* for "C" category is determined by first finding the sum of products of the individual item annual demand, holding cost, and unit cost; then divide that value twice the joint order cost, S^*. Finally, the square root of the resulting value yields n^*. The n^* is 11 orders per year for "C" category spectacle frames.

$$n* = \sqrt{\frac{\$23{,}648.20}{2*\$101.10}} = 11$$

For "C" category items, the total annual demand with holding cost is $23,648.20, as shown in Table 14.

Step 6. The optimal order quantity for one frame from "C" category R-5A BLACK 50–24-150 spectacle frame is

$$\frac{820}{11} = 75.$$

Step 7. The annual holding cost for "C" category R-5A BLACK 50–24-150 spectacle frame is

$$\frac{75}{2} = 37.5 * \$1.23 = \$46.80.$$

Step 8. The annual holding cost equals $n^* * S^*$:

$$11 * \$101.10 = \$1{,}093.32.$$

Step 9. Finally, annual holding costs and order costs are added together to get the total joint ordering cost of $2,186.65.

$$Total\ Joint\ Ordering\ Cost = \$1{,}093.32 + \$1{,}093.32 = \$2{,}186.65$$

Per Table 15, EOQ would have provided $15,742.55 in savings and $31,312.36 for the joint ordering method in comparison to NOSTRA's current strategy. Nevertheless, the joint ordering strategy provides a higher cost savings than the EOQ strategy.

Table 15. Comparing Ordering Strategies for FY 2018 "C" Category Spectacle Frames

Total CURRENT Cost ("C" Category items)	$ 33,499.01
Total EOQ Cost("C" Category items)	$ 17,756.46
Savings (CURRENT - EOQ)	$ 15,742.55
Total CURRENT Cost ("C" Category items)	$ 33,499.01
Total Joint Ordering Cost ("C" Category items)	$ 2,186.65
Savings (CURRENT - Joint Ordering)	$ 31,312.36
Total EOQ Cost ("C" Category items)	$ 17,756.46
Total Joint Ordering Cost ("C" Category items)	$ 2,186.65
Savings (EOQ - Joint Ordering)	$ 15,569.81

3. Sensitivity Analysis

The sensitivity analysis examines two independent variables: holding cost (interest rate) and order cost. The first analysis evaluates the effect of three different holding costs on the EOQ and Total Cost (EOQ) for a sample size of spectacle frames from the FYs 2017 and 2018 Order Data. The second analysis evaluates the effect of three different order costs on the EOQ and Total Cost (EOQ) for a sample size of spectacle frames by using the same data set for this calculation. The third analysis evaluates the combined effect of different holding costs and order costs using a spectacle frame from the same data set

The first analysis uses three holding costs which are 10%, 15% (original input), and 20%. The other variables such as order cost, service level, unit costs, and demand retain their original values. Table 16 shows the effect of the various holding cost on the EOQ. As the holding cost reduces, the EOQ increases. For example, when the AFF BLK 55–18-150 SKL spectacle frames holding cost goes down from 15% to 10%, the EOQ increases from 42 to 52. The increase of 10 AFF BLK 55–18-150 SKL spectacle frames is the result of the lower cost of holding the inventory. On the other hand, as the holding cost goes from 15% to 20%, the AFF BLK 55–18-150 SKL spectacle frames EOQ decreases from 42 to 37. The decrease of five AFF BLK 55–18-150 SKL spectacle frames reflect the higher cost of holding the inventory.

Table 16. Sensitivity Analysis of Holding Cost on FY 2017 Spectacle Frame EOQ

Description	EOQ at 10% holding cost	EOQ at 15% original holding cost	EOQ at 20% holding cost
AFF BLK 55-18-150 SKL	52	42	37
AFF BLK 58-18-140 SKL	52	42	37
AFF GLD 55-18-145 SKL	83	68	59
AFF-JS EBONY AIRCREW 55-22-130	285	232	201
AVIATOR, CHROME, 52-20,140 BAYONET RO	203	166	144
AVIATOR, CHROME, 52-20,145 SKULL RO	203	166	144
AVIATOR, GOLD, 52-20,140 BAYONET RO	203	166	144
COVERT DARK BROWN/ LIGHT BROWN 51-19-140	653	533	462
COVERT DARK BROWN/ LIGHT BROWN 51-19-145	144	117	102
COVERT DARK BROWN/ LIGHT BROWN 53-19-140	92	75	65

The analysis in Table 17 uses three postulated order costs which are $66.12, $101.09 (original input), and $159.94. The $66.12 order cost originates from reducing three tasks performed by two individuals down to one and keeping the receiving order cost the same (see Table 5). The $66.12 is calculated by adding walking the floor ($27.69), building order step #1 ($3.46), building order step #2 ($3.81), and receiving order ($31.16) tasks. The $159.94 order cost originates from increasing the number of personnel for building order step #1 and receiving order tasks by one each. The sum of adding the walking the floor ($83.08), building order step #1 ($6.92), building order step #2 ($7.63), and receiving order ($62.31) tasks is $159.94. The other variables such as holding cost, service level, unit costs, and demand retained their original values.

Table 17. Sensitivity Analysis of Holding Cost on FY 2017 Spectacle Frame Total Cost (EOQ)

Description	Total Cost (EOQ) at 10% holding cost	Total Cost (EOQ) at 15% original holding cost	Total Cost (EOQ) at 20% holding cost
AFF BLK 55-18-150 SKL	$187.74	$229.94	$265.51
AFF BLK 58-18-140 SKL	$187.74	$229.94	$265.51
AFF GLD 55-18-145 SKL	$301.76	$369.57	$426.75
AFF-JS EBONY AIRCREW 55-22-130	$1,033.66	$1,265.97	$1,461.81
AVIATOR, CHROME, 52-20,140 BAYONET RO	$208.82	$255.75	$295.31
AVIATOR, CHROME, 52-20,145 SKULL RO	$208.82	$255.75	$295.31
AVIATOR, GOLD, 52-20,140 BAYONET RO	$208.82	$255.75	$295.31
COVERT DARK BROWN/ LIGHT BROWN 51-19-140	$1,089.21	$1,334.00	$1,540.38
COVERT DARK BROWN/ LIGHT BROWN 51-19-145	$239.37	$293.16	$338.52
COVERT DARK BROWN/ LIGHT BROWN 53-19-140	$153.60	$188.12	$217.22

Table 18 shows that the EOQ decreases in quantity as the order cost decreases. For example, the COVERT DARK BROWN/ LIGHT BROWN 51–19-140 spectacle frame quantity decreases by 102 (533 − 431), as the order cost reduces from $101.09 to $66.12. The opposite effect to the EOQ occurs when the order cost increases. The COVERT DARK BROWN/ LIGHT BROWN 51–19-140 spectacle frame quantity increases by 138 (671 − 533) as the order cost increases from $101.09 to $159.94. The higher order cost reflects the need to place larger order quantities to minimize inventory cost.

Table 18. Sensitivity Analysis of Order Cost on FY 2017 Spectacle Frame EOQ

Description	EOQ at $66.12 order cost	EOQ at $101.09 original order cost	EOQ at $159.94 order cost
AFF BLK 55-18-150 SKL	34	42	53
AFF BLK 58-18-140 SKL	34	42	53
AFF GLD 55-18-145 SKL	55	68	85
AFF-JS EBONY AIRCREW 55-22-130	188	232	292
AVIATOR, CHROME, 52-20,140 BAYONET RO	134	166	209
AVIATOR, CHROME, 52-20,145 SKULL RO	134	166	209
AVIATOR, GOLD, 52-20,140 BAYONET RO	134	166	209
COVERT DARK BROWN/ LIGHT BROWN 51-19-140	431	533	671
COVERT DARK BROWN/ LIGHT BROWN 51-19-145	95	117	147
COVERT DARK BROWN/ LIGHT BROWN 53-19-140	61	75	95

Table 19 shows the effect of the order cost on the Total Cost (EOQ) for each spectacle frame. The Total Cost (EOQ) goes down as the order cost decreases. For example, the COVERT DARK BROWN/ LIGHT BROWN 51–19-140 spectacle frame Total Cost EOQ reduces by $255.11 ($1,334.00 − $1,078.89), as the order cost decreases from $101.09 to $66.12. However, when the holding cost goes up, the Total Cost (EOQ) also increases. The COVERT DARK BROWN/ LIGHT BROWN 51–19-140 spectacle frame Total Cost (EOQ) increases $343.95 ($1,677.95 − $1,334.00) as the order cost increases from $101.09 to $159.94.

Table 19. Sensitivity Analysis of Order Cost on FY 2017 Spectacle Frame Total Cost (EOQ)

Description	Total Cost (EOQ) at $66.12 order cost	Total Cost (EOQ) at $101.09 original order cost	Total Cost (EOQ) at $159.94 order cost
AFF BLK 55-18-150 SKL	$185.97	$229.94	$289.22
AFF BLK 58-18-140 SKL	$185.97	$229.94	$289.22
AFF GLD 55-18-145 SKL	$298.90	$369.57	$464.86
AFF-JS EBONY AIRCREW 55-22-130	$1,023.86	$1,265.97	$1,592.37
AVIATOR, CHROME, 52-20,140 BAYONET RO	$206.84	$255.75	$321.69
AVIATOR, CHROME, 52-20,145 SKULL RO	$206.84	$255.75	$321.69
AVIATOR, GOLD, 52-20,140 BAYONET RO	$206.84	$255.75	$321.69
COVERT DARK BROWN/ LIGHT BROWN 51-19-140	$1,078.89	$1,334.00	$1,677.95
COVERT DARK BROWN/ LIGHT BROWN 51-19-145	$237.10	$293.16	$368.75
COVERT DARK BROWN/ LIGHT BROWN 53-19-140	$152.14	$188.12	$236.62

The first and second analyses for FY 2018 Order Data use the same holding costs and order costs as FY 2017 Order Data. The other variables such as order cost, service level, unit costs, and demand retained their original values. Table 20 shows the effects of the various holding costs on the EOQ. As the holding cost reduces, the EOQ increases. For example, when the ELITE PEWTER 50–19-145 SKL spectacle frame holding cost goes down from 15% to 10%, the EOQ increases from 337 to 413. The increase of 76 ELITE PEWTER 50–19-145 SKL spectacle frames reflect the lower cost of holding the inventory. On the other hand, as the holding cost goes up from 15% to 20%, the ELITE PEWTER 50–19-145 SKL EOQ spectacle frame decreases from 337 to 292. The decrease of 45 ELITE PEWTER 50–19-145 SKL spectacle frames reflect the higher cost of holding the inventory.

Table 20. Sensitivity Analysis of Holding Cost on FY 2018 Spectacle Frame EOQ

Description	EOQ at 10% holding cost	EOQ at 15% original holding cost	EOQ at 20% holding cost
ELITE PEWTER 50-19-145 SKL	413	337	292
ELITE PEWTER 52-21-135 SKL	90	74	64
ELITE PEWTER 52-21-140 SKL	154	126	109
ELITE PEWTER 52-21-145 SKL	359	293	254
ELLSWORTH GUN METAL/OLIVE 51-18-140	435	355	307
ELLSWORTH GUN METAL/OLIVE 51-18-145	133	109	94
ELLSWORTH GUN METAL/OLIVE 53-18-140	446	364	315
ELLSWORTH GUN METAL/OLIVE 53-18-145	217	177	153
FGN,GLD,52-20-140,SKL FG28W99G	313	256	221
FGN,GLD,52-20-140,STB FG28699G	682	557	482

Table 21 shows the effect of the holding cost on the Total Cost (EOQ) for each spectacle frame. The Total Cost (EOQ) goes down as the holding cost decreases. For example, the ELITE PEWTER 50–19-145 SKL spectacle frame Total Cost (EOQ) reduces to $138.51 ($754.82 − $616.31) as the holding cost decreases from 15% to 10%. However, when the holding cost goes up, the Total Cost (EOQ) also increases. The ELITE PEWTER 50-19-145 SKL spectacle frame Total Cost (EOQ) increases $640.65 ($871.59 − $229.94) as the holding cost increases from 15% to 20%.

Table 21. Sensitivity Analysis of Holding Cost on FY 2018 Spectacle Frame Total Cost (EOQ)

Description	Total Cost (EOQ) at 10% holding cost	Total Cost (EOQ) at 15% original holding cost	Total Cost (EOQ) at 20% holding cost
ELITE PEWTER 50-19-145 SKL	$ 616.31	$ 754.82	$ 871.59
ELITE PEWTER 52-21-135 SKL	$ 134.49	$ 164.71	$ 190.20
ELITE PEWTER 52-21-140 SKL	$ 229.68	$ 281.30	$ 324.82
ELITE PEWTER 52-21-145 SKL	$ 535.15	$ 655.42	$ 756.81
ELLSWORTH GUN METAL/OLIVE 51-18-140	$ 1,118.97	$ 1,370.45	$ 1,582.46
ELLSWORTH GUN METAL/OLIVE 51-18-145	$ 342.26	$ 419.18	$ 484.02
ELLSWORTH GUN METAL/OLIVE 53-18-140	$ 1,147.68	$ 1,405.62	$ 1,623.07
ELLSWORTH GUN METAL/OLIVE 53-18-145	$ 558.90	$ 684.51	$ 790.41
FGN,GLD,52-20-140,SKL FG28W99G	$ 555.55	$ 680.40	$ 785.66

Table 22 shows the EOQ decreases in quantity as the order cost decreases. For example, the ELLSWORTH GUN METAL/OLIVE 51-18-140 spectacle frame quantity decreases by 68 (355−287) as the order cost reduces from $101.09 to $66.12. The opposite effect to the EOQ occurs when the order cost increases. The ELLSWORTH GUN METAL/ OLIVE 51-18-140 spectacle frame quantity increases by 91 (446–355) as the order cost increases from $101.09 to $159.94. The higher order cost reflects the need to place larger order quantities to minimize inventory cost.

Table 22. Sensitivity Analysis of Order Cost on FY 2018 Spectacle Frame EOQ

Description	EOQ at $66.12 order cost	EOQ at $101.09 original order cost	EOQ at $159.94 order cost
ELITE PEWTER 50-19-145 SKL	273	337	425
ELITE PEWTER 52-21-135 SKL	60	74	93
ELITE PEWTER 52-21-140 SKL	102	126	158
ELITE PEWTER 52-21-145 SKL	237	293	369
ELLSWORTH GUN METAL/OLIVE 51-18-140	287	355	446
ELLSWORTH GUN METAL/OLIVE 51-18-145	88	109	137
ELLSWORTH GUN METAL/OLIVE 53-18-140	294	364	458
ELLSWORTH GUN METAL/OLIVE 53-18-145	143	177	223
FGN,GLD,52-20-140,SKL FG28W99G	207	256	321

Table 23 shows the effect of the order cost on the Total Cost (EOQ) for each spectacle frame. The Total Cost (EOQ) goes down as the order cost decreases. For example, the ELLSWORTH GUN METAL/OLIVE 51-18-140 spectacle frame Total Cost EOQ reduces by $262.11 ($1,370.45 − $1,108.34) as the order cost decreases from $101.09 to $66.12. However, when the holding cost goes up, the Total Cost (EOQ) also increases. The ELLSWORTH GUN METAL/OLIVE 51-18-140 spectacle frame Total Cost (EOQ) increases $353.40 ($1,723.85 – $1,370.45) as the order cost increases from $101.09 to $159.94.

Table 23. Sensitivity Analysis of Order Cost on FY 2018 Spectacle Frame Total Cost (EOQ)

Description	Total Cost (EOQ) at $66.12 order cost	Total Cost (EOQ) at $101.09 original order cost	Total Cost (EOQ) at $159.94 order cost
ELITE PEWTER 50-19-145 SKL	$ 610.45	$ 754.82	$ 949.46
ELITE PEWTER 52-21-135 SKL	$ 133.21	$ 164.71	$ 207.19
ELITE PEWTER 52-21-140 SKL	$ 227.50	$ 281.30	$ 353.84
ELITE PEWTER 52-21-145 SKL	$ 530.06	$ 655.42	$ 824.43
ELLSWORTH GUN METAL/OLIVE 51-18-140	$ 1,108.34	$ 1,370.45	$ 1,723.85
ELLSWORTH GUN METAL/OLIVE 51-18-145	$ 339.01	$ 419.18	$ 527.27
ELLSWORTH GUN METAL/OLIVE 53-18-140	$ 1,136.78	$ 1,405.62	$ 1,768.08
ELLSWORTH GUN METAL/OLIVE 53-18-145	$ 553.59	$ 684.51	$ 861.03
FGN,GLD,52-20-140,SKL FG28W99G	$ 550.27	$ 680.40	$ 855.86

The third analysis combines simultaneously the three postulated holding costs, (10%, 15%, and 20%) against the three order costs ($66.12, $101.09 and $159.94). The other variables such as service level, unit costs, and demand retained their original values. Table 24 and Table 25 show the EOQ and Total Cost (EOQ) effects of combining various holding costs and order costs.

In Table 24, as the holding cost increases, the Total Cost (EOQ) also increases. However, the EOQ decreases as the holding costs increases. When the holding cost increases from 10% to 15%, at an order cost of $66.12 there is a Total Cost (EOQ) increase

of $34.12 ($185.96 – $151.84). When holding cost is decreased from 20% to 15% at an order cost $159.94, the EOQ decreases by seven units (53−46) representing a decrease of $44.75 ($333.97 − $289.22) in Total Cost (EOQ).

Table 24. Sensitivity Analysis of Various Combinations of Holding Costs and Order Costs on FY 2017 Spectacle Frame EOQ and Total Cost (EOQ)

AFF-BLK 58-18-140 SKL						
S / H	10%		15%		20%	
$ 66.12	42	$ 151.84	34	$ 185.96	30	$ 214.73
$ 101.09	52	$ 187.74	42	$ 229.94	37	$ 265.51
$ 159.94	65	$ 236.15	53	$ 289.22	46	$ 333.97

Table 25 shows similar effects observed in Table 24. Varying the postulated holding costs and order costs produced inverse effects on EOQ and Total Cost (EOQ). When the holding costs increased from 10% to 15% at an order cost of $101.09, there is a decrease in EOQ of ELITE PEWTER 52-21-145 SKL spectacle frames by 66 units (359−293). This represents a $120.27 ($655.41 − $535.14) increase in Total Cost (EOQ).

Table 25. Sensitivity Analysis of Various Combinations of Holding Costs and Order Costs on FY 2018 Spectacle Frame EOQ and Total Cost (EOQ)

ELITE PEWTER 52-21-145 SKL						
S / H	10%		15%		20%	
$ 66.12	290	$ 432.79	237	$ 530.06	205	$ 612.06
$ 101.09	359	$ 535.14	293	$ 655.41	254	$ 756.81
$ 159.94	451	$ 673.12	369	$ 824.40	319	$ 951.94

D. SUMMARY

This chapter began by grouping the FYs' 141 spectacle frames using the ABC analysis into three categories. Each spectacle frame was ranked and grouped according to its contribution towards the total amount spent. Next, the demand analysis was used to formulate variable values such as order cost, service level, and holding cost that were applied to the inventory models and equations. The inventory models and equations were organized and simplified to show real-world applications. The results of the inventory models and equations showed extraordinary cost reduction potential, which aligns with the DHA's cost-saving initiative. Finally, the sensitivity analysis injected "what-if" values to the holding cost and order cost. Both costs had an influential effect on the amount of inventory to hold and order as the amount increases or decreases in the scenarios above.

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V. CONCLUSION AND RECOMMENDATIONS

A. CONCLUSION

This research presents a quantitative analysis to answer the following questions: What inventory management models are suitable for NOSTRA to optimize its inventory practices? How is NOSTRA managing its spectacle frame inventory? Does NOSTRA need to stock approximately 300 styles of spectacle frames on-hand? This analysis aggregates historical data into the best practices inventory management models to determine the optimal inventory and ordering schemes. The literature review and analysis are the framework to examine current inventory practices and adapt new strategies to reduce inventory and cost. It allows management and staff to holistically approach the supply chain process from request to fulfillment. There are reasonable limitations and assumptions within the thesis, yet the benefits drastically outweigh them. Last, this analysis facilitates potential recommendations for improvement and areas of future work.

B. RECOMMENDATIONS

Based on the quantitative analysis, this study has uncovered areas of opportunity that NOSTRA can use to improve its inventory management and policies. To complement the two-bin Kanban system, the ABC analysis will help the organization prioritize orders while reducing inventory levels and cost. Once the ABC analysis is conducted, NOSTRA may use the EOQ, ROP, and SS equations to determine inventory levels. The continuous review system and joint order strategy can be applied to the "A" and "B" categories to simultaneously take advantage of automation, reduce lead times, and lower on-hand inventories. This can also help the supplier side as well, by providing a steady demand signal. The suppliers can forecast demand and have product readily available to meet NOSTRA's order requisitions.

As a matter of policy, there are three recommendations. First, NOSTRA should consider removing "C" category items from on-hand inventory. This recommendation is backed by the short lead time across NOSTRA's suppliers. Furthermore, not stocking "C" category items will relinquish storage space to accommodate more "A" category and "B"

category items. “C” category items can be ordered on an as-needed basis. Second, NOSTRA should consider utilizing the joint ordering strategy for “A” category and “B” category items to significantly reduce the number of orders placed per year. The third suggestion is to advocate or purchase an information technology system that communicates and links the MTFs, NOSTRA, and suppliers. NOSTRA’s current supply chain system runs on three separate information systems: SRTS, DMLSS, and barcode scanning technology. Combining these separate systems into one system will yield the following benefits: improving information accuracy, optimizing inventory, helping to manage service levels, and reducing cost.

C. LIMITATIONS

Several factors limited the scope of this thesis. The design of this thesis was limited to five inventory management models. However, there is a plethora of inventory management models available. These five models are the most frequently used in the supply-chain management industry. These five models are inexpensive when conducting an analysis and do not require special software beyond Microsoft Excel.

The data used in the analysis covered two fiscal years. More years of data might provide more accurate results. NOSTRA carries approximately 3,000 SKUs. This project evaluated 141 SKUs partly due to the time constraint for completing this thesis.

The development of the order cost and holding cost are also limiting factors because of the lack of available empirical research within the DOD and the ophthalmic industry on these topics. The estimates used can be conservative or undervalued compared to similar organizations. Another limiting factor is with NOSTRA implementing the recommendations and studying the results. By having more time, this research can be validated. However, the time commitment for NOSTRA to implement changes goes beyond the scope of this thesis.

D. FUTURE WORK

There are several future projects that could be conducted at NOSTRA. Since this project only evaluates a limited number of frames across two fiscal years, a new project can expand it to more frames and cover three or more fiscal years of data. Another project can use a simulation model to develop optimal order quantities, safety stock levels, and ROPs. Other potential areas for future research include the evaluation of different types of radio frequency identification technology at NOSTRA to improve inventory management. There is also an opportunity to conduct Lean and Six Sigma projects for future studies. All these options for future research have the potential to improve efficiency and reduce cost for the DHA. Finally, another project could evaluate the impact of this thesis's recommendations to NOSTRA.

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APPENDIX A. SPECTACLE FRAME DATA

Table 26. FY 2017 Spectacle Frame Data

Description	Annual Demand	EOQ	ROP	SS
AFF BLK 55–18-150 SKL	48	42	4	4
AFF BLK 58–18-140 SKL	48	42	3	2
AFF GLD 55–18-145 SKL	124	68	8	6
AFF-JS EBONY AIRCREW 55–22-130	1455	232	55	33
AVIATOR, CHROME, 52–20,140 BAYONET RO	210	166	18	15
AVIATOR, CHROME, 52–20,145 SKULL RO	210	166	18	15
AVIATOR, GOLD, 52–20,140 BAYONET RO	210	166	18	15
COVERT DARK BROWN/ LIGHT BROWN 51–19-140	3520	533	156	102
COVERT DARK BROWN/ LIGHT BROWN 51–19-145	170	117	7	4
COVERT DARK BROWN/ LIGHT BROWN 53–19-140	70	75	5	4
COVERT DARK BROWN/LIGHT BROWN 53–19-145	4060	573	137	75
ELITE BLACK 50–19-140 SKL	50	67	3	3
ELITE BLACK 50–19-145 SKL	1860	410	73	44
ELITE BLACK 52–21-135 SKL	50	67	4	4
ELITE BLACK 52–21-140 SKL	20	43	2	2
ELITE BLACK 52–21-145 SKL	5110	680	181	102
ELITE BROWN 50–19-135 SKL	100	95	7	5
ELITE BROWN 50–19-145 SKL	100	95	5	3
ELITE PEWTER 50–19-135 SKL	335	174	16	11
ELITE PEWTER 50–19-145 SKL	769	264	30	18
ELITE PEWTER 52–21-135 SKL	50	67	3	3
ELITE PEWTER 52–21-140 SKL	232	145	12	9
ELITE PEWTER 52–21-145 SKL	754	261	35	23

Description	Annual Demand	EOQ	ROP	SS
ELLSWORTH GUN METAL/OLIVE 51–18-140	2225	341	91	57
ELLSWORTH GUN METAL/OLIVE 51–18-145	100	72	5	3
ELLSWORTH GUN METAL/OLIVE 53–18-140	1850	311	82	54
ELLSWORTH GUN METAL/OLIVE 53–18-145	1085	238	51	35
FGN,GLD,52-20-140,SKL FG28W99G	625	218	24	15
FGN,GLD,52-20-140,STB FG28699G	4225	566	99	34
FGN,GLD,52-20-145,SKL FG28Y99G	400	174	21	14
FGN,GLD,55-20-145SKL FG58Y99G	156	109	9	6
FGN,GLD,58-20-140,STB FG88699G	140	103	8	6
FRAME, EAB-17, BLACK, 43–18-175	658	225	19	9
FRAME, EAB-17, BLACK, 45–18-190	1021	280	31	16
HALFEYE FADE BROWN 48–20-145	180	201	9	6
HALF-EYE FADE BROWN 50–22-145	272	247	13	8
HALF-EYE FADE BROWN 50–22-150	110	157	7	5
HALF-EYE GRAY FADE 48–20-145	148	182	7	5
HALFEYE GRAY FADE 50–22-145	258	241	10	6
HALFEYE GRAY FADE 50–22-150	615	372	20	10
KEESLER BLACK/BRONZE 52–15-140	5803	503	192	103
KEESLER BLACK/BRONZE 52–15-145	620	164	40	31
KEESLER BLACK/BRONZE 55–15-140	8850	621	281	145
KEESLER BLACK/BRONZE 55–15-145	1765	277	70	43
KEESLER BLACK/BRONZE 58–15-140	350	124	26	21
KEESLER BLACK/BRONZE 58–15-145	7095	556	245	136
KINGSVILLE BLACK 51–17-135	805	262	43	30
KINGSVILLE BLACK 51–17-140	50	65	3	3
KINGSVILLE BLACK 53–19-140	3460	543	143	90
KINGSVILLE BLACK 53–19-145	50	65	3	3

Description	Annual Demand	EOQ	ROP	SS
KINGSVILLE BLACK 55–19-145	3495	545	131	77
LIBERTY GOLD 50–18-140	50	57	3	3
LIBERTY GOLD 50–18-145	25	40	2	2
LIBERTY GOLD 52–20-140	300	140	22	17
LIBERTY GOLD 52–20-145	25	40	2	2
LIBERTY GOLD 54–20-140	25	40	2	2
LIBERTY GOLD 54–20-145	770	225	32	20
LIBERTY RUTHENIUM 50–18-145	75	70	5	4
LIBERTY RUTHENIUM 52–20-140	4487	542	131	62
LIBERTY RUTHENIUM 52–20-145	125	90	6	4
LIBERTY RUTHENIUM 54–20-145	75	70	4	3
MUGA BLACK 50–17-135	75	70	4	3
MUGA BLACK 50–17-140	150	99	8	6
MUGA BLACK 52–19-140	6948	674	230	123
MUGA BLACK 52–19-145	830	233	36	23
MUGA BLACK 54–19-140	100	81	6	4
MUGA BLACK 54–19-145	8174	732	248	123
MUGA GOLD 50–17-135	75	70	5	4
MUGA GOLD 50–17-140	75	70	5	4
MUGA GOLD 52–19-140	50	57	3	3
MUGA GOLD 52–19-145	175	107	10	8
MUGA GOLD 54–19-145	50	57	3	3
OSAN BLACK 53–15-140	6740	594	172	68
OSAN BLACK 53–15-145	1810	308	91	63
OSAN BLACK 55–15-140	1690	297	67	41
OSAN BLACK 55–15-145	6915	602	187	81
R-5A BLACK 46–16-135	5249	927	444	363

Description	Annual Demand	EOQ	ROP	SS
R-5A BLACK 46–20-145	60	99	4	3
R-5A BLACK 48–18-135	1080	421	44	28
R-5A BLACK 48–18-145	180	172	8	5
R-5A BLACK 48–20-145	1020	409	37	22
R-5A BLACK 48–20-150	35	76	3	3
R-5A BLACK 50–18-135	220	190	10	6
R-5A BLACK 50–18-140	1220	447	54	36
R-5A BLACK 50–18-145	3772	786	105	47
R-5A BLACK 50–20-135	327	231	11	6
R-5A BLACK 50–20-140	8440	1176	251	121
R-5A BLACK 50–20-145	31780	2281	784	297
R-5A BLACK 50–22-135	60	99	5	4
R-5A BLACK 50–22-145	3916	801	119	59
R-5A BLACK 50–24-145	30	70	3	2
R-5A BLACK 50–24-150	315	227	21	16
R-5A BLACK 52–18-135	190	176	8	5
R-5A BLACK 52–18-140	980	401	27	12
R-5A BLACK 52–18-145	3486	756	108	54
R-5A BLACK 52–18-150	965	398	30	15
R-5A BLACK 52–20-135	100	128	7	5
R-5A BLACK 52–20-140	3990	808	133	72
R-5A BLACK 52–20-145	72897	3455	1796	679
R-5A BLACK 52–22-145	3044	706	116	70
R-5A BLACK 52–24-145	20	57	2	2
R-5A BLACK 54–20-145	30921	2250	699	225
R-5A BLACK 54–22-145	3990	808	130	69
R-5A BLACK 54–22-150	3275	732	176	125

Description	Annual Demand	EOQ	ROP	SS
R-5A BLACK 54–22-160	120	140	8	6
R-5A BLACK 54–24-145	690	336	24	13
R-5A BLACK 54–24-150	700	339	21	10
R-5A BLACK 54–24-155	280	214	15	10
R-5A RP BLACK 46–20-140	180	154	10	7
R-5A RP BLACK 48–22-135	40	72	4	3
R-5A RP BLACK 48–22-140	100	114	9	7
R-5A RP BLACK 48–22-145	520	261	20	12
R-5A RP BLACK 50–22-145	630	287	28	18
R-5A RP BLACK 50–22-150	340	211	14	9
R-5A RP BLACK 50–22-155	30	63	3	2
R-5A RP BLACK 52–24-145	75	99	6	5
R-5A TEMPLES BLACK 150MM	20	85	2	2
R-5AM, BLACK, 48–20-145	2470	636	85	47
R-5AM, BLACK, 48–20-150	20	57	2	2
R-5AM, BLACK, 50–20-140	850	373	45	32
R-5AM, BLACK, 50–20-145	9700	1260	232	83
R-5AM, BLACK, 50–24-140	40	81	4	3
R-5AM, BLACK, 50–24-145	1290	460	37	17
R-5AM, BLACK, 50–24-150	930	390	31	17
R-5AM, BLACK, 52–20-140	220	190	14	11
R-5AM, BLACK, 52–20-145	2410	628	93	56
R-5AM, BLACK, 52–22-145	1715	530	48	22
R-5AM, BLACK, 54–20-145	1250	452	43	24
R-5AM, BLACK, 54–20-150	1865	553	42	14
R-5AM, BLACK, 54–22-145	993	403	35	20
R-5AM, BLACK, 54–22-150	6498	1032	156	56

Description	Annual Demand	EOQ	ROP	SS
THUNDER BLACK 52–17-140	60	75	5	4
THUNDER BLACK 52–17-145	3846	603	116	57
THUNDER BLACK 54–17-140	20	44	2	2
THUNDER BLACK 54–17-145	8601	902	253	121
WILLOW GUN METAL 50–16-140	1928	355	83	53
WILLOW GUN METAL 50–16-145	300	140	16	11
WILLOW GUN METAL 52–18-140	2950	439	120	75
WILLOW GUN METAL 52–18-145	150	99	6	4
WILLOW GUN METAL 54–18-140	75	70	5	4
WILLOW GUN METAL 54–18-145	3325	467	115	64

Description and annual demand retrieved from DMLSS, August 2019

Table 27. FY 2018 Spectacle Frame Data

Description	Annual Demand	EOQ	ROP	SS
AFF BLK 55–18-150 SKL	517	139	20	12
AFF BLK 58–18-140 SKL	64	49	6	5
AFF GLD 55–18-145 SKL	83	56	5	4
AFF-JS EBONY AIRCREW 55–22-130	441	128	18	11
AVIATOR, CHROME, 52–20,140 BAYONET RO	1960	507	94	64
AVIATOR, CHROME, 52–20,145 SKULL RO	210	166	18	15
AVIATOR, GOLD, 52–20,140 BAYONET RO	875	339	53	40
COVERT DARK BROWN/ LIGHT BROWN 51–19-140	3620	541	100	44
COVERT DARK BROWN/ LIGHT BROWN 51–19-145	210	130	11	8
COVERT DARK BROWN/ LIGHT BROWN 53–19-140	110	94	8	6
COVERT DARK BROWN/LIGHT BROWN 53–19-145	5624	674	132	46
ELITE BLACK 50–19-140 SKL	50	67	4	4
ELITE BLACK 50–19-145 SKL	2535	479	77	38
ELITE BLACK 52–21-135 SKL	125	106	7	5
ELITE BLACK 52–21-140 SKL	1042	307	47	31
ELITE BLACK 52–21-145 SKL	4378	629	120	53
ELITE BROWN 50–19-135 SKL	25	48	2	2
ELITE BROWN 50–19-145 SKL	265	155	14	10
ELITE PEWTER 50–19-135 SKL	305	166	12	7
ELITE PEWTER 50–19-145 SKL	1260	337	35	16
ELITE PEWTER 52–21-135 SKL	60	74	4	3
ELITE PEWTER 52–21-140 SKL	175	126	9	7

Description	Annual Demand	EOQ	ROP	SS
ELITE PEWTER 52–21-145 SKL	950	293	29	15
ELLSWORTH GUN METAL/OLIVE 51–18-140	2405	355	67	30
ELLSWORTH GUN METAL/OLIVE 51–18-145	225	109	8	5
ELLSWORTH GUN METAL/OLIVE 53–18-140	2530	364	65	26
ELLSWORTH GUN METAL/OLIVE 53–18-145	600	177	23	14
FGN,GLD,52-20-140,SKL FG28W99G	860	256	29	16
FGN,GLD,52-20-140,STB FG28699G	4081	557	129	66
FGN,GLD,52-20-145,SKL FG28Y99G	625	218	40	30
FGN,GLD,55-20-145SKL FG58Y99G	125	97	7	5
FGN,GLD,58-20-140,STB FG88699G	41	56	3	2
FRAME, EAB-17, BLACK, 43–18-175	228	132	8	5
FRAME, EAB-17, BLACK, 45–18-190	851	256	19	6
HALFEYE FADE BROWN 48–20-145	320	268	16	11
HALF-EYE FADE BROWN 50–22-145	30	82	3	2
HALF-EYE FADE BROWN 50–22-150	260	242	16	12
HALF-EYE GRAY FADE 48–20-145	270	246	11	7
HALFEYE GRAY FADE 50–22-145	100	150	7	5
HALFEYE GRAY FADE 50–22-150	265	244	19	15
KEESLER BLACK/BRONZE 52–15-140	4880	461	172	97
KEESLER BLACK/BRONZE 52–15-145	1030	212	40	24
KEESLER BLACK/BRONZE 55–15-140	12850	749	274	77
KEESLER BLACK/BRONZE 55–15-145	2625	338	71	31
KEESLER BLACK/BRONZE 58–15-140	400	132	18	12
KEESLER BLACK/BRONZE 58–15-145	11253	701	233	61

Description	Annual Demand	EOQ	ROP	SS
KINGSVILLE BLACK 51–17-135	1775	389	50	22
KINGSVILLE BLACK 51–17-140	175	122	12	9
KINGSVILLE BLACK 53–19-140	2313	444	75	39
KINGSVILLE BLACK 53–19-145	175	122	12	9
KINGSVILLE BLACK 55–19-145	2235	436	67	33
LIBERTY GOLD 50–18-140	200	114	9	6
LIBERTY GOLD 50–18-145	100	81	7	5
LIBERTY GOLD 52–20-140	350	151	27	21
LIBERTY GOLD 52–20-145	25	40	2	2
LIBERTY GOLD 54–20-140	25	40	2	2
LIBERTY GOLD 54–20-145	2050	366	50	18
LIBERTY RUTHENIUM 50–18-145	100	81	6	4
LIBERTY RUTHENIUM 52–20-140	3520	480	97	43
LIBERTY RUTHENIUM 52–20-145	525	185	27	19
LIBERTY RUTHENIUM 54–20-145	994	255	39	24
MUGA BLACK 50–17-135	25	40	2	2
MUGA BLACK 50–17-140	1290	291	35	16
MUGA BLACK 52–19-140	5810	617	145	56
MUGA BLACK 52–19-145	1365	299	45	24
MUGA BLACK 54–19-140	50	57	3	3
MUGA BLACK 54–19-145	8010	724	197	74
MUGA GOLD 50–17-135	25	40	2	2
MUGA GOLD 50–17-140	600	198	31	22
MUGA GOLD 52–19-140	50	57	4	4

Description	Annual Demand	EOQ	ROP	SS
MUGA GOLD 52–19-145	100	81	7	5
MUGA GOLD 54–19-145	100	81	7	5
OSAN BLACK 53–15-140	4525	487	131	61
OSAN BLACK 53–15-145	408	146	12	6
OSAN BLACK 55–15-140	250	114	13	9
OSAN BLACK 55–15-145	7390	622	186	73
R-5A BLACK 46–16-135	155	159	11	9
R-5A BLACK 46–20-145	20	57	2	2
R-5A BLACK 48–18-135	820	366	28	15
R-5A BLACK 48–18-145	190	176	7	4
R-5A BLACK 48–20-145	5115	915	149	71
R-5A BLACK 48–20-150	90	121	6	5
R-5A BLACK 50–18-135	160	162	8	5
R-5A BLACK 50–18-140	1335	468	41	20
R-5A BLACK 50–18-145	3270	732	82	32
R-5A BLACK 50–20-135	340	236	18	13
R-5A BLACK 50–20-140	4630	871	151	80
R-5A BLACK 50–20-145	2190	599	66	33
R-5A BLACK 50–22-135	25	64	2	2
R-5A BLACK 50–22-145	4900	896	115	40
R-5A BLACK 50–24-145	100	128	7	6
R-5A BLACK 50–24-150	820	366	24	12
R-5A BLACK 52–18-135	100	128	9	7
R-5A BLACK 52–18-140	1105	425	28	11

Description	Annual Demand	EOQ	ROP	SS
R-5A BLACK 52–18-145	1935	563	92	63
R-5A BLACK 52–18-150	180	172	12	9
R-5A BLACK 52–20-135	90	121	6	5
R-5A BLACK 52–20-140	695	337	37	27
R-5A BLACK 52–20-145	1850	550	73	45
R-5A BLACK 52–22-145	510	289	21	13
R-5A BLACK 52–24-145	110	134	6	5
R-5A BLACK 54–20-145	1330	467	58	37
R-5A BLACK 54–22-145	70	107	5	4
R-5A BLACK 54–22-150	40	81	3	2
R-5A BLACK 54–22-160	70	107	5	4
R-5A BLACK 54–24-145	1145	433	32	14
R-5A BLACK 54–24-150	140	151	9	7
R-5A BLACK 54–24-155	170	167	8	5
R-5A RP BLACK 46–20-140	120	125	8	6
R-5A RP BLACK 48–22-135	15	44	1	1
R-5A RP BLACK 48–22-140	80	102	7	6
R-5A RP BLACK 48–22-145	930	349	22	7
R-5A RP BLACK 50–22-145	1430	433	37	15
R-5A RP BLACK 50–22-150	150	140	8	6
R-5A RP BLACK 50–22-155	25	57	2	2
R-5A RP BLACK 52–24-145	110	120	7	5
R-5A TEMPLES BLACK 150 MM	200	269	8	5
R-5AM, BLACK, 48–20-145	280	214	12	7

Description	Annual Demand	EOQ	ROP	SS
R-5AM, BLACK, 48–20-150	170	167	9	7
R-5AM, BLACK, 50–20-140	80	114	5	3
R-5AM, BLACK, 50–20-145	2590	651	152	112
R-5AM, BLACK, 50–24-140	20	57	2	2
R-5AM, BLACK, 50–24-145	1180	440	40	22
R-5AM, BLACK, 50–24-150	600	313	26	17
R-5AM, BLACK, 52–20-140	360	243	16	10
R-5AM, BLACK, 52–20-145	490	283	15	7
R-5AM, BLACK, 52–22-145	150	157	9	7
R-5AM, BLACK, 54–20-145	340	236	17	12
R-5AM, BLACK, 54–20-150	2125	590	73	40
R-5AM, BLACK, 54–22-145	968	398	28	13
R-5AM, BLACK, 54–22-150	715	342	60	49
THUNDER BLACK 52–17-140	280	163	12	8
THUNDER BLACK 52–17-145	1020	311	34	18
THUNDER BLACK 54–17-140	150	119	8	6
THUNDER BLACK 54–17-145	1270	347	35	15
WILLOW GUN METAL 50–16-140	225	121	11	7
WILLOW GUN METAL 50–16-145	175	107	9	6
WILLOW GUN METAL 52–18-140	1455	309	60	37
WILLOW GUN METAL 52–18-145	350	151	14	8
WILLOW GUN METAL 54–18-140	50	57	4	4
WILLOW GUN METAL 54–18-145	855	237	33	20

Description and annual demand retrieved from DMLSS, August 2019

APPENDIX B. SUPPLY CHAIN MANAGEMENT TERMINOLOGY

A. COUNCIL OF SUPPLY CHAIN MANAGEMENT PROFESSIONALS

The definitions below come directly from the Council of Supply Chain Management Professionals.

1. Cost-to-hold or opportunity cost is cost of holding inventory. It is expressed as the cost of a company's capital standards multiplied by average net value of inventory. (CSCMP, 2013, p. 105)

2. Cost-to-order or order fulfillment is a part of the order management cost. This includes costs associated with order processing, inventory allocation, ordering from internal or external suppliers, shipment scheduling, order status reporting, and shipment initiation. (CSCMP, 2013, p. 137)

3. Common cost is a cost that cannot be directly assignable to segments of the business, but that is incurred for the business. (CSCMP, 2013, p. 37)

4. Customer in a distribution (for example, Walmart or Safeway) is referred to as the trading partner or reseller. Another type of customer is characterized as direct-to-consumer, the end customer or user. (CSCMP, 2013, p. 50)

5. Demand is what customers or users want. Typically associated with the consumption of products or services as opposed to a prediction or forecast. (CSCMP, 2013, p. 57)

6. Base Demand is the level of demand for a product, which is based on actual history and/or known customer contracts. (CSCMP, 2013, p. 17)

7. Excess and obsolescence (E&O) is the accounting value assigned to the cost associated with inventory that is disposed of as being excess or obsolete. (CSCMP, 2013, p. 75)

8. Active Inventory is materials held in a facility, which are intended to be consumed in manufacturing/assembly, or sold in a specified period. (CSCMP, 2013, p. 4)

9. Available Inventory is also called net inventory; this is the quantity of stock that is available to use after considering allocations, reservations, backorders, and quantities set aside to compensate for quality problems. (CSCMP, 2013, p. 14)

10. Product life cycle is the life of a product in a market with respect to business sales and profits over time. There are five stages to the product life cycle: product development, introduction, growth, maturity, and decline. (CSCMP, 2013, p. 155)

11. Logistics is the process of planning, implementing, and controlling procedures for the efficient and effective transportation and storage of goods including services, and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements. This definition includes inbound, outbound, internal, and external movements. (CSCMP, 2013, p. 117)

12. Logistics Chain Manager plans appropriation of logistics chain resources to meet logistics chain requirements. (CSCMP, 2013, p. 117)

13. Inventory management is the process of ensuring the availability of products through inventory administration. (CSCMP, 2013, p. 105)

B. DOD SUPPLY CHAIN MATERIEL MANAGEMENT

The following definitions come directly from the DOD Supply Chain Materiel Management (DOD Manual 4140.01).

> 1. Cost-to-hold is the sum of the annual charge for funds invested in inventory, storage costs and losses due to obsolescence, inventory losses, misplacement, theft, or damage. For purposes of computing order quantities, cost-to-hold is expressed as a percentage of the inventory value being held in storage and considered synonymous with cost to store. (DOD, 2018a, p. 64)
>
> 2. Cost-to-order is the sum of the administrative expenses involved in procuring or requisitioning and issuing a single lot of one item regardless of the number of units ordered, their weight, cube, or dollar value. The major tasks contributing to the cost-to-order calculation include requirements determination, order or requisition preparation and recording, receipt processing and stowage of materiel, accounting for the transfer of funds between the ordering activity and the source of supply, and in the case of a requisition filled from a distribution depot, issue processing. For purposes of computing order quantities for time-phased demand, cost-to-hold is synonymous with lot size independent cost. (DOD, 2018a, p. 64)
>
> 3. Customer is an organization or end-user that consumes materiel through the DOD supply chain. (DOD, 2018b, p. 14)
>
> 4. Demand is an indication of a requirement, a requisition, or similar request for an item of supply or individual item. Demand is categorized as either recurring or non-recurring. (DOD, 2018b, p. 15)
>
> 5. Excess is materiel at a retail supply activity that is excess to that activity's requirements and is subject to return to the wholesale materiel manager, redistribution within the DOD supply chain, or disposal by DLA Disposition Services. (DOD, 2018b, p. 15)
>
> 6. Inventory is materiel, titled to the U.S. government, held for sale or issue, held for repair or held pending transfer to disposal (DOD, 2018b, p. 15).
>
> 7. Life cycle is the total phases through which a system or an item passes from the time it is initially developed until the time it is either consumed in use or disposed of as being excess to all known materiel requirements. (DOD, 2018b, p. 15)
>
> 8. Logistics is procurement, maintenance, and transportation of military materiel and personnel including organizing, supplying, equipping, training, servicing, mobilizing, demobilizing, administering, and

maintaining forces; constructing, outfitting, and repairing military equipment; constructing, maintaining, and repairing buildings, structures, and utilities; and acquiring, managing, and disposing of real property or natural resources. (DOD, 2018b, p. 15)

9. Materiel manager is any DOD organization or defense agency that has been assigned materiel management responsibilities for the DOD and participating federal agencies. The term includes responsibilities performed by either wholesale materiel managers or retail materiel managers. Those responsibilities include managing, cataloging, demand and supply planning, determining and defining requirements, and performing activities such as procurement, distribution, overhaul and repair of reparable materiel, and disposal of materiel. (DOD, 2018b, p. 16)

10. Inventory Control Program is established by the DOD component heads to maintain a physical inventory control of materiel (wholesale and below wholesale) in the DOD supply chain to provide for the economical and efficient stewardship of DOD supply system materiel and to serve as a key internal control for producing accurate and timely information on on-hand item quantities supporting inventory financial statement. (DOD, 2019, p. 5)

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