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Standardizing Ammunition Distribution within the United States Navy as either a Push or Pull Methodology

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MBA PROFESSIONAL REPORT

Standardizing Ammunition Distribution within the United States Navy as either a Push or Pull Methodology

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By: Kevin C. Richardson and Michael H. Malone

June 2012

Advisors: Geraldo Ferrer
Michael Dixon

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The purpose of this MBA Project is to investigate and provide a comprehensive assessment for standardizing the ammunition distribution system used by the United States Navy. This project was conducted with the sponsorship and assistance of the Naval Supply Systems Command – Global Logistics Support. The goal of this project was to identify and document both the push and pull methods of supply chain distribution and then recommend one of these methods, or possibly a hybrid of the two, to Naval Supply Systems Command for potential implementation. Analysis was performed on requisition information from the eight major Naval Weapons Stations to end users (those ordering particular types of ammunition) in an effort to determine which potential method would have the greatest economic impact for cost savings.

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STANDARDIZING AMMUNITION DISTRIBUTION WITHIN THE UNITED STATES NAVY AS EITHER A PUSH OR PULL METHODOLOGY

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Submitted in partial fulfillment of the requirements for the degree of

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STANDARDIZING AMMUNITION DISTRIBUTION WITHIN THE UNITED STATES NAVY AS EITHER A PUSH OR PULL METHODOLOGY

ABSTRACT

The purpose of this MBA Project is to investigate and provide a comprehensive assessment for standardizing the ammunition distribution system used by the United States Navy. This project was conducted with the sponsorship and assistance of the Naval Supply Systems Command – Global Logistics Support. The goal of this project was to identify and document both the push and pull methods of supply chain distribution and then recommend one of these methods, or possibly a hybrid of the two, to Naval Supply Systems Command for potential implementation. Analysis was performed on requisition information from the eight major Naval Weapons Stations to end users (those ordering particular types of ammunition) in an effort to determine which potential method would have the greatest economic impact for cost savings.

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LIST OF ACRONYMS AND ABBREVIATIONS

AMMOLANT	Ammunition Atlantic
AMMOPAC	Ammunition Pacific
CNO	Chief of Naval Operations
CONUS	Continental United States
DLA	Defense Logistics Agency
DoD	Department of Defense
DTCI	Defense Transportation Coordination Initiative
EAD	East Asia Division
GAO	Government Accountability Office
GRBLP	Global Requirements Based Load Plan
IUID	Item Unique Identification
JDDOC	Joint Deployment And Distribution Operations Center
JIT	Just In Time
JITD	Just In Time Distribution
JRIMM	Joint Regional Inventory Material Management
JTL	Joint Theater Logistics
LMS	Logistic Management Specialist
NAVMAG	Naval Magazine
NAVSUP GLS	Naval Supply Systems Command Global Logistics Support
NMC	Naval Munitions Command
NSN	National Stock Number
OIS	Ordnance Information System
RBS	Readiness Based Sparing
RFID	Radio Frequency Identification
SCM	Supply Chain Management
SLCM	Submarine Launched Cruise Missile
TPS	Toyota Production System
VERTREP	Vertical Replenishment
VMI	Vendor Managed Inventory

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The authors would like to thank all those who assisted in the completion of this project, most notably Professor Geraldo Ferrer and Professor Michael Dixon for their guidance and help throughout this process. Your support and instruction enabled us to accomplish this project. Additionally, the researchers would like to thank and acknowledge Captain Brian Drapp and Captain David Meyers for their direction and support of this sponsored project. The researchers offer special thanks to Mr. Craig A. Murphy, Mr. Robert N. Conquest, and Ms. Jill M. Bolig at the NAVSUP Global Logistics Support center for their insight into the current ammunition distribution system employed by the Department of the Navy.

LCDR Kevin C. Richardson

LT Michael H. Malone

I wish to thank my lovely wife, Haley, for her love and support during the duration of this project, because without her being there for me this project would have never left the ground. I would also like to thank my beautiful daughter, Madison, who always knew how to put a smile on my face after a tough day at work.

LCDR Kevin C. Richardson

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LT Michael H. Malone

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I. INTRODUCTION

A. PROBLEM BACKGROUND

Ammunition distribution for the United States Navy involves receiving a requisition from an end user and then shipping that required item to the customer. The current system is a "pull-based" method, which means that it is dependent upon the customer initiating the resupply process. Munitions distribution costs the Navy approximately $30M per year in total costs with nearly $9M of that being expedited shipments.

B. PURPOSE OF THE STUDY

The purpose of this MBA Project is to investigate and provide a comprehensive assessment for standardizing the ammunition distribution system used by the United States Navy. This project was conducted with the sponsorship and assistance of the Naval Supply Systems Command – Global Logistics Support. The goal of this project was to identify and document the current system used for ammunition distribution, discuss both the push and pull methods of supply chain distribution, and then recommend one of these methods, or possibly a hybrid of the two, to Naval Supply Systems Command for potential implementation based on data analysis. Analysis was performed on requisition information from Naval Munitions Commands to end users (those ordering particular types of ammunition) in an effort to determine which potential method would have the greatest economic impact for cost savings.

C. RESEARCH QUESTIONS

Little research has been conducted in the specific topic of ammunition distribution for any of the armed forces, so our efforts focused on reviewing the system currently in use and then comparing it to industry best practices. From this study and the creation of a Monte Carlo Simulation based on the last seven years' worth of requisition data, we determined a possible new approach for distribution that has the potential for considerable dollar savings for the Navy. Recognizing that each Service has different requirements for support and readiness, this proposed distribution system may not be compatible with the other services or DoD agencies.

We organized this project as follows: Chapter II is a discussion of what the Push and Pull Methodologies are and a literature review of what has been discussed previously. Chapter III provides background on each of the eight major Naval Munitions Commands and Chapter IV discusses the current ammunition distribution system used by the Navy as well as industry best practices for supply chain distribution models. We conducted data analysis and discuss Monte Carlo Simulation in Chapter V. Additionally, we provide our recommendations for future action by the Navy with regard to changing the ammunition distribution system in Chapter V. Finally, we conclude with recommendations for future studies in Chapter VI.

II. SUPPLY CHAIN DISTRIBUTION SYSTEMS

A. PUSH METHODOLOGY

In the following two sections, we discuss how supply chain strategies are categorized as either a Push- or Pull-based strategy. Each strategy is unique, with individual characteristics along with advantages and disadvantages. We explain in detail each one of these strategies.

The Push-based system of distribution has been in existence and documented as being used in production and manufacturing since the beginning of the twentieth century (although it was not always called "push"), coinciding with the manufacturing revolution that occurred during this same time period. In this system, manufacturers produce and distribute their products based on historical retailer orders data. With this historical data, a manufacturer/supplier is able to create a demand forecast, allowing them to make production quantity decisions (Skjott-Larsen, Schary & Mikkola, 2007). Under the Push system, "production is dominated by large consumer goods manufacturers. The manufacturers have long production runs in order to gain efficiencies of scale and minimize unit costs" (Bonacich & Wilson, 2008). Under this system, manufacturers often entice retailers with promotions and discounts in order to attain large advanced purchases pushing products out to the retailers' warehouses.

As with any type of supply chain strategy, there are always advantages and disadvantages of this production and distribution system. One advantage of using a push-based system is the idea of "product certainty." Manufacturers know with little doubt that the demand for their product will be consistent, so they can continue to have long production runs. Certain commonly used and mass-production items (see Figure 1) such as diapers, office supplies, basic construction materials, soap or detergent, pasta, etc., will yield success within a push system because they will always have a constant demand. This illustration shows this point by showing that these products "are characterized by predictable demand and slow product introduction frequency," which are suited best by utilizing a push-based strategy, yielding supply chain efficiency and high inventory turns (Simchi-Levi, Kaminsky & Simchi-Levi, 2008).

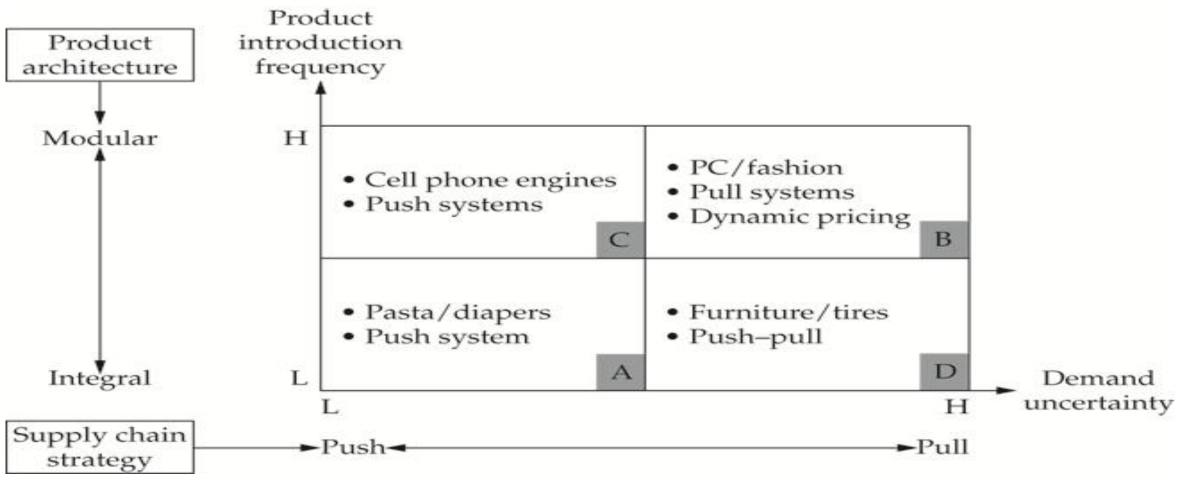

Figure 1. Supply Chain Strategies (From Simchi-Levi et al., 2008)

Another advantage and reason for manufacturers to use a push-based strategy is to have long production runs of a product, which ultimately lowers the per-unit cost of each item for the manufacturer. They are able to save money with their production costs because they are manufacturing more products per production run vice having to set up their production line to run that product more often creating economies of scale. Through these economies of scale, the company is able to achieve a larger item capacity, therefore they are able to offer their product to consumers at a lower price. Also, with long production runs, the chances of running out of a product are lowered because the manufacturer has produced enough for the retailer to last until the next scheduled production run.

Due to production and distribution being based on demand forecasts, it takes longer for a push-based supply chain system to react to the changing market place, which can lead to overreaction and the bullwhip effect. The manufacturer maintains a consistent production schedule and unless there is communication with the retailer about the current demand for a product, the product could be overproduced if demand drops. This potential for overproduction would then lead to a lower number of inventory turns and high average on-hand inventory, as well as increased inventory costs. In many common production scenarios, there is almost no communication between the retailer and manufacturer regarding customer demand, so the “lack of visibility on the manufacturer” will ultimately lead to excess inventory because the manufacturers base their production runs and distribution on demand forecast as opposed to actual sales (Viale, 1996). Another disadvantage with push-based strategy is tied to the actual demand forecast never being completely accurate, which can lead to either “lost sales, obsolete inventory, and inefficient utilization of resources” (Simchi-Levi et al., 2008).

During particular seasons, like Christmas, there is little to no flexibility to accommodate “a sudden surge in consumer demand for a hit product.” An example of this occurred in 1996 with the “Tickle Me Elmo” doll. The manufacturer, Tyco Toys, had no idea that its product would be in such high demand and did not have the manufacturing capacity to complete a quick production run in order to meet the unexpected surge, losing all potential sales. Because customer demand was underestimated for this toy, Tyco Toys manufacturers were caught with a demand level in excess of what they could support.

If the supplier obtains demand information directly from its customers, and if the customers allow the supplier to control the shipments, this push-based system is called a Vendor Managed Inventory (VMI). VMI has advantages in potential inventory reduction because of just in time distribution from the supplier to the retailers. These benefits are typically counted by a requirement for a high level of trust to exist between the supplier and retailer for this type of system to work. As will be discussed later in this project, the element of trust is necessary for a VMI distribution system to operate efficiently.

To summarize, a push-based strategy is good for the manufacturer if they are able to produce large amounts of a single product, spreading the setup costs against a large number of units. This will ultimately lower the individual costs to manufacture that item. This strategy is also good for items that have a predictable demand because the manufacturer can continue to produce this item knowing that the demand will not falter. The disadvantage of a push-based system is its reliance on forecasts used to determine production levels. There is no guarantee that the forecast will always be accurate; thereby creating the risk that there will not be enough of the product to meet demand or that there will be too much product raising inventory holding costs.

B. PULL METHODOLOGY

The "Pull" inventory management system, sometimes called Just-In-Time (JIT), began as one facet of Toyota's "lean" production methodology. The background idea of lean manufacturing was to create the desired product with as little waste as possible, with the definition of waste being anything that the customer did not want. If done properly, "lean" can provide immense gains "by eliminating non-value-adding activities, reducing lead times and faster flow through the factory by driving manufacturing through customer demand (pull) and continuous improvements" (Patni Computer Systems, 2005). This pull management system has now been incorporated into many manufacturing processes by a number of suppliers due to its direct impact on total costs through the reduction of operational expenses.

The pull inventory management system performs as follows. When any item is sold by a retailer, that retailer places an order to replace that single item only. That single item, which would be the finished product handled by the supplier, is shipped to the retailer. The supplier now has a gap in its finished product inventory, so that supplier will now "pull" another finished product from upstream to replace what was shipped. If no finished product exists, an upstream workstation may have to complete the manufacturing process. Regardless of the number of workstations involved in this total process, only one order moves at a time with each station pulling from the next upstream workstation. Eventually, the "last" upstream station is reached—that of bringing raw materials into the factory to begin the work-in-process labor. In practice, the pull system may involve larger orders (instead of a single unit) constituting what is called a Kanban: the standard lot size calculated for that particular item managed by the pull system.

Boundaries, or clear separation points, can be created between push and pull methodologies where one method might be more profitable than the other. Performance measures such as customer wait time and service goals will allow the manufacturer to choose the correct support and distribution method. When determining this boundary between push and pull (see Figure 2), "the decoupling point separating the part of the supply chain operating in a make-to-order environment [pull] from the part of the supply chain based on planning [push]" must be ascertained (Croxton, Garcia-Dastugue, Lambert, & Rogers, 2001).

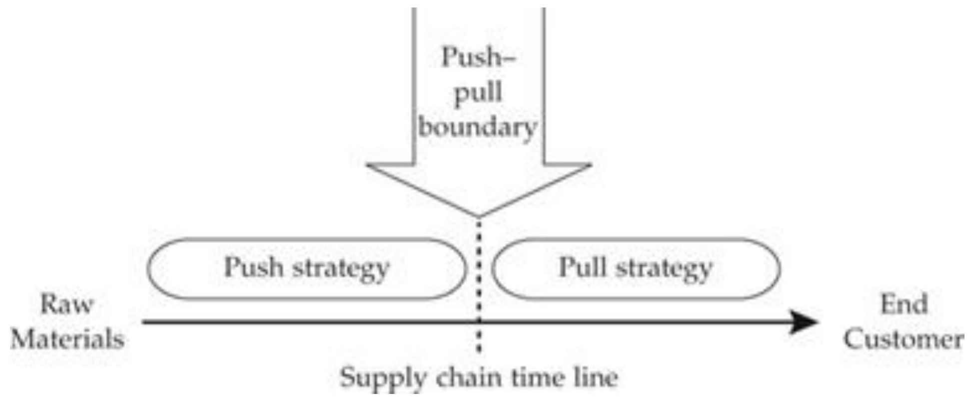

Figure 2. Push-Pull Boundaries (From Simchi-Levi et al., 2008)

The Kanban system (see Figure 3) is an example of the pull methodology in action. Also developed by Toyota, the Kanban system incorporates a visual trigger to signal demand. While the word "kanban" means "sign" or "instruction card," there are also other paperless methods for controlling product movement. One example is the use of containers or bins—if the bin is empty, it means that the worker at that station has used up all available resources and must be resupplied in order to continue working. This empty bin is then filled by the next upstream worker from his own bin of ready for transfer parts. Other production lines might use colored golf balls to signify a requirement of a certain type of part needed in the manufacturing process. The key difference between the pull and push systems of inventory management can be seen with this example—while a worker may have material that is ready to be used by the next person downstream in the manufacturing process, that material is not sent "down-the-line" until it is requested. Thus, the downstream worker pulls material from upstream rather than having it pushed to him (Jacobs, Chase, & Aquilano, 2009). Stated a different way, "the ordering quantity for each process is determined on the basis of the consumed quantity at the inventory station where the items processed at the process are stocked" (Takahashi & Nakamura, 2004).

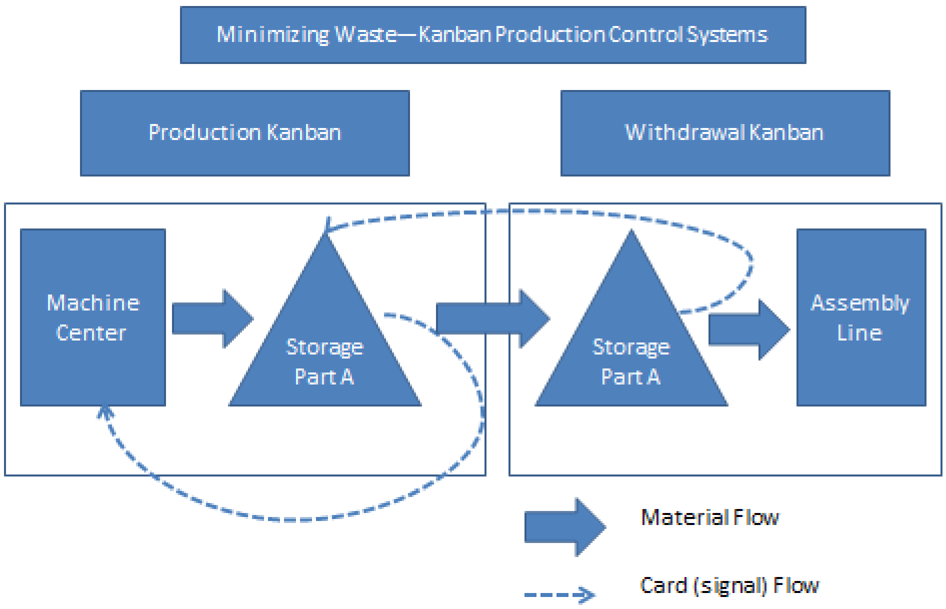

Figure 3. Kanban System (After Jacobs, Chase, & Aquilano, 2009)

The greatest benefit of the pull methodology is the reduction in operational expenses because of the elimination of waste. Since orders are placed only upon a sale, another benefit is a reduction of working capital required for operations because work-in-process inventory only needs to be as large as the next order (no stockpiling is required). Capital requirements are also reduced due to the fact that large amounts of cash are not typically tied up in held inventory—the retailer has an initial start-up cost to fill his or her shelves but, after that, only orders what is actually selling. The pull method also allows for a retailer to take action only if demand changes, preventing the retailer from suffering from the bullwhip effect (Arts, 2004).

Some of the risks of shifting to a pull method for inventory management include higher ordering costs, transportation costs, and strains on the supplier-retailer relationship because of more frequent orders. Due to the reduced order size when using the pull method (as opposed to the push methodology which orders up to a desired on-hand inventory number) and assuming that there is a fixed cost of placing an order, the ordering costs will rise in correlation to the increased number of orders. This ordering cost should be fairly stable after fully conversion to the pull system, which will then make holding costs an overriding factor for implementation decisions. Since pulling inventory reduces the on-hand inventory requirement, the holding costs should also be reduced and the pull system should become “more cost-effective at a wider range as the demand level increases” (Abuhilal, Rabadi, & Sousa-Pouza, 2006).

Similar to ordering costs, the transportation costs that a business incurs when shifting to a pull inventory management system are likely to increase. These cost increases are due to the more frequent but smaller-sized deliveries that have to occur to ensure that a factory can remain a just-in-time producer. The increase in transportation costs may, however, be offset by the reduction in on-hand inventory requirements, so the total operating costs may actually fall (Aron, 1998). Additionally, if a retailer is able to receive split vendor shipments, where merchandise originating from many companies is loaded onto the same truck for delivery, costs may be reduced by receipt of a single truck rather than numerous partially filled ones.

Finally, the relationship between a supplier and a retailer can become strained when implementing a pull management system. “With a pull contract the manufacturer/ supplier bears the inventory risk because only the supplier holds inventory while the retailer replenishes as needed during the season” (Pearson, 2008). Many of these retailers are risk averse and carry only the inventory that is found on the shelves of their stores, so they have to be willing to directly communicate with their suppliers and often even share real-time data. Retailers that have incorporated the pull inventory management system often have some of the best information and technology infrastructure as well as supply chain management concepts in order to achieve this symbiotic working relationship with their suppliers (Wong, Arlbjorn, & Johansen, 2005).

As can be seen from the above discussion, there are many varying opinions on which method is best for production and distribution. While most academics and practitioners tend to favor the pull methodology, this is not always the correct option for every circumstance. The pull system is excellent in many various environments, but it can also be disastrous in other operations. The main issue is that the pull system cannot react quickly to sudden increases in demand while the push system protects against these surges in demand by having an increased on-hand inventory at all times. This balance between on-hand inventory and protection level is what will be discussed in this project.

C. LITERATURE REVIEW

In this section, we discuss the literature on Supply Chain Management and Push and Pull Methodologies as used within private business strategies that can be applied to the Naval Ammunition Distribution System.

Simchi-Levi, Kaminsky, and Simchi-Levi (2008) discuss how the supply chain in any industry is the group of suppliers, producers, transporters, distributors and end customers, and supply chain management (SCM) is the process of managing the relationships between each of these groups whom often have different goals and metrics for performance. They specifically defined SCM as "a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wide costs while satisfying service level requirements."

Sahay and Mohan (2003) address how inventory replenishment is conducted using a push-based system and how the long-term forecasting models used by this system can affect retailer's warehouses. Specifically, because of flaws in the forecasting model, a retailer might have a glut of inventory that customers are not willing to buy or a shortage of items that are in high demand. They briefly discuss the pull inventory process and its respective influence on inventory management. This influence is based expressly on the movement of a product from the store's shelves due to customer demand. Production in the pull system is thus demand driven in an effort to only replace what was removed and not what is forecasted to move in the future.

Takahashi and Nakamura (2004) indicate that, within the SCM framework, there are three methods of control—those of push, pull, or a hybrid mix of the two. Their writings reflect that the amount of inventory flowing through a system is the key factor when determining which method of distribution is best suited for use. When the push system is used, a company will typically have a larger amount of work in process within their production and distribution systems and conversely, a pull system will have less work in process inventory held at a particular location but will require more frequent shipments between locations or workstations. Finally, a hybrid version can be created that may be able to balance the areas in production that require higher levels of inventory (push-based) with those that require less (pull-based).

Aron (1998) reported on how industries shift from push to pull methods in SCM by analyzing what she deemed the "old" (push) and "new" (pull) ways of doing business. Her article lists many of the costs of shifting from push to pull, which can be applied to any industry or supply chain, whether it is a private company or in the public domain such as the DoD. Examples of these costs include increased transportation costs due to an increase frequency of shipments and ordering costs if there is a set price for placing an order. In turn, these costs may be offset by the reduced amount of inventory required to be held on-hand by the pull system.

Croxton, Garcia-Dastugue, Lambert, and Rogers (2001) enter the discussion on SCM by defining what they deem the eight core SCM processes and how each core element must be implemented at both operational and strategic levels if a fully effective supply chain is to be built. Examples of these core SCM processes include "customer relationship management, demand management, order fulfillment, and manufacturing flow management." They stress that the level of flexibility desired by the customer within each of these processes will ultimately determine the push-pull boundary for stocking points. One of the key additions of these authors' writings is that they identify where the Push-Pull Boundary in production and distribution may exist. It is this boundary point where the possibility of creating a hybrid system of push and pull might alleviate strains associated within each of these systems.

Pearson (2008) reviews how push and pull strategies are incorporated into manufacturing, and how each strategy places the inventory risk on different places of the overall supply chain. When using the push strategy, the manufacturing process is driven by customer due dates and the stocking levels of the retailer. Risk must be accounted for due to the forecasting nature of the push system because orders are placed prior to the selling season, so if customer choice changes, the retail store is left with unsellable merchandise. With the pull strategy, it is the manufacturer that bears risk because they might not be able to meet customer demand in a timely fashion and would thus lose sales to a competitor. Thus, the pull system can be more appropriate when the demand is predictable or when the supplier has sufficient capacity to supply during times of peak demand. Additionally, Pearson elaborates on how customer demand and the distribution strategies will influence each other—something of particular interest in both public and private industry.

Agarwala (2005), who wrote for Patni Computer Systems Limited, discusses Supply Chain Optimization, which is a subset of SCM seeking to optimize every step by identifying and working with "value chain members" within the total supply chain. Agarwala specifically shows how lean manufacturing, one step in the pull strategy, can not only eliminate non-value added activities within the supply chain, but also lead to the adoption of a pull distribution system. She illustrates how software applications can support lean techniques, such as using a pull-based scheduling system of delivery to minimize inventories and work-in-process.

Wong, Arlbjorn, and Johansen (2005) reviewed the supply chain of a private industry in Europe where volatility of customer demand and the seasonality directly impact how retailers stock their shelves. They specifically discuss the toy industry and how seasons and holidays associated with those times of year directly affect new product lines (new products are introduced around Christmas holidays). Additional strains on this supply chain exist because of the storage and disposal costs associated with an inventory that can quickly become obsolete. They discuss how point-of-sale data sharing improves retailer support from its suppliers, which ultimately provides the customer with the right product at the right time. They conclude by discussing relationships within the supply chain for the suppliers and retailers and how any gaps between policies and risk attitudes between the two can be narrowed.

Powell (2002), writing in a Conference Board report, relays information on the transformation of the supply chain within the business model due to technology improvements (enterprise resource planning software, the Internet, etc.), global reach of companies, and senior executive influence. This reorganization and transformation has led to new measures of effectiveness and performance. Powell proposes the most effective metrics according to senior business executives whose jobs depend on effectively and efficiently managing their supply chains. These metrics include "total year-over-year savings; lower inventory levels expressed in dollars; reduced logistics and delivery costs; increased speed in supply chain operations; reduced lead times" among others. They can be used to determine if a supply chain is performing at optimum levels and where to potential make changes to improve the overall process.

Abuhilal, Rabadi, and Sousa-Poza (2006) perform a comparative study on Just-In-Time (pull) distribution systems with Material Requirements Planning (push) systems. After identifying numerous parameters (such as cost of facilities, inventory, transportation, and information) that can be used to determine the best system for one's supply chain, they present a methodology for comparison and selection. The most important elements for determining the best methodology are "inventory costs, demand patterns, and the average demand level." If the desire is to have the lowest inventory costs, then a pull system should be selected; whereas if all available information provides only average demand levels and patterns, then a push system would be better suited for the total process.

Trebilcock (2009) discusses how Defense Logistics Agency (DLA) is working with Accenture, a non-defense company, to overhaul its supply chain management processes and systems to become more demand driven. Rather than relying on historical forecasts to push material, DLA wants to capture real-time demand and use supply chain planning and management tools to provide items according to demand. Trebilcock shows how this demand-driven supply chain can work with regards to planning aircraft maintenance parts.

Lavallee (2009) suggested in an article that appeared in The Globe and Mail (Canada) that in order for the U.S. auto industry to survive, they needed to revamp their "centrally-planned push system that breeds complexity and inefficiency." He specifically discussed General Motors and its need to convert their push-production and supply chain model into a consumer-driven demand pull production model, which in the end would allow them to compete effectively because their product lines and production systems would be dramatically simpler, their business models would be lower-cost, and their supply chains would be tightly integrated from suppliers all the way to the dealers. While many companies did shift to a pull-type system, some of these same companies had shifted back to push-based systems because of changes in philosophies in senior management.

The Government Accountability Office (GAO) issued a progress report in 2009 that the DoD needed to produce significant improvements to the inventory management and distribution aspects of supply chain from a "high" to a lower risk level. The overall GAO recommendation is to improve the provision from suppliers to the war-fighter and to improve readiness of equipment while reducing and/or avoiding costs. DoD plan on achieving this by concentrating on three major focus areas: Asset Visibility, Forecasting, and Distribution. By applying metrics and baselines to the focus areas, the DoD set about to start ten major initiatives listed below:

- Radio Frequency Identification (RFID)
- Item Unique Identification (IUID)
- Joint Regional Inventory Material Management (JRIMM)
- Readiness Based Sparing (RBS)
- War Reserve Material Improvements
- Commodity Management
- Joint Theater Logistics (JTL)
- Joint Deployment and Distribution Operations Center (JDDOC)

- Defense Transportation Coordination Initiative (DTCI)
- Business Enterprise Priorities

A majority of the initiatives listed above do not specifically call out utilizing a push or pull system of distribution, but the long-term goal of this study was to ensure that “responsive, consistent, and reliable support” could be provided to the war-fighter during peacetime and war, which involves utilizing either a push, pull or hybrid mixture of a distribution system.

The DoD replied to a GAO report in 2007 acknowledging having major issues within its Supply Chain Management practices. There have been several audit organizations that provided over 400 recommendations that focused specifically on improving certain aspects of the DoD’s Supply Chain Management, which included management oversight, performance tracking, planning, policy, and processes. At the time of the response, the DoD had implemented 275 of the recommendations. The GAO acknowledged that the DoD had made a strong commitment to improving Supply Chain Management, but stated that the DoD’s plan lacked outcome-focused performance metrics and cost metrics that would enable tracking the efforts in order to demonstrate improvements in Asset Visibility, Forecasting and Distribution.

A number of websites were useful in our discussion of Naval Munitions Commands. Specifically, we used www.ToyotaGlobal.com, www.GlobalSecurity.org, www.MilitaryNewComers.com, www.Navy.Memorieshop.com, and www.CNIC.Navy.mil. Each of these websites provided valuable information that was difficult to locate otherwise due to the relatively new status of Naval Munitions Commands (previously called Naval Magazines and Naval Weapons Stations).

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III. NAVAL MUNITIONS COMMANDS BACKGROUND

A. OVERVIEW

In this section, we outline each of the eight major Naval Munitions Centers (NMC) (displayed in Figure 4). Located on both east and west coasts, as well as at overseas locations, these NMCs directly support a direct customer base. We include their locations and who their main end-user customers are as part of this discussion.

Figure 4. Major Naval Munitions Command

B. NAVAL MUNITIONS COMMAND (NMC) - EARLE

NMC Earle is located along the northern shore of New Jersey and is currently the homeport to 4 support ships (USS SEATTLE, USS DETROIT, USS SUPPLY, USS ARCTIC) and the Combat Logistics Group 2. Named after Rear Admiral Ralph Earle, who was the Chief of the Bureau of Ordnance during World War I, NMC Earle was opened in 1943. The most distinguishing characteristic of this munitions center is “Wye” shaped pier (see Figure 5) that stretches over two miles into the Sandy Hook bay

(GlobalSecurity.org website, 2011). This pier was designed so that multiple deep draft vessels could pull into the bay and conduct weapons onloads at a safe distance from land (and the civilian population).

Additionally, there is the “Mainland” portion of the base which is used to house ammunition that is provided to the fleet. NMC Earle has “an integrated work force of military and civilian personnel [that] operate the inland storage, renovation, transshipment and demilitarization facilities” (GlobalSecurity.org website, 2011). Today, NMC Earle’s main customers are those supply ships that onload weapons and then sail to meet combatant ships for munitions transfers conducted at sea.

Figure 5. “Wye” Pier at NMC–Earle (From GlobalSecurity.org website, 2011)

C. NAVAL MUNITIONS COMMAND - YORKTOWN

NMC Yorktown is located in Yorktown, Virginia, and is the home of the Navy Munitions Command. This command “is designed to align all ashore ordnance support operations in the United States and Asia into one worldwide unit and consolidate 2.100 personnel under three divisions: CONUS East Division, CONUS West Division and East Asia Division” (Navy.mil website, 2011). Near the home of the Atlantic Fleet in Norfolk, Virginia, NMC Yorktown is the home of 25 tenant commands and directly supports the fleet as supply, amphibious and combatant ships can been seen arriving and departing either of the base's two piers.

D. NAVAL MUNITIONS COMMAND - CHARLESTON

NMC Charleston is located in Charleston, South Carolina, and is the home to the Naval Nuclear Power Training Command and the Navy Munitions Command CONUS East Division Detachment. The Nuclear Power Training Command is where officers and enlisted sailors undertake intensive training to operate nuclear propulsion plants on either aircraft carriers or submarines. The then-Weapons Station was first appointed in 1690 as a "Powder Receiver" and was formally commissioned in 1941 and designed to hold more than 60 million pounds of conventional ordnance.

"NMC CED Detachment Charleston maintains 55 magazines and seven above ground storage sites which have a capacity of more than 60 million pounds of explosives. It provides ordnance support to the Marine Corps and Army Pre-positioned Afloat Programs, provides ordnance to military units in theater and throughout the world, supports the ordnance needs of the Federal Law Enforcement Training Center, and arranges world-wide ordnance transportation requirements for Naval Weapons Station and tenant activities including The Citadel" (MilitaryNewcomers.com website, 2011).

E. NAVAL MUNITIONS COMMAND – INDIAN ISLAND

NMC Indian Island is located in Washington State between Port Townsend Bay and Kilisut Harbor and is the only deep water ammunition depot on the Pacific coast for naval combat ships and Military Sealift Command vessels in the Pacific Fleet and joint services. Previously a naval magazine, the United States Navy also uses Indian Island as a servicing center for the converted Ohio-Class Ballistic Missile submarines (now SSGNs). The ammunition pier at Indian Island is capable of handling multiple ships at once and is large enough to service a Nimitz-class aircraft carrier. NMC Indian Island has a working staff of twelve active duty military and approximately 124 civil service and contract employees who handle the receipt, storage, issuance, and inspection of ammunition (Navy.Memorieshop.com website, 2011).

F. NAVAL MUNITIONS COMMAND – SEAL BEACH

NMC Seal Beach is located in Seal Beach, CA. Since World War II the base has evolved into the Navy's primary West Coast ordnance storage, loading and maintenance installation. Under the station's primary tenant, the Navy Munitions Command, cruisers, destroyers, frigates, and medium-sized amphibious assault ships are loaded with missiles, torpedoes, countermeasures devices and conventional ammunition at the facility's 1,000-foot-long wharf (more information on these vessels and weapons can be found at the Navy Fact File). In addition, larger ships can be accommodated within a protected explosives anchorage located in nearby Long Beach Harbor. Personnel also perform maintenance on some weapons systems. An average of 50 vessels either onload or offload weapons here each year. The weapons station services a majority of the U.S. Pacific Fleet.

NMC Seal Beach also has two detachments located in Fallbrook, CA, and Norco, CA, each serving a different purpose. Unique among most naval weapons facilities, Detachment Fallbrook is located 9 miles inland. Ammunition is transferred to and from ships by a process known as Vertical Replenishment, or VERTREP. In this operation, ammunition is taken by truck from a magazine on base to a helicopter pad located inside Camp Pendleton. From the helicopter pad, MH-60S Seahawk helicopters lift the load and transfer it to the receiving ship waiting several miles off the coast. In this manner, large vessels such as amphibious assault ships can be loaded without leaving their primary Southern California operating and training areas.

Detachment Fallbrook is also home to the only West Coast Air-Launched Missile Production and Storage Facility. Here air-launched missiles are inspected, maintained and re-certified. Overall, the installation stores munitions with a monetary value of approximately half a billion dollars. Detachment Norco is a weapons research facility where they conduct and assess current and future weapons (CNIC.Navy.mil website, 2011).

G. NAVAL MUNITIONS COMMAND – PEARL HARBOR

NMC Lualualei is located in the State of Hawaii on the island of Oahu. The magazine complex at the Lualualei Headquarters Branch occupies approximately 7,498 acres of land in the Lualualei Valley on the Leeward (western) coast of Oahu. The mission of Naval Munitions Command, Lualualei is to receive, renovate, maintain, store, and issue ammunition, explosives, expendable ordnance items and weapons, and technical ordnance material for the Navy, Air Force, and Army and other activities and units as designated by the Chief of Naval Operations (CNO). Fifty W-800—munitions for Tomahawk Submarine Launched Cruise Missiles (SLCM) and 40 nuclear aerial bombs are stored in the Lualualei Naval Magazine (NAVMAG) at West Loch on Oahu, Hawaii (GlobalSecurity.org website, 2011).

H. NAVAL MUNITIONS COMMAND – GUAM

NMC – East Asia Division (EAD) Guam is located in Hagatna, Guam and is the Navy's largest and most capable overseas mine shop. The primary mission is to store, maintain, assemble, and deliver underwater mines in response to tasking from Unified Theater Commanders. NMC EAD Guam directly supports Commander SEVENTH FLEET aircraft and submarines; however, the primary mine delivery platforms that they support are United States Air Force strategic bombers, which fly missions out of Andersen Air Force Base, also located on the island of Guam (CNIC.Navy.mil website, 2011).

I. NAVAL MUNITIONS COMMAND – SASEBO (JAPAN)

NMC EAD Detachment Sasebo is located in Sasebo, Japan, and maintains the largest ordnance facility in the Western Pacific Ocean area. The primary mission is to provide ammunition and other ordnance material to the war fighter. The two facilities at Maebata and Harioshima play a vital role in arming our forward-deployed Navy, Marine Corps, Army and Air Force units, who protect the 7th Fleet area of concentration. Currently, there are close to 40,000 tons of Navy and Marine Corps Ammunition housed at the detachment facilities in Sasebo (CNIC.Navy.mil website, 2011).

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IV. ORDNANCE SUPPLY CHAIN AND INDUSTRY BEST PRACTICES

A. ORDNANCE SUPPLY CHAIN

1. Current Process Review

In this section, we discuss the current ordnance distribution phase of the supply chain that is employed in the United States Navy. For this discussion, we split the distribution of munitions into two categories: the first being the Load Plan Requisition Distribution Model and the second being the End User Distribution Model.

a. Load Plan Requisition Distribution Model

This portion of the distribution supply chain begins with the Strategic Storage facilities. These deep storage facilities house munitions which are received directly from contractor sites or maintenance facilities to be distributed to various Naval intermediate storage points prior to shipment to the end user. For the Navy, the Naval Munitions Commands play the role of the intermediate storage facility. The inventories located at the NMCs are managed by the Naval Supply Systems Command (NAVSUP) Logistic Management Specialists (LMS), who oversee the inventory of the non-nuclear ammunition supply chain.

The Load Plan Requisition Distribution Model is designed for the resupply of Naval Munitions Commands for the support of the Global Requirements Based Load Plan (GBRLP). The Load Plan for a NMC is defined as the required munitions that must be maintained on hand to ensure that its stated customers (end users such as ships, aircraft squadrons, SEAL Teams, SEABEE Battalions, Coast Guard units and United States Marine Corps aviation units) can place a requisition and have their on-hand allowances at 100%. Essentially, the Load Plan stocking thresholds are calculated based on the cumulative total of weapons required by the end users supported by that particular NMC. These NMCs are supplied based on gaps in the Load Plan requirements. For example, if one NMC is tasked with supporting the weapons allowance for 10 Destroyers, that NMC must hold any munitions that are required to get those individual destroyers up to their

100% on-hand allowance. So, if a destroyer has an allowance of 100 5-inch rounds and only has 75 currently on-hand, the NMC must have the remaining 25 on-hand and ready for shipment to that destroyer.

If the NMC falls ever below 90% of what is required to be on-hand to satisfy the Load Plan, that NMC is deemed non-compliant (R. M. Conquest, personal communication, March 7, 2012). There are two methods of remedy if this situation occurs. The first is for the NMC to send a requisition to the strategic storage facility to replenish any munitions that may have been shipped to an end user to bring the inventory level back to compliance. This system is a "pull" system because the customer, in this case the NMC with a shortage, is pulling more material from upstream. The second method of resupply is done by a LMS in which he reviews the on-hand inventories at numerous NMC locations and directs the transfer from one NMC to another. This cross-shipment between NMCs is a "push" system because one facility is being directed to send goods to another location. Thus, the NMC's are either pushed ammunition based on what the LMS sees in the virtual inventory, or the NMC's will pull munitions based on future events that they know, but the LMS's may not, such as particular training exercises prior to a unit's deployment. This total system of re-supply to the NMCs is depicted in Figure 6, where the solid lines are the munitions shipments from the deep storage facility to the NMC and the dashed lines are the cross-shipments between the NMCs.

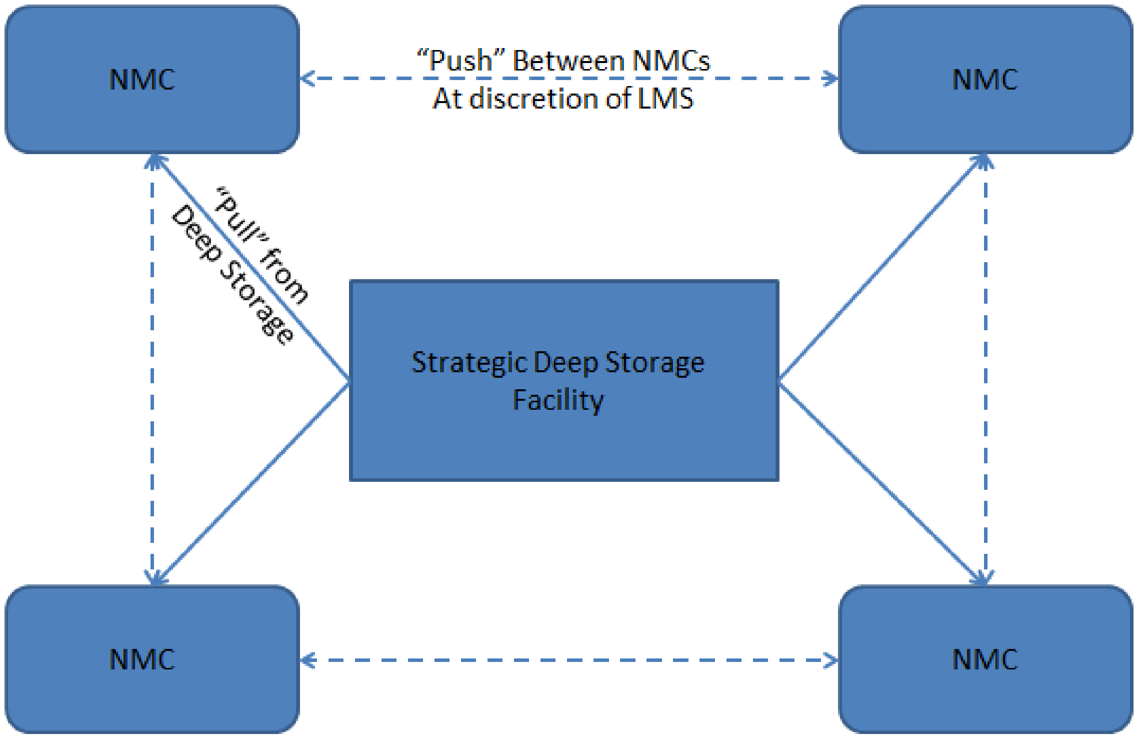

Figure 6. Load Plan Distribution Network

b. End User Distribution Model

The End User Distribution Model is solely dependent upon a requisition from an end user signaling to the ordnance supply system that re-supply is required. End users send requisitions into the Ordnance Information System (OIS) for resupply of their expended rounds. The majority of these requisitions are filled directly from their supporting NMC per the discussion above. AMMOPAC/AMMOLANT host pre-deployment meetings with the end users and conduct a "spot check" to determine what ammunition they need to order and tell the end user exactly what to order. Munitions are never pushed from the NMC to the end user.

When an end user's requisitions are submitted into the OIS, they are processed in one of two ways. The business rules within the OIS application then route the requisition to the appropriate person—either a LMS or a waterfront representative at AMMOLANT or AMMOPAC for action. These rules are primarily based on the geographic location of the customer. If the customer is located east of the Mississippi

River, then the requisition is forwarded to AMMOLANT. Conversely, the requisition is forwarded to AMMOPAC if the customer is home-ported west of the Mississippi River. If an item is deemed to be in short supply, the requisition is routed directly to a LMS for action. Additionally (and beyond the scope of our thesis project), “mini-AMMOs” exist in Combined Task Force 63 and 73 that allow those sites to work requisitions from customers that are currently deployed to the Mediterranean or Asian operating areas, respectively.

If the requisition is routed to a LMS for action, that LMS ensures that the requisition was entered into the supply system correctly and it is forwarded to that end user’s supporting NMC for fill. The main difference between these two sourcing methodologies is that a waterfront representative on either coast can direct an NMC to support a unit that is not assigned to that NMC’s Load Plan. This is one of the potential reasons why one NMC may be short of its required Load Plan and may require “push” support as directed from the LMSs. This process is depicted in Figure 7, where the end user submits a requisition for material needed (a pull signal to the distribution system). This requisition then hits a decision point where either NAVSUP-GLS or waterfront representative may process the requisition and direct a NMC to support that requirement from the end user.

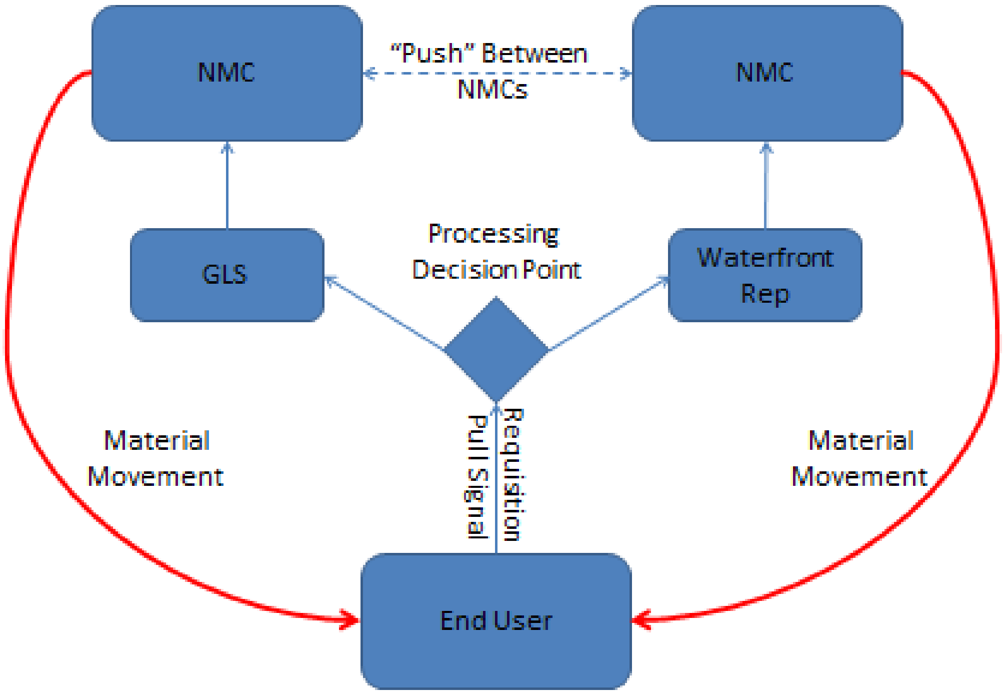

Figure 7. End User Distribution Model

2. Current Process Discrepancies and Problems

While the above describes the process in terms of how it should operate, there exists the potential for problems to occur which change how the system actually works. The first of these potential issues has already been listed—that of the lack of a standard operating procedure when determining how a requisition will be processed. Currently, the waterfront representatives serve in more of a reactive role, meaning that a customer asks for aid in processing a requisition for munitions before that representative gets involved. Additionally, the LMS has a "virtual inventory" in OIS which shows the on-hand balance for every warehouse and end user, but that information is only as good as the last update to the database, normally a 99.5% accuracy rate (C. A. Murphy, personal communication, March 8, 2012). If munitions are transferred from an NMC to an end user at the direction of a waterfront representative, the LMS does not have visibility of that filled requisition until a database update occurs. This is the typical situation for how one particular NMC may fall below the 90% requirement and be deemed non-compliant with its individual Load Plan.

Another problem with this process is related to the number of requisitions that "error out" of the supply system. When errors occur, business processes within OIS route the requisition to the appropriate action addressee. One area of concern is that error processing is not standardized across the ammunition supply system. Depending on the type of error, the requisition may not be corrected by a LMS or waterfront representative on either coast. For example, if an end user inputs an incorrect National Stock Number (NSN), the requisition is voided and the requisitioner receives a "rejection" status. In another example, if a ship orders material in excess of its allowance, the requisition is verified with the Type Commander and one of two possibilities exists. First, if the allowance in OIS is correct, the requisition is rejected. Second, if the allowance needs to be tailored due to a specific mission assignment, the allowance changes and the requisition is processed for shipment. In a final example, if the unit of issue within a requisition is incorrect, a LMS manually corrects the individual requisition and then it is processed by the OIS system.

Approximately 54.7% of all 251,068 requisitions placed in the last seven years by end users have had errors that caused the requisition to be cancelled or required an LMS to correct the requisition prior to releasing that order to an NMC for fill. As depicted in Figure 8, these errors made by customers have begun to trend down starting in 2010, but there are still a considerable number of errors that require many man-hours to correct. It is estimated that each requisition requires an average of fifteen minutes to correct (J. M. Bolig, personal communication, March 8, 2012). Based on this estimate, 33,000 man-hours (or 17 years of labor) have been required to correct these 137,000 requisitions.

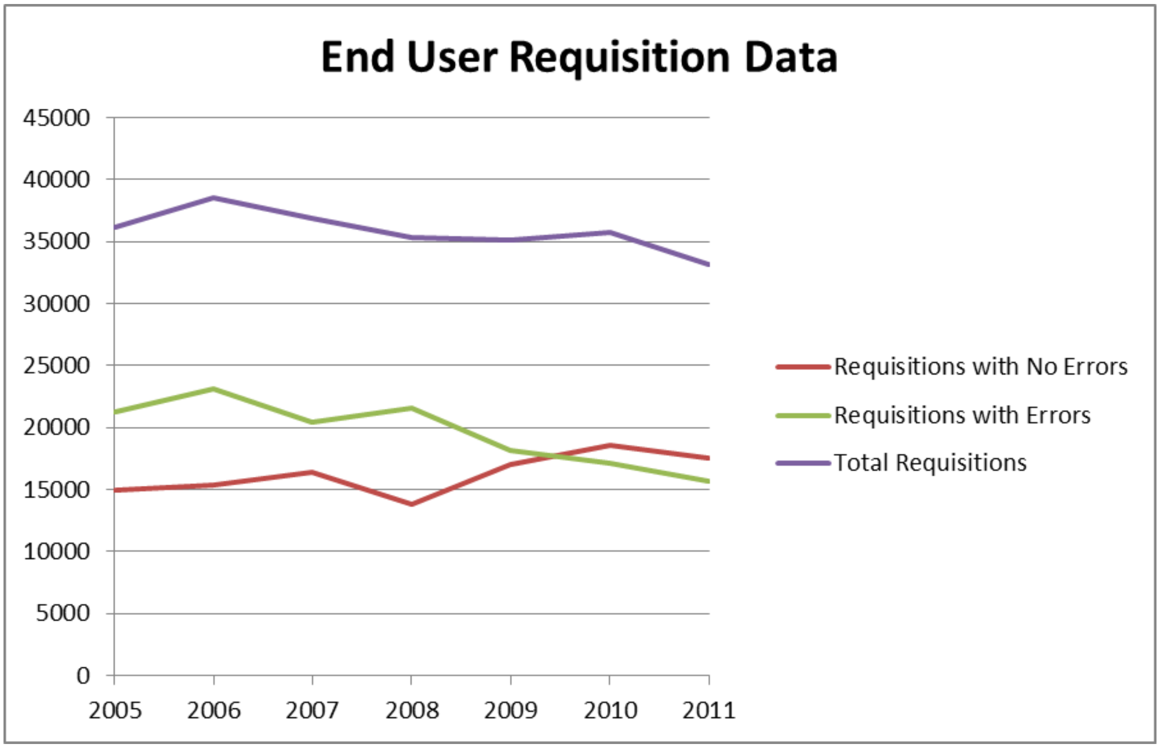

Figure 8. End User Requisition Data

Due to the sheer number of incoming requests for parts and munitions to the supply system, there are not individualized notifications sent for each of these incorrect orders. Instead, it is up to the end user to check their incoming requisition status files to determine if there were any problems. End users can receive help when placing requisitions from both the waterfront representatives and LMSs to ensure validity when initiating an order, but with the number of end users placing orders, both the representatives and LMSs would quickly be overwhelmed if each customer asked for help.

B. INDUSTRY BEST PRACTICES

In this section, we cover how the push, pull and hybrid distribution systems have been used effectively in the civilian sector. Three successful corporations which have incorporated either push distribution, pull distribution or a hybrid version of both are Barilla, Toyota and Wal-Mart, respectively. Each has found their own niche through mastering their distribution processes.

1. Push Distribution

The first corporation that will be reviewed is Barilla, Inc, which is the world's largest pasta producer (Simchi-Levi et al., 2008). During the late 1980s, Barilla suffered increased operational inefficiencies and cost penalties that were the result of large week-to-week variations in its distributors' order patterns. Barilla was unable to accurately forecast this demand for many reasons, such as long lead times, no minimum or maximum order quantities, promotional activities, volume discounts and transportation discounts. Some distributors offered customers discounts and free transportation if they ordered full truckloads of pasta, and sales representatives earned larger salaries and commissions based on the amount of pasta they sold. Thus, Barilla began looking for a way to curb these variations in weekly orders from the distributors.

Brando Vitali, who was the Director of Logistics at Barilla, recommended that they utilize "Just in Time Distribution (JITD)," which was modeled after the popular "Just in Time (JIT)" manufacturing concept. By using this process, he estimated that he could reduce the amount of variation in customer orders. He proposed that, "rather than follow the traditional practice of delivering product to Barilla's distributors on the basis of whatever orders those distributors placed with the company, Barilla's own logistics organization would instead specify the 'appropriate' delivery quantities—those that would more effectively meet the end consumer's needs yet also distribute the workload on Barilla's manufacturing and logistics systems more evenly" (Simchi-Levi et al., 2008). In order to do this, Barilla had to have the full support of the distributors because the distributors would be giving up control on how much of an item they order and the times on when they place those orders. In essence, the distributor would have no control over what stock they would receive and would be totally dependent upon the manufacturer to send them the right stock at the right time.

In order for JITD, or "Vendor Managed Inventory (VMI)" to work for Barilla, they had to have visibility over the pasta that was being ordered from the distributors and being delivered to the supermarkets where it was being sold. By having this data, Barilla would be able to send the distributors only what they needed, no more or no less, which would ultimately reduce distribution costs, inventory levels and manufacturing costs.

This system was designed so that each distributor would provide daily information to Barilla regarding what products were shipped out to the retailers and the status of their current inventory level for each product. With this data, Barilla could then compare all the data and make shipment decisions based on updated forecasts.

With so many changes in their business processes, there was considerable push-back from Barilla’s sales associates and distributors. Some were worried about Barilla not being able to effectively manage the inventory levels at the warehouses, thus leading to “increased risk of having the supermarkets stock out of product,” and opening the door for competitors to seize the demand of customers (Simchi-Levi et al., 2008). A manager at one of the distribution centers told Barilla, “managing stock is my job; I don’t need you to see my warehouse or my figures. I could improve my inventory and service levels if you would deliver my orders more quickly” (Simchi-Levi et al., 2008). They did not have faith that Barilla could manage the inventory, and because of that, they did not want to share the shipment data.

Barilla decided that the only way they could get the buy-in would be to run an experiment at one of the distributor sites. Within the first month of implementing JITD, inventory levels at the warehouses dropped from 10.1 days to 3.6 days, and service levels to retail stores increased from 98.9% to 99.8%. Distributors were not comfortable with having only 3 days of inventory on hand, so Barilla agreed to increase the number to 5 days. Over a six month period, Barilla analyzed daily shipment data of the distribution center and created a new and improved forecast based on this data. The stock out rate prior to the experiment was between 2% and 5%, and after implementation it dropped down to less than .25%. Deeming the experiment a success, Barilla began implementing the Just in Time Distribution method at all their distributors. The benefits of this method for the distributor were improved fill rates to the supermarkets and reduced inventory holding costs. Barilla also benefited by having reduced manufacturing costs, better relationships with their distributors, improved forecasting method using daily data, and an overall reduction in inventory levels (Simchi-Levi et al., 2008).

2. Pull Distribution

Next, we look at Toyota, which is the leading Japanese automobile producer whom is known for producing quality personal vehicles. They created the "Toyota Production System (TPS)," which is founded on the philosophy of "the complete elimination of all waste imbuing all aspects of production in pursuit of the most efficient methods" (ToyotaGlobal.com website, 2012). Toyota uses a version of the "Pull" methodology called "Just-In-Time (JIT)," where they only make vehicles when they are actually ordered by customers instead of manufacturing many vehicles based on a forecast. Again, this is based on the concept that "each process produces only what is needed by the next process in a continuous flow" (ToyotaGlobal.com website, 2012). With this system and process shown in Figure 9, Toyota can efficiently, effectively and quickly produce vehicles of high quality and per customer specifications that will fully meet the customer's needs.

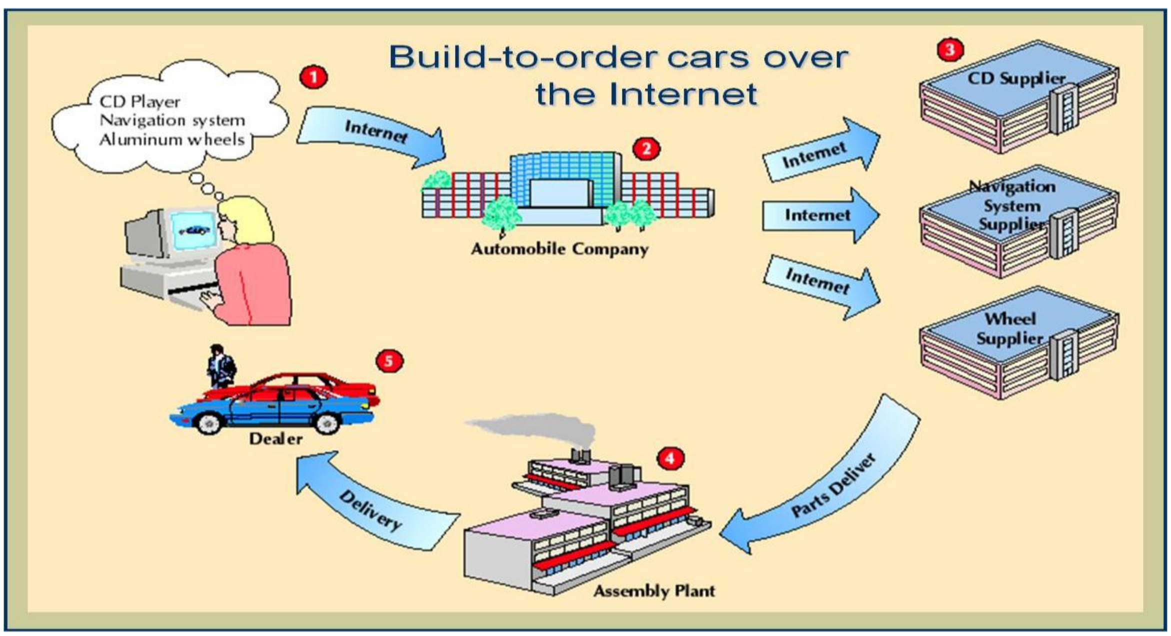

Figure 9. Example of Automobile Push Production System Diagram (From Russell & Taylor, 2005)

Toyota has mastered this method by adhering to the sound principle of only producing what is needed when it is needed and in the right amount. The first step in the process occurs when an order is placed for a vehicle; that order must be sent to the production line as quickly as possible to prevent unnecessary delays. The second step is to ensure that the assembly line is stocked and equipped with all necessary parts and equipment to manufacture that vehicle. The third step is to ensure that all parts that were used for producing that vehicle are immediately replaced on the assembly line by parts from their stock. The final step is to ensure that the parts that were pulled from stock are replenished by their supplier. By achieving these steps and only producing a vehicle when it is ordered, they avoid overproduction. TPS is very effective for Toyota because they base their production on customer demand, not forecasts or historical data. By doing this, “they minimize their work in process and warehousing of inventory by stocking small amounts of each product and frequently restocking based on what the customer actually takes away” (Liker, 2004).

Another reason why Toyota has been so successful with the “Pull” or “Just-In-Time” strategy is because they have a culture of constantly looking for ways to improve themselves. They are interested in lean manufacturing, and the workers are actively providing improvement suggestions on how the process can be improved. Toyota encourages their employees to make suggestions for improvements and depends on them because they are the ones actively involved in the day-to-day operations. Toyota’s philosophy is that they would rather stop or slow down production in order to get the quality right the first time with hopes of enhancing productivity in the long run.

One of the drawbacks of using JIT is that any potential disruption in the supply chain could hinder Toyota from getting the parts they need in a timely manner and thus affect their manufacturing capabilities. Toyota recently experienced this rare disruption in March 2011 when a 9.0 magnitude earthquake occurred off the coast of Japan. This earthquake caused a huge tsunami that wreaked havoc on the northern Japanese coastline and disrupted the production and delivery of parts between Toyota and its suppliers. With Toyota operating on a Just in Time system, they did not have large inventory levels on hand to keep up with customer demand, so they were unable to produce the required number of vehicles and thus lost business to its competitors.

3. Hybrid Distribution

Lastly, we look at Wal-Mart, who is one of the top discount retailers in the world. They employ a hybrid version of the "push-pull" distribution system, which they break down into two processes. The first process is the customer purchase cycle, which is when a product is sold at a local Wal-Mart store. This sale is captured within their point-of-sale system and it triggers their virtual inventory that there is an empty spot on the shelf that needs to be replenished. This demand for a product is then relayed to the distribution center, and the distribution center sends this product to the store to fulfill their requirement (to restock the shelf). This is the "pull" part of the process because the Wal-Mart store is pulling products from upstream based solely on customer demand.

The second process is the "push" portion, which occurs in the replenishment, distribution, manufacturing and procurement cycles. All data that was collected in the first step is also received by the manufacturers and distributors. This data is then merged with past historical data and their forecasts for products are created. The manufacturers and distributors then deliver merchandise to the stores when it is needed as shown in Figure 10.

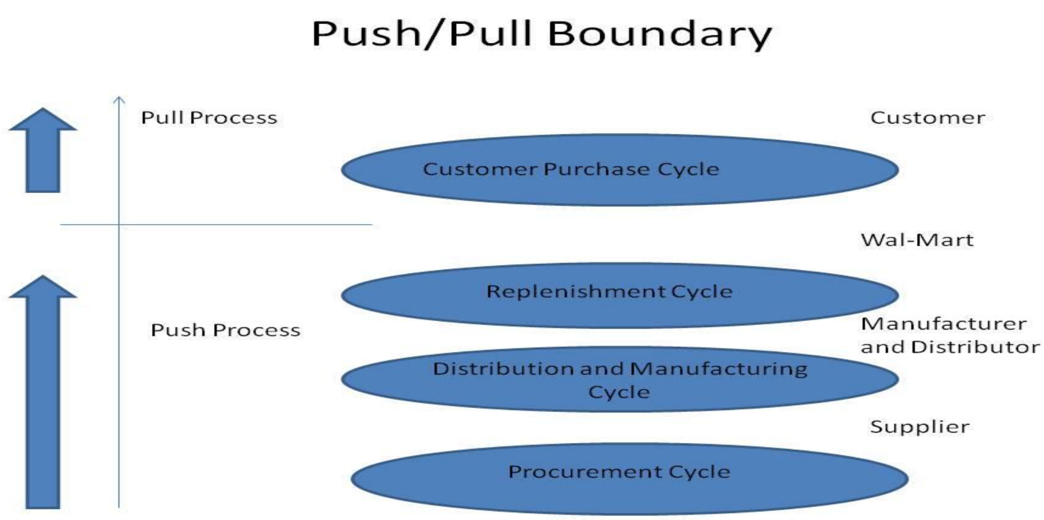

Figure 10. Depiction of Push/Pull Boundary used by Wal-Mart

4. Conclusions of Best Practices

In closing, it is clear that the three companies highlighted above have found the distribution system that works best for them. Each organization must take a look at what they are trying to accomplish with their distribution system and then tailor their needs to meet their desired goals. In the beginning of Barilla, they used a pull system, but they were experiencing numerous problems so they made the switch to a push system and have had success since. While the pull system works for Toyota, it does not work for General Motors, and therefore they utilize the push system for their manufacturing of vehicles. Wal-Mart has found a way to take the best of both systems and make it their own, and have thus achieved superior results allowing them to be the top retailer in the world. Each distribution system has positives and negatives and a company must decide what type of system they need to succeed and remain competitive in their marketplace and competitive industry.

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V. DATA ANALYSIS

A. DATA RETRIEVAL

The data for our thesis project was provided by Naval Supply Systems Command–Global Logistics Support. This data included seven fiscal years of the total number of requisitions placed by end users, orders placed by Naval Munitions Commands for replenishment of on-hand stock, and requisitions entered into the system by Logistics Management Specialists (LMS) to push ammunition to an NMC (if the NMC was below its required allowance and had not placed a replenishment order). From 2005 through 2011, there were a total of 251,068 customer-based requisitions. Of those requisitions, 4.99% (12,525) were expedited as the customer’s behest based on a Required Delivery Date code 999. Code 999 indicates that the customer requires this material as soon as possible, so it must be expedited vice being sent via normal means of shipment.

While the actual dollar values for independent shipments of munitions were not available, expedited shipments had shipping charges between $400 and $1,400 more than routine shipments, and the total dollar amount spent annually for the past seven years on all shipments was around thirty million dollars (C. A. Murphy, personal communication, March 8, 2012). The average Navy expenditure for expedited shipments was nearly nine million dollars a year, meaning that while these expedited shipments were a relatively low percentage of the total orders, they did account for approximately 30% of the total shipping costs for all ammunition (C. A. Murphy, personal communication, March 8, 2012). Thus, the potential for dramatic cost savings exists if the overall system can be modified to reduce the number of shipments that must be expedited.

Additionally, the data from NAVSUP included the number of requisitions that had some error within the order. Some of these errors required that the requisition be cancelled and re-entered into the system by the end user while others could be corrected by an LMS. Computations show that 63.39% of the expedited requisitions contained errors and 54.26% of the routine orders had errors. This information is portrayed in Table 1.

	Expedited w/ Error	Expedited w/o Error	Routine w/ Error	Routine w/o Error
2005	1104	591	20127	14330
2006	1418	738	21753	14656
2007	1164	589	19308	15843
2008	1328	709	20239	13060
2009	947	692	17175	16351
2010	1078	687	16063	17918
2011	901	579	14767	16953
Totals:	**7940**	**4585**	**129432**	**109111**

Table 1. Requisition Error Data

B. MODEL DEVELOPMENT

Prior to creating the model for conducting data analysis, it was decided that a Monte Carlo simulation would be used for working with this data. This determination was made because of the limited nature of the data that was available and the variability and randomness in customer order patterns, such as the total number of orders for the past seven years, the number that was required to be expedited, and those orders that had errors. Additionally, a group of assumptions and random variables was developed that needed to be tested, and running a Monte Carlo simulation provided the best possible set up and analysis of these variables.

The initial objective of this simulation was to use the data provided and recreate expedited and total shipping costs per NAVSUP-GLS information. In order to achieve approximate values of $30M in total shipping costs and $9M in expedited shipping costs, assumptions had to be made about the data, which are covered below. Once the model simulation was created, it was then used to test potential scenarios if the ordering system were changed from a pull-based system to a push-based system. Specifically, the scenarios involved reductions in shipping costs and labor hours required to correct requisitions.

1. Relevant Assumptions and Variables

The first assumption made in this project was to assume that expedited costs are higher than non-expedited costs. Based on this, some level of savings should be achieved if the total number of expedited shipments decreased. This assumption seemed to be intuitive since rushed shipments are almost always more expensive in cost when compared to "normal" modes of shipment, but without this assumption being made, there would be no reason to change the current process. In order to validate the simulation based on the total shipping costs identified by NAVSUP-GLS, $700 was multiplied by the number of routine shipments (95% of all requisitions are routine in nature based on historical data). There were approximately 34,000 routine requisitions, meaning that $23.8M was spent on average for routine shipping. The other 1,800 requisitions (5% of the total number of requisitions) are expedited and were multiplied by a random uniform dollar value between $4,500 and $5,500. The average cost of expedited shipments was $8.9M per year.

The second assumption made was that requisition rework could be reduced by changing the current ordering process. While it is extremely unlikely that any change would be 100% effective, any elimination of rework would result in costs savings in terms of labor expenditure. As stated earlier, the current ordnance supply chain is a pull-based system where requisitions are generated by end users that need to be resupplied based on expended ordnance. The current system requires an LMS to correct any requisition that has an error. NAVSUP personnel currently spend between ten and twenty minutes on each requisition that contains an error (J. M. Bolig, personal communication, March 8, 2012). By changing to a push-based system, where the LMS inputs the requisition directly into the system for the customer, a reduction in labor hours spent correcting requisitions would be attained because the OIS interface LMSs use does not allow any errors into the system. Corrections would be made immediately and the requisition would be processed instantaneously. Accordingly, this range of time that it takes to correct a single requisition was incorporated into the simulation using historical error rated for expedited and routine requisitions. The sum totals for each type of error is then added and converted into hours for labor analysis.

2. Model Creation and Initial Output

The first step in creating the model was to determine the expected number of annual ordnance requisitions and how many of those would be expedited or sent via routine transport. Using the data provided from NAVSUP, analysis of the last seven years of data determined that the average number of orders per month over the seven years was 2,985 orders/month with a standard deviation of 531 orders/month. In an effort to increase to attain a clearer picture of most likely outcomes within the model simulation, these annual numbers were run 10,000 times and then converted into monthly figures. To generate a random number of monthly requisitions in the simulation, a normal distribution with a mean of 2,985 and the standard deviation of 531 was used. The percentages of previous orders (4.99% expedited and 95.01% routine) were multiplied by the results of this monthly figure, which provided the starting point for analysis with the assumption that a similar number of munitions orders would be placed on a monthly basis in the future.

At this point, the simulation was divided in order to run two variables. The first variable that was tested related to the cost structure of shipments. To validate the model based on current shipping charges, routine shipments were assumed to have a constant cost of $700 per shipment and expedited shipments had a random cost between $4,500 and $5,500 per shipment. This initial simulation generated a total shipping cost averaging more than $32M and expedited shipment cost averaging $8.9M.

The second simulation tested the labor hours expended on making corrections to requisitions containing errors. Again, using the randomly generated monthly requisition totals for routine and expedited requests, the model determined the total expected number of requisitions that would contain errors based on the historical data from the past seven years by multiplying by an error rate of 63.39% for expedited shipment requests and 54.29% for routine orders. These numbers were then multiplied by a randomly generated number between ten and twenty minutes, which is the average amount of time that is required to correct a requisition (J. M. Bolig, personal communication, March 8, 2012). When computed into hours, there was an average of 4,901 hours annually expended on these corrections with a standard deviation of 376 hours.

C. MODEL OUTPUT AND ANALYSIS

1. Initial Model Output

After running the model with 10,000 trials using routine shipping costs of $700 and a random distribution between $4,500 and $5,500 per expedited shipment, the mean value for total shipping costs was $32.8M as seen in Figure 11. Mean expedited shipments, depicted in Figure 12, accounted for $8.9M. Based on these two data pulls, expedited shipments accounted for 27% of the total shipping costs.

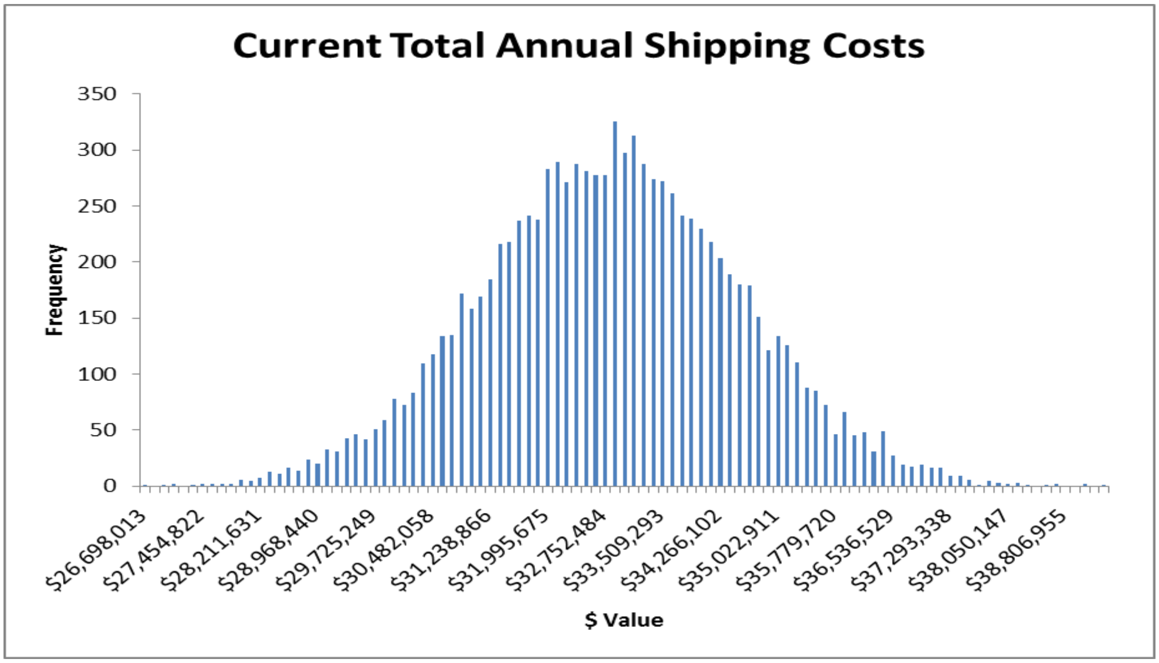

Figure 11. Current System Total Annual Shipping Cost

Figure 12. Current System Annual Expedited Shipping Cost

When determining the initial number of labor hours needed to correct requisitions containing errors, the model used the randomly generated monthly requisition totals for routine and expedited requests multiplied by the previously stated error rates. As seen in Figure 13, an average of 4,901 hours is annually expended on these corrections. When viewed through the framework that the average employee works 160 hours per month, this means that 30.6 months (or just over two and a half years) of labor is required for these corrections each year. In other words, two and a half full-time workers must be employed to fix these errors each year of the current system's operation.

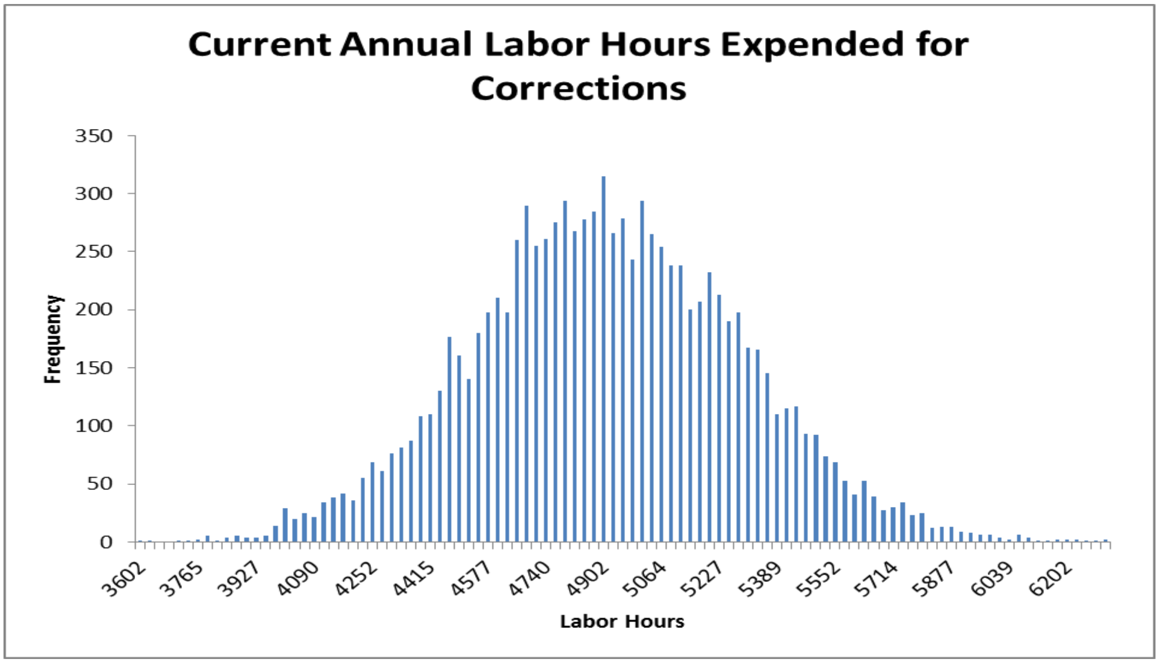

Figure 13. Current Annual Labor Hours Expended on Corrections to Requisitions

These results are based on the initial run of the model that was developed and also include all possible outcomes from the data distributions. This was the starting point for our data analysis. We then developed a worst case scenario for changes as well as middle and best case scenarios. Finally, we created a scenario that was most likely based on guidance received from NAVSUP personnel.

2. Worst-Case Scenario

In the worst-case scenario, errors in customer orders were dropped by 20% for each type of orders. Specifically, estimated errors in expedited orders decreased from 63.39% to 43.39% and routine orders from 54.26% to 34.26%. Additionally, an assumption was made that there would be no reduction in the total number of shipments that had to be expedited. Since no change in total number of shipments occurred in this simulation run, the average total annual shipping costs and expedited shipping costs remained the same. However, the average of total labor hours spent making corrections dropped to 3,111 hours. This amounted to a reduction of 1,790 hours, or nearly one full labor-year of work performed by a LMS. While these may seem like modest savings, this reduction would amount to more than $85,000 if a Petty Officer First Class was employed to correct errors in requisitions. For continuity, it was assumed that a Petty Officer First Class made all corrections so that the same annual DoD composite rate of compensation could be employed throughout the analysis.

3. Middle-Case Scenario

For the middle-case scenario, two changes were made within the model. First, the total number of requisitions with errors was reduced to 5% total for both expedited and routine orders. Second, the total number of orders that had to be expedited was reduced from 4.99% to 3.00%. These assumptions were made based on the belief that having a LMS enter the requisitions would significantly reduce error generation and, through use of a virtual inventory, a LMS would place the orders early enough that there would be a reduction in the total number of requisitions requiring expediting.

The results of this simulation showed significant reductions in both shipping costs and labor hours spent correcting errors. The mean total number of labor hours was reduced to 447 hours as shown in Figure 14. With this amount of savings, the Navy could reduce overtime work to less than 3 months (447 hours / 160 hours/month = 2.79 months) instead of the current 2.55 years (4,901 hours / 160 hours/month / 12 months/year) and have a savings of more than $216,000.00. Separately, this could lead to lower utilization rates for LMSs, which might provide for reduction in the total labor force.

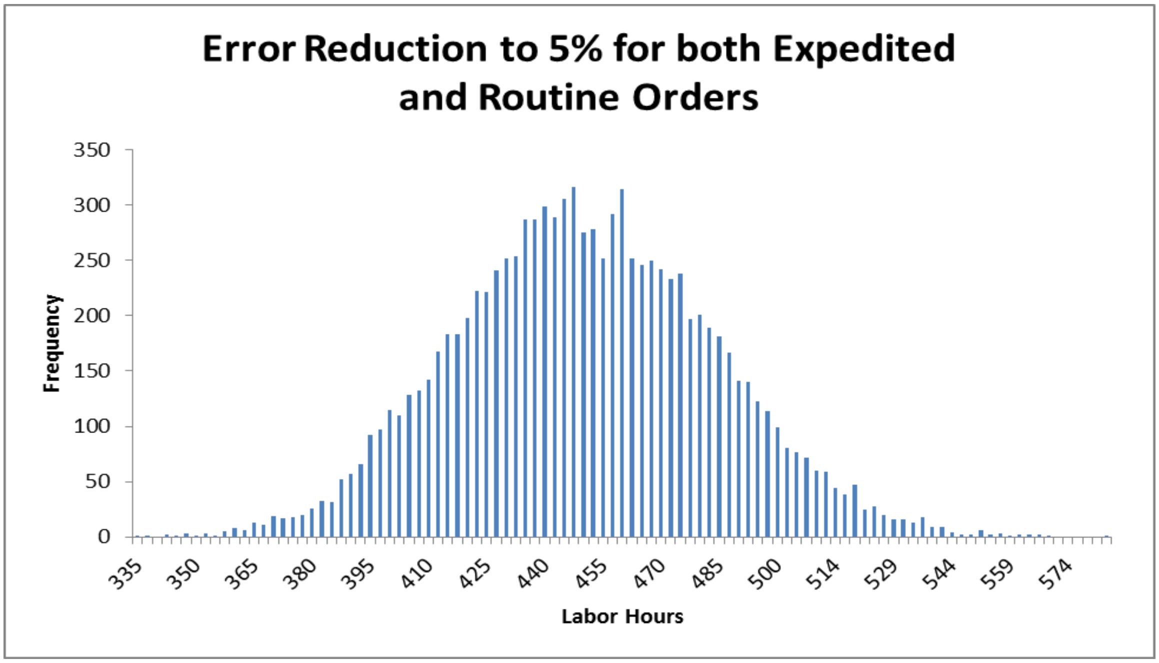

Figure 14. Error Reduction to 5% Total for both Expedited and Routine Orders

Average total shipping costs were reduced from $32.8M to $29.6M, as seen in Figure 15, which included expedited shipping costs reductions of approximately $3.6M (Figure 16). Overall, with these assumptions, a total average savings in shipping of $3.2M is generated.

Figure 15. Total Shipping Costs when Expedited Orders Equal 3% of Total Orders

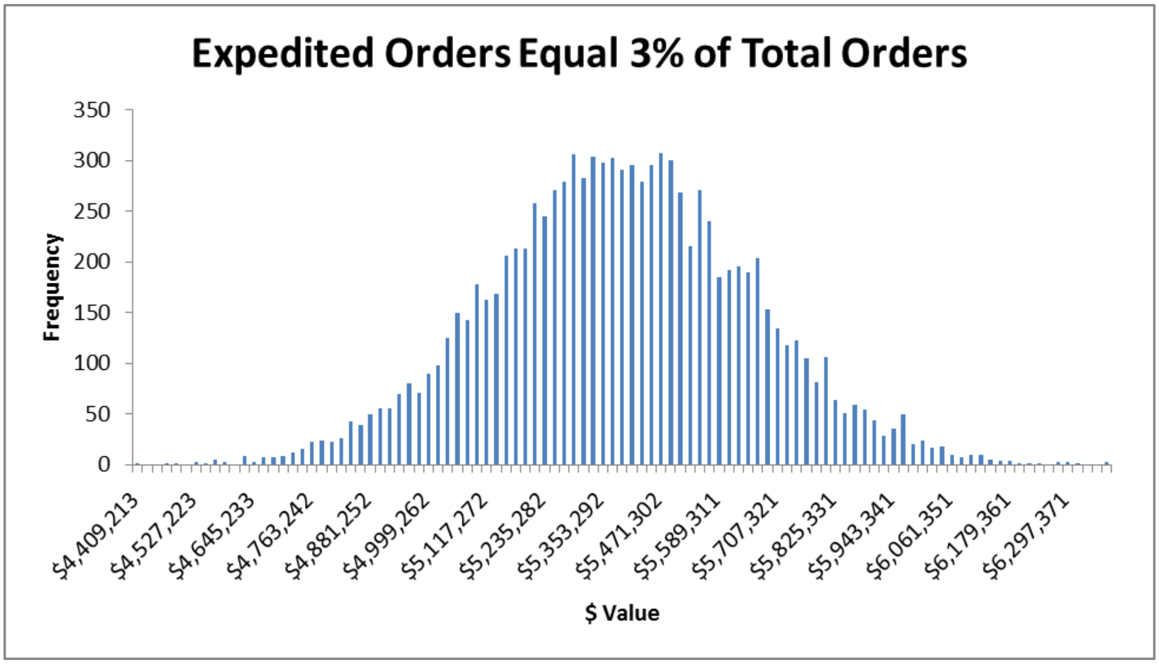

Figure 16. Expedited Orders Equal 3% of Total Orders

4. Best-Case Scenario

In the best-case, errors in both expedited and routine orders were reduced to 1% and only 1% of all orders required expedited shipment. These are drastic numbers, especially for the number of expedited shipments, but they showed that changing the current ordnance distribution system from a customer driven pull system to a virtual inventory push system would have significant cost savings for the Navy. The total average number of labor hours was reduced to 90 hours (Figure 17). This reduction amounts to an average man-hours savings of 4,811 hours and more than $233,000.00, and with errors occurring this infrequently, the amount of rework is cut to less than one month's overtime (90 hours / 160 hours/month = 0.56 months).

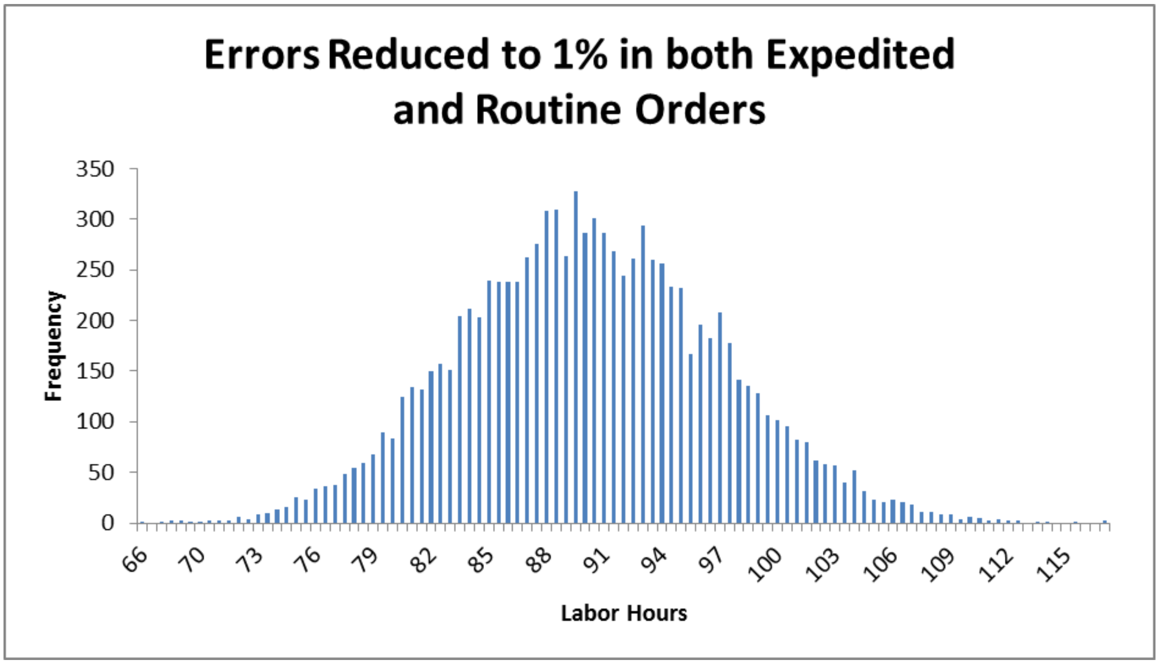

Figure 17. Errors Reduced to 1% in both Expedited and Routine Orders

Total shipping costs were reduced from an average of $32.8M to $26.6, as seen in Figure 18. In addition, mean expedited shipping costs were cut down from $8.9M to $1.8M (Figure 19). An estimated total savings in the best case scenario would be $6.2M. When labor cost savings are included, total savings for this model simulation amount to more than $6.4M.

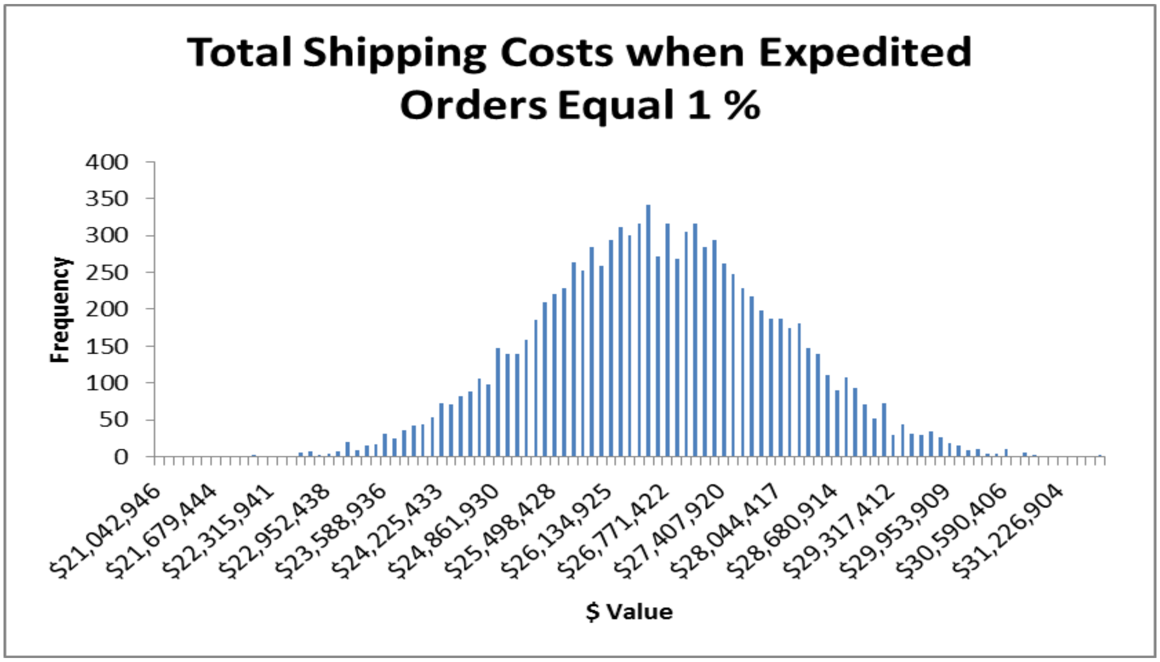

Figure 18. Total Shipping Costs when Expedited Orders Equal 1%

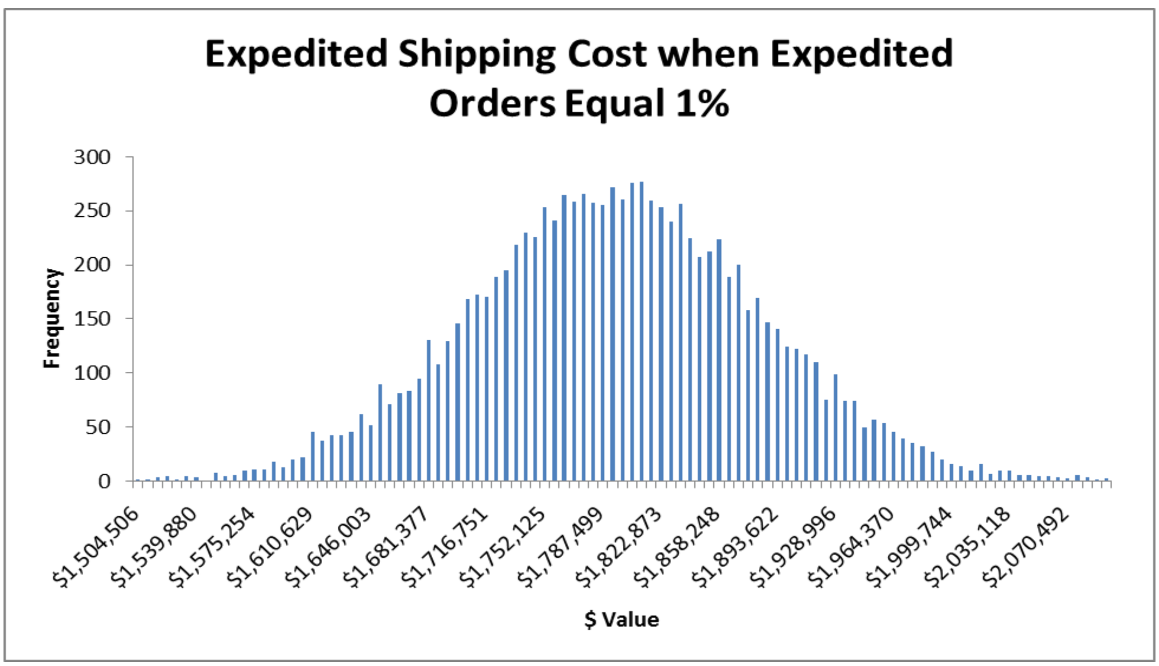

Figure 19. Expedited Orders Equal 1% of Total Orders

5. Most Likely Scenario

Based on inputs received from NAVSUP, we determined that the most likely scenario if the ordnance requisitioning system is changed from a pull to a push system would be for the total number of errors to be reduced to 1% and that 3% of all requisitions would have to be expedited. The error rate was based upon the fact that if an order is entered into the OIS incorrectly, it would immediately show and the error would not be processed. The LMS, who is the expert at using the OIS, could then make the required corrections on the spot and there would be no time lost in the processing the order. Separately, there would always be contingencies that the Navy must be ready and thus reducing the likelihood of expedited requirements down to 1% did not seem feasible.

This most likely scenario combines the findings from the middle and best-case simulations already run. Specifically, the number of labor hours spent correcting errors would be reduced from 4,901 hours per year to 90 hours per year, which amounts to a total cost savings in labor of more than $233,000. Average total shipping costs were reduced from $32.8M to a total of $29.6M while expedited shipping costs were reduced from $8.9M to $5.3M. Based on these assumptions, the most likely total savings would be $3.2M in terms of shipping and $233,000.00 in labor costs for a total of $3.4M per year.

D. RECOMMENDATIONS FOR DISTRIBUTION CHANGE

1. Recommendation for Change

Based on our findings from simulation, and numerous discussions with personnel from the NAVSUP GLS, we recommend that the ammunition distribution system for the Navy be changed from a pull-based system to a push-based vendor-managed inventory system. As shown in the results from each of the simulation scenarios, shifting distribution systems would result in savings in both labor and transportation costs. If the simulation is accurate, expedited shipments would show an actual reduction of approximately $3.6M and routine shipment costs would increase by approximately $500,000. As listed above, an additional $233,000 in labor savings could be realized, which brings the total savings to over $3.3M for each year if the ordnance supply chain is modified from a pull system to a push system. The results of the simulations can be seen below in Table 2. The value of this simulation is shown in the cost savings that will result from a shift in distribution policy. While three million dollars is relatively small in terms of savings within the scope of the DoD budget, implementation of a similar policy throughout each of the services has the potential to result in magnified savings within DoD.

	Labor (Hours)	Labor Reduction %	Total Shipping Cost	Expedited Shipping Cost
Current Values	4901	N/A	$32.8M	$8.9M
Worst-Case Scenario	3111	37%	N/A	N/A
Middle-Case Scenario	447	91%	$29.6M	$5.3M
Best-Case Scenario	90	98%	$26.6M	$1.8M
Most Likely Case	**90**	**98%**	**$29.6M**	**$5.3M**

Table 2. Simulation Results Table

2. Potential Conflicts to Change

While we are recommending a complete change in the requisitioning and thus distribution system for ammunition, there are a number of potential conflicts that might hamper implementation. One of the most immediate issues is the element of trust that be engendered between the end user and the GLS personnel. A ship's commanding officer is unlikely to relinquish the ordering process for ammunition unless it is shown that a shift will actually improve the total readiness of the fleet. A test run, similar to one conducted by Barilla, Inc., would be required to insure that the change to the system would work before a full implementation Navy-wide.

A second issue has the potential to limit the amount of savings in labor costs. While removing the ordering process from a customer who, in general, gets the requisition incorrect the majority of the time, this change may require additional LMSs to serve the fleet as a whole. While our best case scenario showed that 2.5 labor years could be reduced in terms of correcting errors to requisitions, it may take those 2 employees or potentially more to actually take over the system and act on behalf of all end users within the system. We expect that a slight increase in personnel would be required to achieve the system shift from pull to push-based after the initial start-up, these employees could be phased out and labor savings would be realized.

With proper training and emphasis, these potential issues would be offset. The ability to continuously and effectively support a deploying fleet would put any commanding officer’s concerns at ease. Labor savings would be realized once the new system is fully up and functional and finally, the total potential costs savings to the Navy in a time of tightening budgets would help with total fleet and personnel readiness.

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VI. RECOMMENDATIONS

A. RECOMMENDATIONS FOR FUTURE RESEARCH

During our research, we identified some areas within our project that should be looked at in more depth and potentially be used for future research projects. In particular, we assumed that the number of requisitions for ammunition would remain the same even though strategic policy has the United States' military reducing its footprint in areas of current operations. Additionally, data points for actual shipping costs were not able to be attained. Actual shipping values would increase the realism of the Monte Carlo Simulation. Other potential areas of study are listed below:

- Obtain actual total shipping costs for each requisition within the data provided to solidify actual cost savings for switching from pull-based to push-based. This project used only averages for expedited shipping costs that were provided by NAVSUP GLS.
- Analyze certain munitions categories, such as precision guided weapons and small arms and then look at actual shipping costs for each category. Within doing this, there is the potential to reveal that one category spends more on shipping than the other, so it could be researched whether or not to ship items in bulk vice smaller single requisitions can save on shipping.
- This study was conducted with data used during war-time, so usage of ammunition was high, as opposed to reduced usage during peace-time. Analyze the effect of shipping costs by losing economies of scale with regards to shipping items in bulk to save money. Also, analysis could be conducted on manpower requirements if customer demand decreases.
- Research potential risk-pooling for Naval Munitions Commands to relieve the requirement of maintaining 100% of a ship's load plan. By risk-pooling, cost savings might be realized by the reduction of inventory.

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