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A cost analysis of forward positioning material in the Fifth Fleet Area of Responsibility

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MBA PROFESSIONAL REPORT

A COST ANALYSIS OF FORWARD POSITIONING MATERIAL IN THE FIFTH FLEET AREA OF RESPONSIBILITY

December 2014

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The results indicate that the current forward-staging efforts are saving the Navy money and lowering customer wait time. The Navy's share of the holding cost at the COCO warehouse is relatively small when compared to how much money is saved by shipping material via surface transportation instead of by expedited air. This is partially due to the heavy weight of some of the items listed on the planned stocking list. The lead time analysis shows substantial savings in lead time days and even greater improvement in lead time categories. We conclude that the 29 percent reduction in overall lead time is a direct result of the forward staging efforts in the Fifth Fleet at the COCO warehouse. We anticipate additional cost savings and even lower lead times as the warehouse becomes fully stocked.

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A COST ANALYSIS OF FORWARD POSITIONING MATERIAL IN THE FIFTH FLEET AREA OF RESPONSIBILITY

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LIST OF ACRONYMS AND ABBREVIATIONS

AAC	acquisition advice code
ACA	Airlift Clearance Authority
AOR	area of responsibility
CLF	combat logistics force
CLO	combat logistics officer
CNO	Chief of Naval Operations
COA	course of action
COCOM	Combatant Commander
COMAIR	commercial air transportation
CONUS	continental United States
COG	cognizance symbol
CTF	combined task force
CY	calendar year
DDC	defense distribution center
DDNB	Defense Depot Navy Detachment, Bahrain
DHL	DHL Airways
DLA	Defense Logistics Agency
DLR	depot level repairable
EBS	Enterprise Business System
EOPC	Enterprise Operations Planning Council
EOQ	economic order quantity
FDP	forward distribution point
FEDEX	Federal Express
FILL	fleet issue load list
FLC	Fleet Logistics Center
FY	fiscal year
GATES	Global Air Transportation Execution System
GSA	General Services Administration
HULL	high usage load list
MILAIR	military air transportation

MRO	material requisition order
MSC	Military Sealift Command
NAVCENT	Naval Forces Central Command
NAVSUP	Naval Supply Systems Command (Echelon II Command)
NAVSUP GLS	Naval Supply Systems Command Global Logistics Support (Echelon III command)
NAVSUP WSS	Naval Supply Systems Command Weapon System Support (Echelon III command)
NIIN	national item identification number
NWCF-SM	Navy Working Capital Fund–Supply Management
OCO	Overseas Contingency Operations
OCONUS	outside the continental United States
PSL	planned stock list
SDDC	Surface Deployment and Distribution Command
SRC	special requirements code
SWT	service wide transportation
UPS	United Parcel Service
WSDC	weapon system designator code

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I. INTRODUCTION

A. BACKGROUND

The Chief of Naval Operations (CNO), Admiral Jonathan Greenert, has made operating forward and maintaining a strategic presence one of his three primary tenets. In his 2014 statement before the House Armed Service Committee on the FY 2015 Department of the Navy Posture, he emphasized that the Navy will continue to operate forward by forward basing, operating, and stationing ships in the Asia-Pacific, Europe, and Middle East (Department of the Navy, 2014, p. 6). In order to meet the CNO's mandate, mission-critical and high-demand material must also be forward staged to support the forward operating forces and maintain a war fighting capability. This is an ongoing effort and requires the coordination of multiple key stakeholders to ensure success and complete mission objectives. There have already been several efforts to increase forward staging of critical items in the Fifth, Sixth, and Seventh Fleet areas of responsibility (AOR). As of September 2013, there have been 7,500 line items forward positioned in Bahrain, Yokosuka, and Sigonella (Mazzarella, 2013). Forward staging efforts in the Fifth Fleet AOR have been the most robust of the various fleets and these efforts will be the focus of this analysis. We do not analyze any demand or shipment data for the Sixth or Seventh Fleet AORs in this paper.

This project will answer the following research questions:

- Are the current policy and courses of action the U.S. Navy has taken to forward stage material in the Fifth Fleet AOR saving them money?
- What is the impact on lead time of the Defense Logistics Agency (DLA) commercially owned commercially operated (COCO) warehouse in Bahrain?

B. CURRENT POLICY

In response to the CNO's mandate, the Naval Supply Systems Command (NAVSUP) created policy and procedures contained in NAVSUPINST 4440.192 for

forward positioning naval material outside of the United States. The intention of this policy is to:

1. Improve fulfillment and customer service delivery performance of transiting, scheduled deployment and forward deployed naval forces.

2. Optimize safety stock and total supply chain investment

3. Align inventory for supply chain planning and operations to drive cost efficiencies. (Naval Supply Systems Command, 2013, p. 2)

The first intention lays out what forces and units will be directly affected by the efforts. There are several types of units permanently stationed in Bahrain including mine counter measure (MCM) ships and patrol craft (PC) that will be considered when forward staging items. There are also units deploying in (or deployed to) the Fifth Fleet AOR including carrier air wings, ballistic missile defense (BMD) ships, and ground forces such as explosive ordinance disposal units and mobile diving units. Finally, the first intention addresses units that might be transiting the AOR. Most of the units that fall into this category will be transiting the Red Sea either to the Mediterranean Sea or to the Indian Ocean. Appendix A shows the geographical boundaries of the Fifth Fleet AOR.

The second intention focuses on ensuring appropriate inventory levels are on hand to meet customer needs while optimizing the supply chain assets. It is important to identify the key items that must be stocked and available to customers in order to minimize operational down time of equipment. It is also important to optimize supply resources such as warehouse space and shipping container space.

The third intention is concerned with ensuring the inventory levels are set to the most cost effective quantities while providing planners the appropriate information to make decisions. It is important to have the right items on hand to meet customer demand for mission-critical items, but having too much of an item on hand or items that require special handling and storage can quickly drive up costs. There is a risk involved with having too few of an item on hand, but the forward staging efforts are designed to minimize this risk while saving the most amount of money and driving cost efficiencies.

The instruction states actions and responsibilities for subordinate commands, NAVSUP Global Logistics Support (GLS) and NAVSUP Weapon Systems Support (WSS), involved in forward staging and policy initiatives. It is the responsibility of NAVSUP, Assistant Commander for Supply Operations and Logistics Policy (N3/4), to guide and monitor all subordinate stakeholders and ensure they meet all requirements outlined in the instruction (Naval Supply Systems Command, 2013, p. 4). A list of key players and stakeholders in developing and implementing Fifth Fleet forward staging initiatives are listed below. Note that all support organizations are responsible for monitoring costs as well.

- Combined Task Force (CTF 53)–CTF 53 is primary concerned with all logistics at sea in the AOR. This would include coordinating replacement shipments as well as transporting mission-critical items from Bahrain to the requesting unit.

- Defense Distribution Center (DDC)–DDC is concerned with getting the requested national item identification number (NIIN) from their distribution centers to the appropriate area of debarkation.

- Defense Depot Navy Detachment, Bahrain (DDNB)–DDNB has the primary responsibility of managing the forward staged items and replenishing as needed.

- Defense Logistics Agency (DLA)–DLA developed the EMQ model and is concerned with what items will be forward staged and ensuring there is proper space and facilities to house the items. DLA manages the forward staged items on behalf of the Navy.

- General Services Administration (GSA)–GSA's role is to coordinate with NAVSUP and DLA to determine what GSA-managed items will be forward staged.

- Military Sealift Command (MSC)–MSC is primarily concerned with transporting requested replenishments via MSC assets.

- NAVSUP GLS–GLS coordinates with DLA and MSC to establish load lists. They also manage the NIIN selection process for special requirements code (SRC) items.

- NAVSUP Headquarters (HQ)–HQ is overall in charge of creating policy and procedures for forward positioning naval material. In addition, they manage the service wide transportation (SWT) and Navy Working Capital

FundSupply Management (NWCF-SM) accounts (Department of the Navy, 2009, p. 7).

- NAVSUP WSS–WSS Manages the repair parts for naval weapon systems and is critical in determining what items will be forward stocked and ensuring that there is full asset visibility.

- Transportation Command (TRANSCOM)–TRANSCOM is responsible for all military transportation.

Fleet commanders also have an influence on which items are forward staged to meet specific requirements. These commands include Pacific Fleet, Submarine Force Atlantic, Surface Force Atlantic, the Navy Expeditionary Combat Command and Naval Forces Central Command. The instruction dictates the joint supply alignment business rules. These rules bring key logistical agencies including DLA, GSA, Combatant Commanders (COCOM), and TRANSCOM together in order to determine the most practical and efficient way to dispense supplies and parts to naval forces OCONUS. It is critical that all major players agree to and follow the same business rules in order to prevent duplication of effort and more importantly that the right material gets selected and forward staged.

Forward positioning efforts will be evaluated continuously by NAVSUP to look for and identify process improvements. It is the responsibility of each stakeholder to follow all prescribed procedures and monitor forward staging costs as needed. NAVSUP requires an annual forward positioning analysis be conducted for the Third, Fifth, Sixth, and Seventh Fleet AORs; however, there is currently no guidance on how to conduct this analysis and what information should be provided (Naval Supply Systems Command, 2013, p. 3).

C. BUDGETARY ENVIRONMENT

The defense budget has been on a steady decline since 2010 (Department of Defense, 2014). Figure 1 depicts a timeline for defense spending since 1950, based in 2015 dollars. There is a discernable trend of high peaks during the height of a war or armed conflict followed by a sharp decline once the conflict is over. There is no surprise then that there was steady decline in spending after the United States pulled troops out of

Iraq and Afghanistan in 2011. The Department of Defense estimates that by FY19 the defense budget would have decreased by 27 percent compared to FY 10 (Department of Defense, 2014). Although this would not be the largest drop in defense funding after an armed conflict, the decline is still a substantial amount and will put fiscal and budgetary constraints on defense spending.

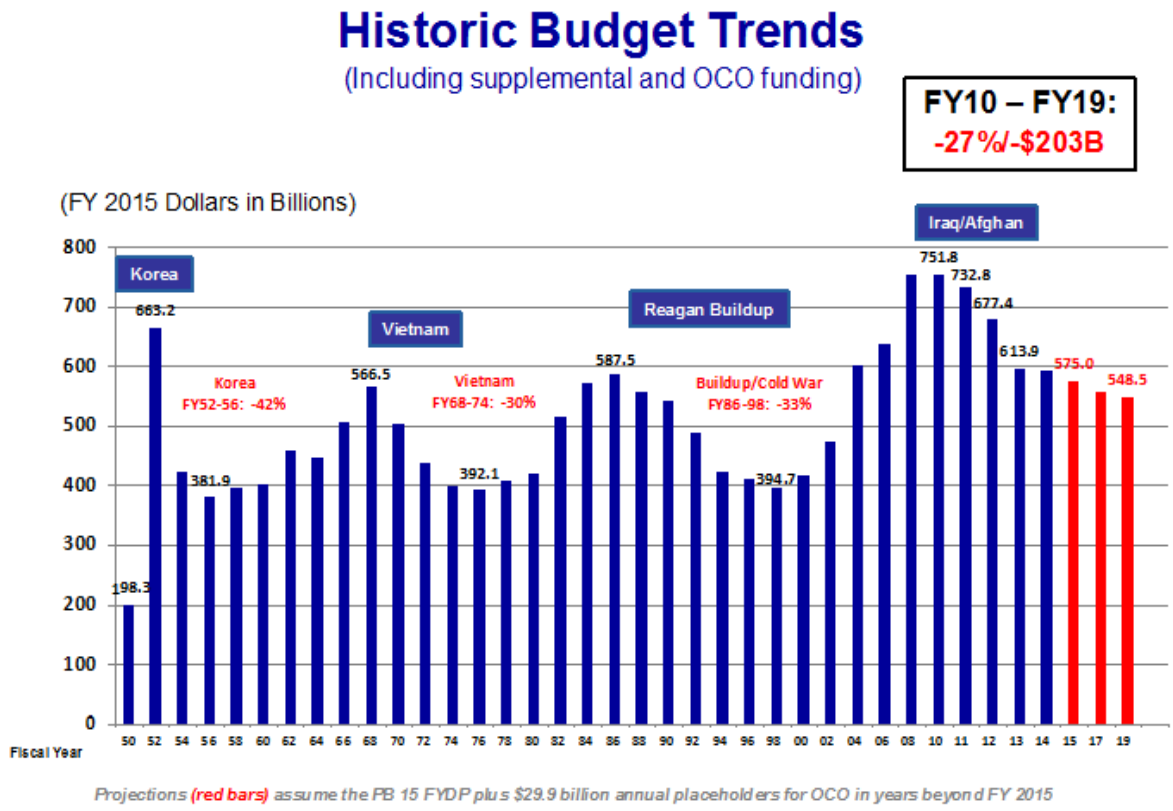

Figure 1. Defense Budget History (from Department of Defense, 2014)

Not only is defense spending decreasing because the United States is no longer fighting a major armed conflict, but also because the Budget Control Act of 2011 was enacted (Korb, Hoffman, & Blakeley, 2014). The Budget Control Act put a cap on discretionary spending through FY21 with each year's cap increasing by two percent. In 2013, the Bipartisan Budget Act was passed and increased the defense spending caps to $520 billion in FY14 and $521 billion in FY15 (Korb et al., 2014).

There is also a growing trend of decreasing Overseas Contingency Operation (OCO) funding which the military has come to rely on to maintain its current operational tempo and is separate from the baseline budget (Korb et al., 2014). OCO funding is not subject to spending caps and there is some concern that in order to meet mission needs the Department of Defense might use OCO funding for baseline requirements (Korb et al., 2014). The military has come to rely on the contingency funding to pay for items that should have been included in their baseline budget (Korb et al., 2014). Figure 2 shows the contingency funding levels since 2001. The height of the OCO supplemental was in FY 2008. Since then, OCO funding has been decreasing, which is forcing the United States military to make some tough decisions on cutting programs and reducing budgets. The reduction in funding is also forcing the military to find cost efficiencies whenever possible.

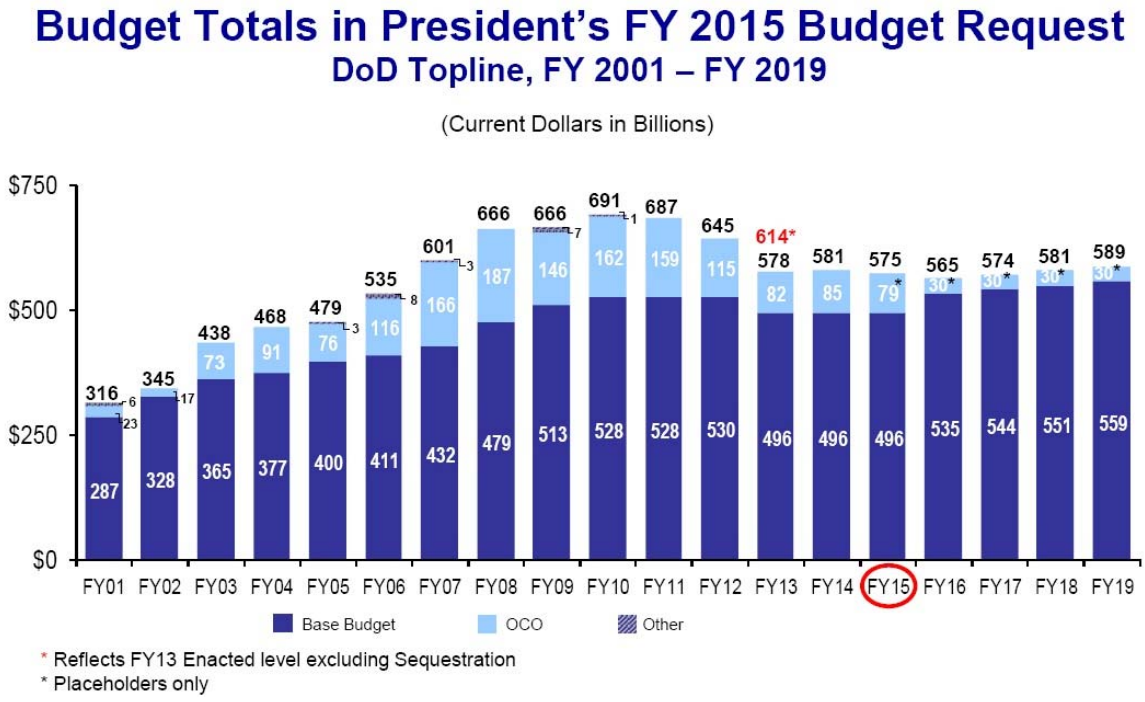

Figure 2. FY 2015 Budget Request
(from Department of Defense, 2014)

There is high competition for funding among various government agencies and, to worsen the situation, the Navy has to compete with the other defense services. As the Navy's budget decreases, decisions must be made as to the best use of funds while meeting the strategic goals and requirements of the President, Secretary of Defense, and the CNO. One of the CNO's goals is maintaining a forward presence overseas (Department of the Navy, 2014). The current forward staging policy and efforts are meeting this requirement; however, because of recent budget cuts, the policy and efforts must be re- examined to determine if they are the most cost effective courses of action.

D. NAVY REQUISITION PROCESS AND IDENTIFICATION

While afloat forces are outside of the United States territorial waters, the first point for resupply for items not carried or out of stock in the ships' organic inventory is material positioned on combat logistics force (CLF) ships. CLF assets can carry several categories of items to include fleet issue load list (FILL), high usage load list (HULL), and deck load items (Naval Supply Systems Command, 1997, pp. 1–24). FILL items are based off projected demand requirements to satisfy 85 percent of deployed force requirements (Naval Supply Systems Command, 1997, pp. 2–77). It is the responsibility of the AOR Combat Logistics Officer (CLO) to determine if the requisition will be filled by CLF assets or cancelled and require the requesting activity to submit the request to CONUS activities. There was an incentive for requesting activities to circumvent the CLO because of the possibility of having to resubmit the requisition, so most requesting activities would submit the requisition directly to CONUS (Mazzarella, 2013, p. 1). If the priority of the requisition is high, then the item would be shipped via air transportation and thus incur a higher transportation cost than if the item was filled by a CLF asset. This is one reason why the Navy has been incurring high shipping costs. NAVSUP has identified the circumvention as an unnecessary cost increase. To mitigate the chance of the policy not being followed, they have given the CLO permission to forward the requisition to ashore activities without canceling it. In addition, NAVSUP is in the process of developing a way for CTF-53 to monitor and enforce this submission requirement (Mazzarella, 2013, p. 1). By forward positioning more material, it will

increase the number of requisitions the CLO can fill with material located at DDNB and via CLF assets. Prior to the forward staging initiative only 18 percent of the requisitions were screened by the CLO however as of April of 2014 62 percent of the requisitions were screened by the CLO (Naval Supply Systems Command, 2014, p. 2).

Prior to the Fifth Fleet forward staging efforts, most requisitions that could not be filled by CLF ships were forwarded to CONUS activities to be filled. The primary reason to forward the requisition to CONUS activities is that OCONUS sites were not equipped and did not have material on hand to fill the requisitions. The need for forward presence with a high fleet readiness while minimizing costs dictated that selected NIINs be forward staged. It should be noted that aviation material does not have to be filled by CLF ships firsts (Naval Supply Systems Command, 1997, pp. 1–23). Rather, aviation material should be filled by the closest activity. This is another reason for the importance of forward staging material; it will ensure that aviation requirements are filled expeditiously.

As mentioned earlier the items at the DDNB warehouse are managed by DLA. DLA works very similar to a fleet logistics center (FLC) in that they manage and distribute material for the Navy; however, DLA manages common use items for all military services. They manage nearly all consumable material for the military and nearly 85 percent of the military's spare parts. Requisitions that they fill typically come from one of 25 distribution centers worldwide (Defense Logistics Agency, 2014). Approximately 60 percent of the integrated Navy supply system items are managed by DLA (Naval Supply Systems Command, 1997, pp. 1–28). DLA plays a critical role in filling requisitions with assets that a FLC cannot provide, both CONUS and OCONUS.

The priority of the requisition will generally determine the speed in which the FLC and DLA fill a requisition. The priority code is constructed from the force activity designator (FAD) and the urgency of need designator (UND). The FAD is a rating of the military importance of the requesting activity. The FAD ranges from FAD I, which is for the highest importance and assigned by the Secretary of Defense, to FAD V which is for the lowest importance activities. All naval forces deployed or operating in the Fifth Fleet AOR will be in a FAD II, and activities must use their appropriate FAD when ordering

material (Naval Supply Systems Command, 1997, p. 46). It is important for material to be available and relatively close for forces in FAD II because of their operation tempo and strategic importance.

The second factor that determines the overall priority of the requisition is the UND. The UND is assigned by the requesting activity and is a measure of the importance of the requested item to the activity's mission readiness. The UND ranges from ''A,'' which is for immediate requirements, to ''C,'' which is for routine requirements. Each UND has a set of criteria that must be met in order for the requesting activity to use the designator (Naval Supply Systems Command, 1997, pp. 3–49). For example, UND ''A" should only be used for material that is preventing the activity from performing one of its primary missions or if the material is associated with an "anticipated not operationally ready supply" (ANORS) requisition or a "not operationally ready supply" (NORS) requisition, also known as a casualty report (CASREP) (Naval Supply Systems Command, 1997, pp. 3–49).

Once both the FAD and UMD have been identified, the priority will be assigned to the requisition utilizing Table 1.

Table 1. Priority Designator (from Naval Supply Systems Command, 1997, p. 3-53)

Urgency of Need Designator		FAD				
		I	II	III	IV	V
		Priority Designator				
A	Unable to Perform	01	02	03	07	08
B	Performance Impaired	04	05	06	09	10
C	Routine	11	12	13	14	15

In addition to using the above priorities, requesting activities can use the code 999 in place of the required delivery date. The code 999 informs the entity filling the order, whether it is FLC or DLA, that the requesting activity wants the most expeditious handling possible. The use of 999 is restricted to those requisitions involving ANORS/CASREPS that must be filled within 15 days of actual combat requirements or

five days for all other worldwide requirements (Naval Supply Systems Command, 1997, pp. 3–31). In addition, the requesting activity must be a Navy force overseas or within 30 days of deployment overseas. The required delivery date of 777 can be used in situations that do not qualify for the use of 999, but the item has been assigned a priority of 04–08 and requires expeditious handling (Naval Supply Systems Command, 1997, pp. 3–56).

Acquisition advice codes (AAC) also play a factor in how and under what restrictions an item will be acquired. AACs fall into one of three categories either by requisition, by fabrication or assembly, or by local purchase. This study is concerned with items that have an AAC of C, D, J, V, and Z. See Appendix B for selected AAC definitions.

The Airlift Clearance Authority (ACA) controls the movement of air-eligible material and plays a large role in determining the mode of transportation for a given shipment. ACA manages an airlift challenge program which questions and validates air shipment requests based off a set of criteria. If the request exceeds one of the set criteria then it will be challenged and either be shipped via surface transportation or the requirement will need approval for air shipment from a higher echelon command. This process is in place to prevent misuse of the military transportation system and to lower the cost to transportation funds. High priority requisitions like those that are filling CASREPs in the Fifth Fleet are exempt from several of the challenge criteria which can lead to high transportation costs associated with these requisitions.

E. TRANSPORTATION FUNDS

There are two major funds that are associated with transporting NIINs: the Navy Working Capital Fund–Supply Management (NWCF-SM) and the Service Wide Transportation (SWT) fund. The Navy uses both accounts regularly, but depending on the NIIN's classification, one account will be charged for a shipment instead of another. Below each fund is defined per the Office of the Chief of Naval Operations Instruction 4600.24D.

> 1. NWCF-SM material pertains to consumable and repariable spare and repair parts managed by NAVICP under odd Cognizance Symbol (COG) symbols and purchased by a revolving fund account.
>
> Transportation costs associated with shipment of NAVICP odd managed material from DLA distribution depots to CONUS and OCONUS Point of Debarkation (POD) is initially paid by DLA, and then reimbursed by NWCF-SM. Material movements from the OCONUS POD to the end user are paid by the requisitioner, not NWCF.
>
> 2. SWT is a NAVSUP Second Destination Transportation (SDT) centrally managed Operation and Maintenance, Navy (O&MN) account with a discrete line in the Navy budget. The account was established to provide transportation funding for Navy cargo and mail movement that is clearly not the responsibility of an end use activity. (Department of the Navy, 2009, p. 8)

Depending as to whether the NIIN is an even or odd COG, and in what situation the item is being shipped, will determine which account to use. In general, shipment of even COG material, also known as appropriated purchases account (APA) material, should be charged to the SWT account while odd COG material, also known as Navystock account (NSA) material, should be charged to the NWCF-SM or the Transportation Account Code (TAC) of the Navy stock point issuing the material. Items being shipped from CONUS directly to the end user get charged to the SWT fund.

F. CURRENT FORWARD-STAGING PROCESSES

DLA uses an EMQ model in selecting the most cost effective NIINs to forward stage. The model is based on a variation of the Economic Order Quantity (EOQ), which minimizes the ordering costs and inventory holding cost for each NIIN (Defense Logistics Agency, 2013, p. 4). The model compares whether it is less expensive to ship a NIIN via surface transportation and manage at a forward distribution point or if it is more economical to hold the NIIN CONUS and ship via air transportation either by military air through TRANSOM or via a commercial carrier such as FEDEX or DHL express. These commercial carrier shipments and international small parcel shipments are also referred to as worldwide express shipments. The EOQ was customized by DLA to focus on the holding, handling, and transportation costs.

The selection process for DLA managed NIINs begins with a threshold requirement for the items to have four demand hits in two separate months over one year. By making this a requirement, DLA prevents dead stock that could take up valuable space and have high holding costs. The second criterion to be eligible is the NIIN must have a weapons systems essentiality code (WSEC) of 1–the item is needed to keep the system from failing, 5–personal safety, 6–the item is needed for a legal requirement or climatic requirement, or has a weapons systems designator code (WSDC) of 21N-Navy Reactor. In addition, the item must fall into classes of supply of II (Clothing and Textile), III (Petroleum, oil, and liquids), IV (Construction and equipment), VII (Medical), and IX (Repair parts). NIINs are reviewed monthly for consideration to be stocked (Defense Logistics Agency, 2013, p. 1).

The next step in the process is to identify any NIIN candidate that is restricted from being stored or managed due to the storage or operational capabilities of the depot. Any item that cannot be physically stored and managed at the forward distribution point (FDP) will be thrown out of consideration (Defense Logistics Agency, 2013, p. 3).

DLA uses the following EOQ variant (Defense Logistics Agency, 2013, p. 4):

$$EMQ = \sqrt{\frac{2 \times Dmd \times C_0}{C_h \times C_p}}$$

where:

Dmd = Demand = the Manugistics software forecast (annualized); if the forecast is not available, then Demand = Manugistics software history (annualized)

Co = the cost to order; which for the replenishment model is the net landed cost (NLC) rate to pick/pack/ship/receive/put-away; based on each item's weight band and handling characteristics

Ch = the cost to hold one dollar of inventory for one year–expressed as a percentage; the NLC blended rate used for OCONUS is 18 percent

Cp = the per unit price of the item.

The formula used by DLA for the economic number of replenishments per year is below.

$$E_{(\text{replens})} = \frac{Dmd}{EMQ}$$

The formula used by DLA for the economic replenishment frequency is below.

$$E_{(\text{frequency})} = \frac{365}{E_{(\text{replens})}}$$

Once the number of replenishments and frequency has been determined, the NIIN will be assigned two Pareto codes based off two separate processes. The first process involves using extended weight as a significant factor of cost. The NIINs are sorted by weight in descending order, a cumulative extend weight is calculated, and then a cumulative percentage of weight is calculated. The Pareto category value is then assigned as follows:

1. "A" Items = those items whose cumulative percentage is from zero (0 percent) up to, but not including 70 percent

2. "B" Items = those items whose cumulative percentage is equal to 70 percent up to, but not including 85 percent

3. "C" Items = those items whose cumulative percentage is equal to 85 percent up to, but not including 95 percent

4. "D" Items = those items whose cumulative percentage is equal to 95 percent up to 100 percent, thus capturing the remaining items. (Defense Logistics Agency, 2013, p. 5)

The second Pareto code assigned is based off material requisition order (MRO) count. The NIINs are sorted by MRO count in descending order, a cumulative MRO count by item is calculated, and then a cumulative percentage of total MRO counts by item is calculated (Defense Logistics Agency, 2013, p. 5). The Pareto category value is then assigned as follows:

1. "A" Items = those items whose cumulative percentage is equal to zero (0 percent) up to, but not including 70 percent

2. "B" Items = those items whose cumulative percentage is equal to 70 percent up to, but not including 85 percent

3. “C” Items = those items whose cumulative percentage is equal to 85 percent up to, but not including 95 percent

4. “D” Items = those items whose cumulative percentage is equal to 95 percent up to 100 percent, thus capturing the remaining items (Defense Logistics Agency, 2013, p. 5)

The overall Pareto code that is assigned to an item will be the higher of the two codes. The calculated fill rate is determined based of the final Pareto code assigned (Defense Logistics Agency, 2013, p. 5). Below are the fill rate targets:

1. “A”–Fill Rate Target = 95 percent

2. “B”–Fill Rate Target = 85 percent

3. “C”–Fill Rate Target = 70 percent

4. “D”–Fill Rate Target = 50 percent

The last step requires the NIINs selected to pass a cost comparison between the total costs to forward stage the NIIN to the cost to ship the item via air transportation from CONUS. The total cost of forwarded staging is comprised of the surface shipping cost per pound, the handling costs to replenish the OCONUS inventory, and the holding costs based off the EMQ contribution. Whichever cost is lower will determine if the NIIN is recommended for forward staging or not. DLA policy dictates that the item must be at least $500 more cost effective at the FDP to be added to the planned stock list (PSL) (Defense Logistics Agency, 2013, p. 6). Appendix C lists the additional calculations, definitions, and assumptions DLA used in creating their model.

The Navy also has a SRC process described in NAVSUP instruction 4440.192 that complements the EMQ model and will provide a recommendation for selected NIINs to be forward positioned. Items that are designated with a SRC will have inventory levels based off the Enterprise Business System (EBS) unless the parameters are manually overridden. Even though these items were not selected by the EMQ process, they are considered by the Navy to have a significant impact on the readiness of forward deployed units. If the requested item inventory is based off historical data, then levels will be calculated with DLA’s EBS, and if the item inventory is based off anticipated demand,

then the Navy will request specific inventory levels (Naval Supply Systems Command, 2013, p. 11).

The Navy SRC process is shown below:

- Coordinate with applicable COCOM, TYCOM, or regional partner prior to analysis
- Pull 12-months of demand for specific theater / platform (meets 4-2-12 rule)
- Remove all recorded demand with bad COGS, cancelled requisitions, forms, pubs, etc.
- Filter on all records that are “W,” “G,” 777, 999, IPG1, or IPG2
- Select all NIINs ordered by two or more UICs in AOR
- Determine if NIINs are carried in CARGO
- Pull weight, cube and cost data for transportation analysis…if hazmat, pull HMIC
- Ensure NIINs have valid WSDC
- Retain NIINs with AAC of C, D or Z. Assess AAC J and V for demand history
- Remove NIINs already carried on DLA PSL or WSS OCONUS stocking list
- Segregate NIINs into DLS, GSA and WSS categories
- Forward recommended NIINs to COCOM, TYCOM, or regional partner
- Forward recommended NIINs to DLA/WSS/GSA for approval
- Forward approved DLA/GSA NIINs to WSS code 08
- Forward approved WSS/GSA to DLA for compatibility check at applicable OCONUS Depot
- Monitor implementation and effectiveness via monthly scorecard. (Naval Supply Systems Command, 2013, p. 15)

The SRC selection criteria can be modified and adapted as necessary to accommodate different situations such as AOR specific requirements or unique items such as hazmat. Once the list of all SRC NIINs is created, it is worked by the National Account Manager (NAM) and J-332 Stock Positioning if the extended money value of the recommended SRC additions are less than $250K. For lists greater than $250K but less than $500K, it will be worked by the respective supply chain. If the extended value of the list is greater than $1M, then it will be approved at the Enterprise Operations Planning Council (EOPC) level (Naval Supply Systems Command, 2013, p. 16).

The end result of the DLA EMQ and Navy SRC process is the creation of a PSL. The PSL will contain the entire site specific NIINs that have met the required criteria/thresholds and are recommended for forward staging. The list will also contain any item that has been classified a SRC and passed the SRC process. The PSL is site specific and will vary from operating area to operating area. By letting PSLs vary, it allows for different mission sets to be accomplished in different AORs. For example, the Bahrain PSL is the only listing that contains NIINs associated with mine countermeasure ships and patrol crafts. The NIINs identified by the EMQ model will be reviewed monthly, and items that have not met the EMQ criteria for more than one year will be removed. The SRC items will be reviewed annually for retention on the PSL (Naval Supply Systems Command, 2013, p. 16).

II. DATA COLLECTION

For this analysis, we required data that covered at least two years and included data before the standup of the DDNB warehouse and after. We required a list of the NIINs, their weights, size, and cost shipped from DLA for both surface and air transportation to Bahrain. In addition, we required the Navy's portion of the historic holding cost at the DNNB. Finally, we required the demand data for all NIINs requisitioned in the Fifth Fleet AOR to include order and ship dates, mode of transportation, weight, and size of the NIIN. We obtained our data from DLA and NAVSUP. All data sets were in Excel format, and our available computers had the necessary power to conduct all filtering requirements and calculations. In the next several sections, we will describe our data.

A. AIR SHIPPING COST DATA

Shipping cost data was obtained from DLA. The data includes all historic air transportation costs to send required items from a DLA distribution point CONUS to Bahrain. The data set contains 225,120 individual air shipments over the months of March 2012 to February 2014. There were a total of 137,094 shipped via DHL, 10,304 shipped via FEDEX, 67,399 shipped via United Parcel Service (UPS), 10,192 items shipped via military airlift, and 131 shipped via MWA, see Figure 3 for shipment percentages. Shipping through DHL comprised more than half of the total shipments. The items were shipped from all around the United States. The three most frequent points of origin include Susquehanna, Pennsylvania, Norfolk, Virginia, and San Joaquin, California. Shipping weights ranged from .01 to 3,606 pounds. The package sizes ranged from 0 to 216 cubic feet. If an item was listed at 0 cubic feet it meant the package was smaller than .1 cubic foot. Charges ranged from $8.23 to $9,924. The shipments arrived at the Bahrain International airport and then transferred to Manama or Muharraq. There are several data points that were removed from the data set because they did not meet the criteria of being listed on the Bahrain PSL. Some examples include

items that had all zeros for NIINs and nomenclatures in the place of the NIIN column. In order to filter the data, we used the PSL for each month against the shipping data for that month.

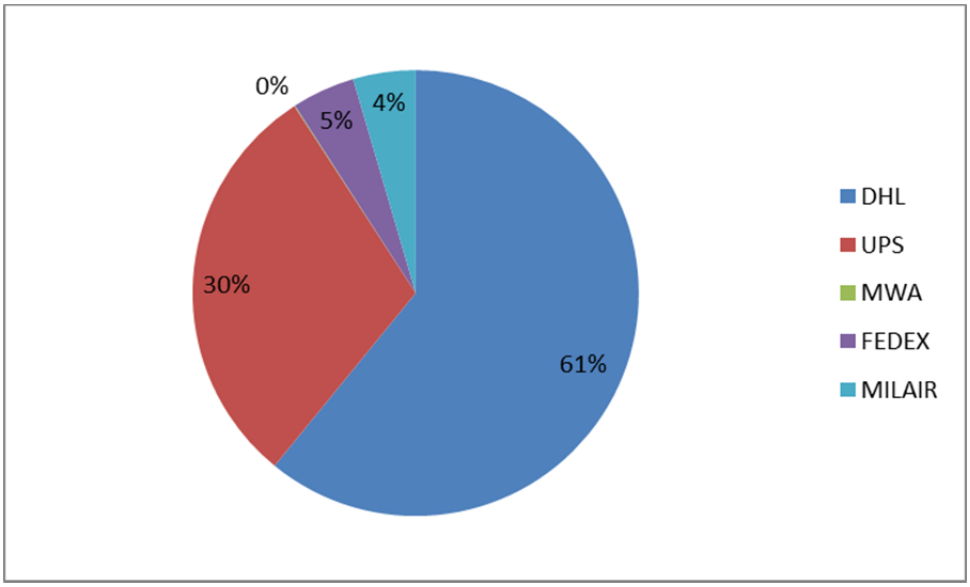

Figure 3. Percentage of Shipments by Carrier (after DLA, 2014)

B. SURFACE SHIPPING COSTS

Historic shipping costs could not be provided because individual NIINs could not be broken out using the TRANSCOM Ocean data; however, a list of NIINS, their corresponding weights, and year shipped was provided by DLA. This data set includes 6,229 requisitions with the heaviest NIIN weighing 244,015 pounds and the lightest weighing one-tenth of a pound. Because individual historic costs are not available, we will be using the average dollar per pound surface shipping rate for container shipments from CONUS East Coast to Bahrain which was received from DLA. This rate has been steadily decreasing over the last three years, from $.79 per pound in FY12, to $.71 in FY13, and $.58 in FY14, respectively. This is a $.21 decrease per pound and a 36 percent decrease from the FY12 rate. The rates were obtained from DLA using Global Air Transportation System (GATES) surface shipment history and Surface Deployment and Distribution Command (SDDC) published container general cargo billing rates. The rates

will be multiplied by the weights given in the surface shipment data in order to approximate the surface shipping cost. We plotted the shipping weights over time to see if there were any trends with heavier objects being shipped prior or during the standup of the DDNB COCO warehouse, see Figure 4. There does appear to be an increase in weights in 2013, which coincides with the standup of the COCO warehouse and the fact that the DLA EMQ model was created in early 2013, which favors heavier NIINS.

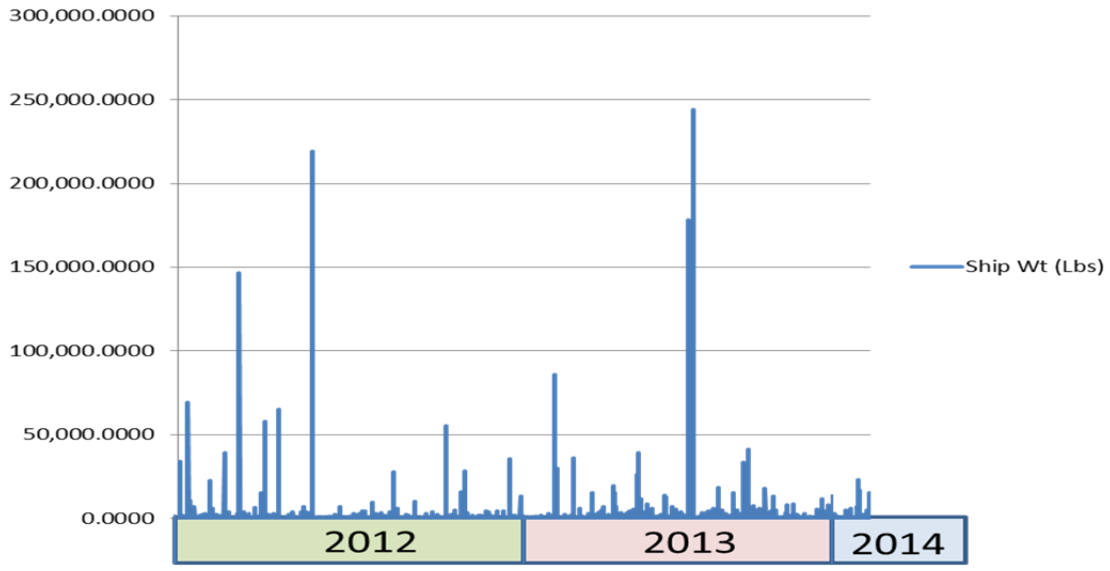

Figure 4. Surface Shipping Weights Over Time (after DLA, 2014)

C. HOLDING COST DATA

The holding cost data was acquired from DLA. The data set includes the total forward stocking charges for the DDNB warehouse and the Navy's portion of the stocking and handling charges. The data does not include any financial opportunity costs. The data ranges from March 2012 to February 2014. The total charges per month range from $17,018 to $674,138 and the Navy's portion ranges from $2,443 to $54,089. In aggregate, the Navy's share is approximately 10 percent of the total forward stocking charges. In addition, the data is limited to those shipments billed under forward stocking to support DDNB. The Navy's portion of the holding costs is based on the monthly billing percentage. We plotted the total DDNB holding cost with the Navy's portion from

March 2012 to February 2014, see Figure 5. The data shows that the Navy has consistently paid only a small portion of the holding cost. Even with the significant spike from February 2013 to June 2013, the Navy's portion only increased a moderate amount. The large spike is primarily due to the standup of the DDNB COCO warehouse. In addition, the Navy's portion appears to follow the trend of the total holding cost; however, it is not nearly as volatile from month to month.

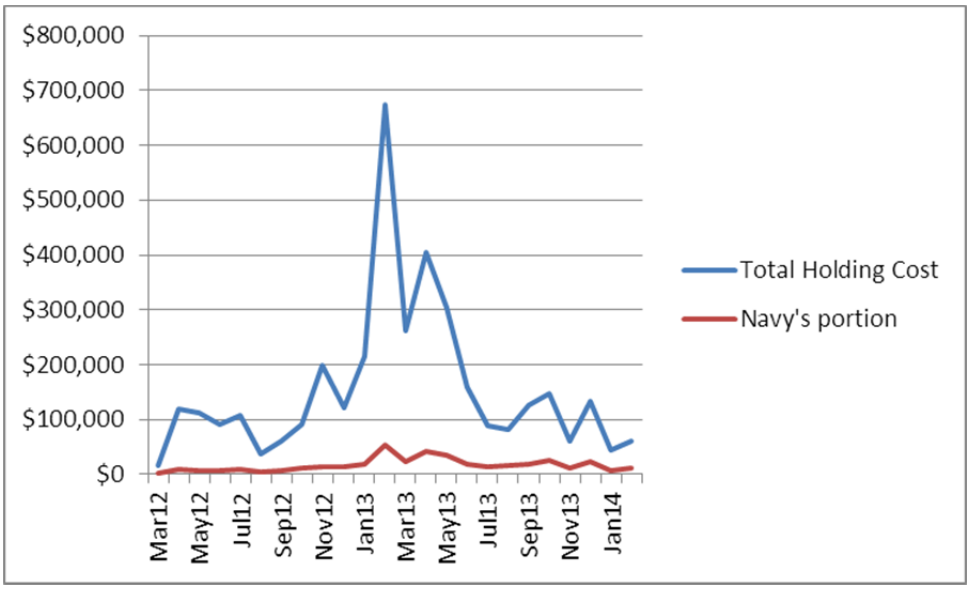

Figure 5. The Navy's Portion of DDNB Holding Costs (after DLA, 2014)

D. FIFTH FLEET PLANNED STOCK LIST

DLA provided a CY12, CY13, and CY14 DDNB PSL. Each PSL contains 12 months of data, with the exception of CY14, which only had three months. The PSLs from January 2012 to March 2013 lists NIINs that were selected using DLA's EMQ model. In April 2013, the PSLs began including NIINs selected by the Navy's SRC selection process. The NIINs listed with a SRC also comment on the military platform the NIIN primarily affects and the NIIN's associated supply chain. The platforms affected included BMD, PC/MCM, PC unique and MCM unique. The supply chains affected include land, construction and equipment, maritime, and aviation. We combined

all PSLs onto one spreadsheet and then removed any duplicate NIINs. There are 4,692 unique NIINs that have been listed on various PSLs from March 2012 to February 2014. Figure 6 lists the quantity of NIINs on the PSL each month. There is a steady increase in quantity which can most likely be attributed to the growing demand to forward stage parts and the fact that DLA now has ten times more space to warehouse items.

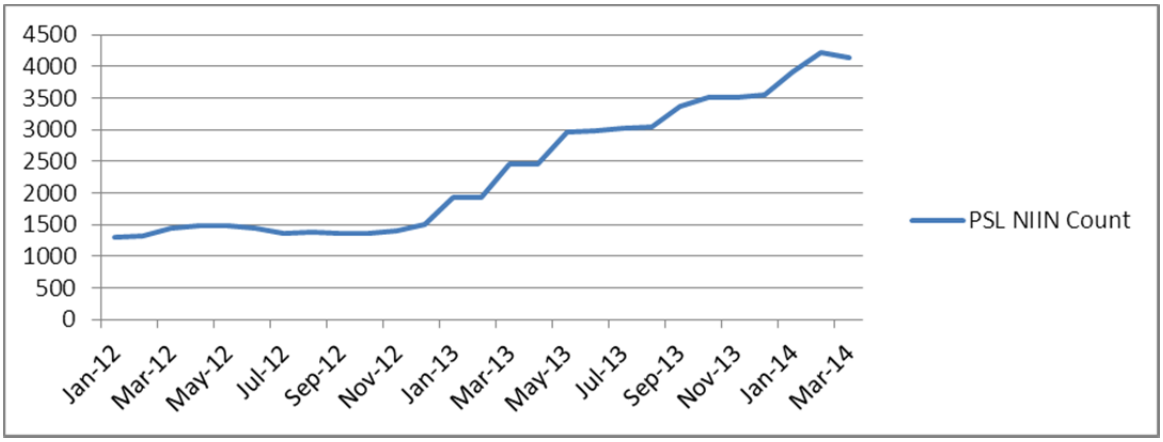

Figure 6. Quantity of NIINs Listed on DDNB PSL (after NAVSUP, 2014)

Figure 7 shows the percentage of SRC listed items on each PSL. There is a decreasing trend in the number of SRC items listed; however, it was very surprising to see that on average 80 percent of the NIINs on the PSL were selected by the SRC process and recommended for enclosure in the DDNB PSL. We anticipated the DLA EMQ model would drive most of the items stocked, leading to a small percentage of SRC items on the PSL. However, the opposite is true. There are more items on the PSL selected by the Navy's SRC selection process than the DLA EMQ selection process.

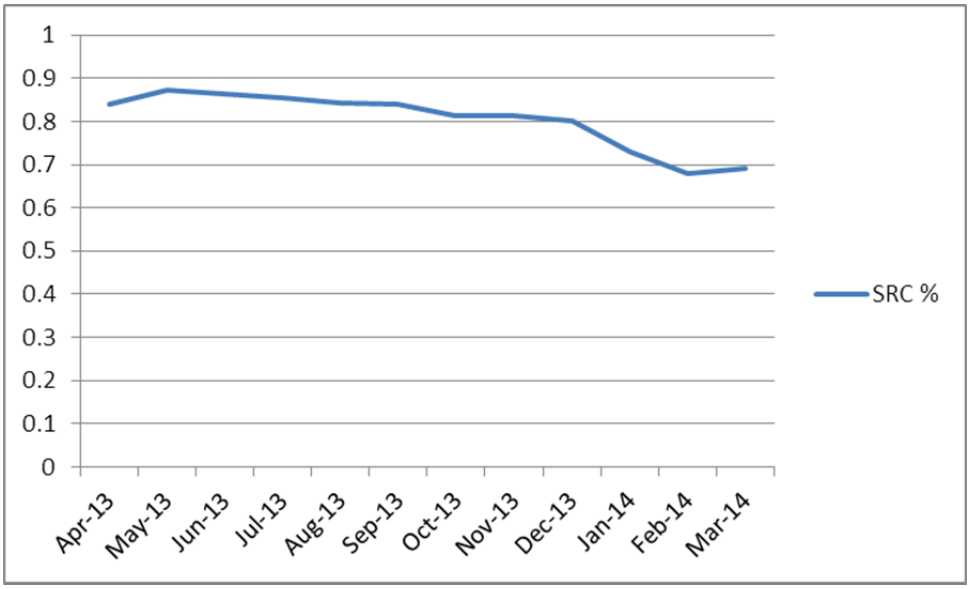

Figure 7. The Percentage of SRC listed NIINS on DDNB PSL (after NAVSUP, 2014)

E. FIFTH FLEET DEMAND DATA

Demand data was obtained from NAVSUP GLS and contains two years of demand data for the Fifth Fleet AOR. It includes any requisition that was requested by a unit operating in the AOR, to include deployed units and units stationed OCONUS. The data set contains 410,929 individual requisitions and spans from March 2012 to February 2014. The weights of the NIINs requested range from under 0.1 pounds to 32,360 pounds, and size ranged from less than one cubic foot to 269 cubic feet. The heaviest item requisitioned weighed 32,360 pounds and was a ship propeller, NIIN 2010012480377. The largest item requisitioned was 269 cubic feet, NIIN 4920013459714, a motion convertor encoder. The most valuable item requisitioned, in terms of monetary value, was an air reeling machine, NIIN 1680015106774, with a unit price of $381,451. Of the 410,929 requisitions, 34,167 had required delivery dates of 999 and 169,554 had a required delivery date of 777. Figure 8 shows the percentage of requisitions that had 999 and 777 for the required delivery date for all requisitions and only those that were listed on the PSL. In both situations, requisitions with 999 and 777 appear to make up approximately 50 percent of the total requisitions.

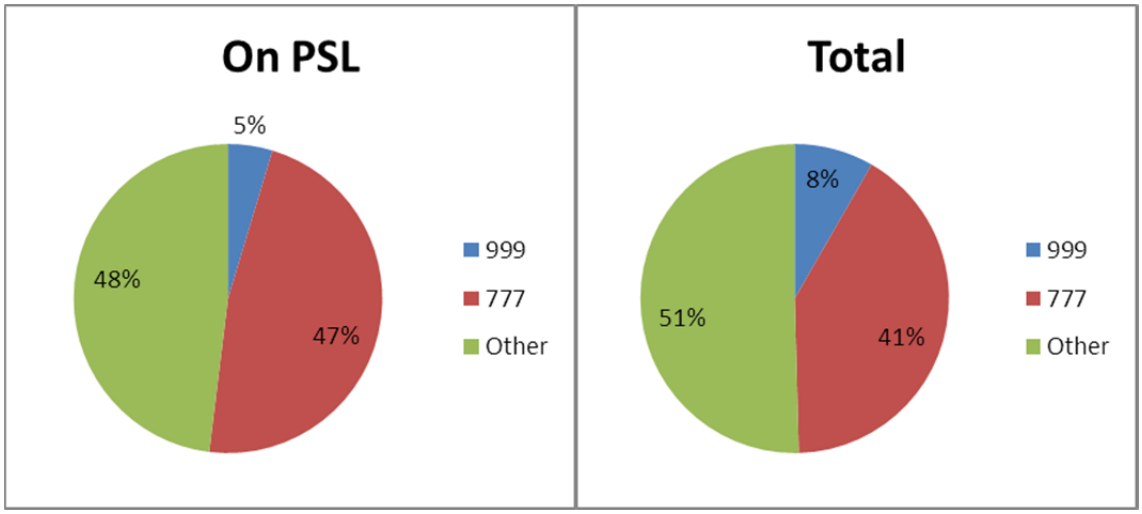

Figure 8. Percentage of High Priority Requisitions (after NAVSUP, 2014)

We also created an AAC breakdown chart for the demand data to look for differences in proportions in each type, see Figure 9. Acquisition advice code D, DOD integrated material managed, made up a large portion of the total AAC on the demand data with only PSL NIINs. This is in line with what would be expected for items forward staged and managed by DLA. There were nine percent of the PSL requisitions that did not have an ACC of C, D, J, V, and Z, which can be attributed to the DLA EMQ NIIN selection process.

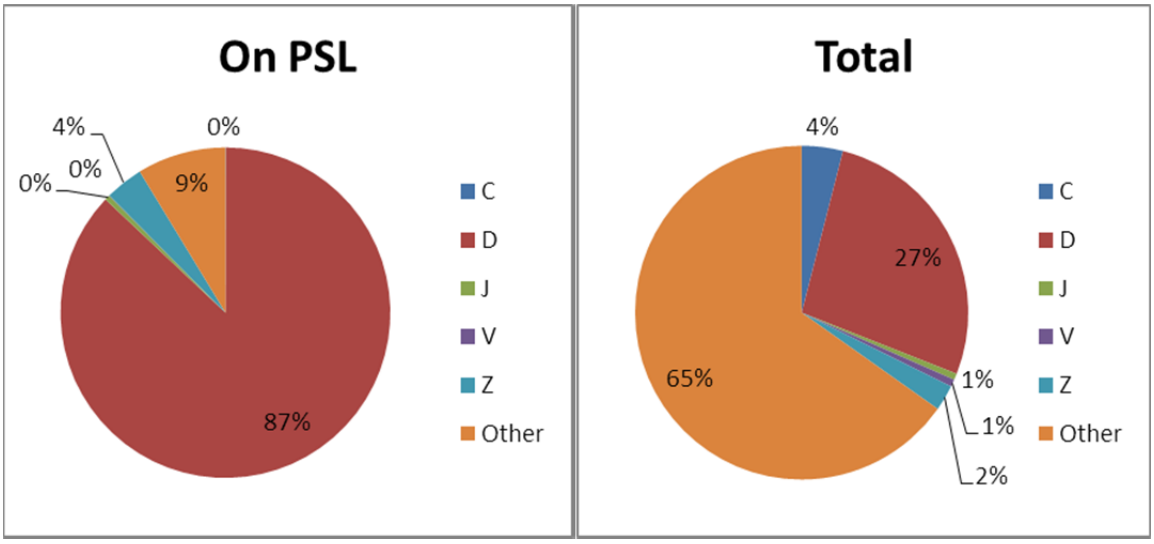

Figure 9. AAC Breakdown (after NAVSUP, 2014)

We sorted the demand data to only list the items that were on the DDNB PSL from March 2012 to February 2014. We then created a frequency chart for the various modes of shipment, see Figure 10. Appendix D has a list of all the shipment code explanations along with the individual frequency for each method. Air Small Package Carrier, code J, was the highest used shipment method of the PSL items. This shipment method accounted for 29 percent of the total shipments. The second most used method is via the Air Mobility Command, code F, which accounted for 16 percent of the total shipments. The third most used shipment method is via local delivery, code 9, which accounted for 15 percent of the shipments. Items that were locally delivered means the item was pulled from the DDNB warehouses or some other warehouse in Bahrain. SEAVAN and Surface Small Carrier, code U and 5, came in fourth and fifth in the frequency of use. The column labeled “Blank” represent requisitions in which the shipment mode field was not filled out.

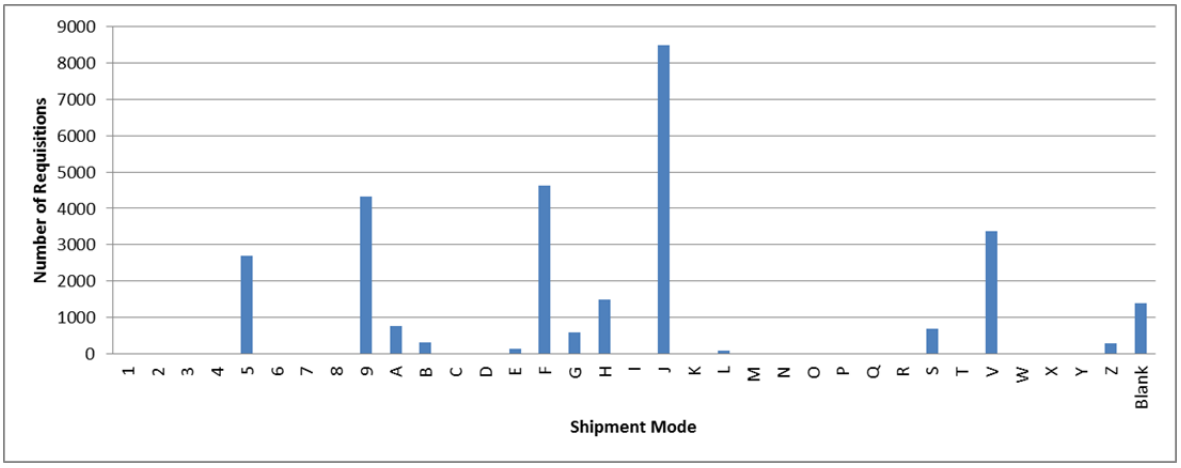

Figure 10. Shipment Mode Frequency (after NAVSUP, 2014)

Another way to look at the frequency information is to put the methods into three categories of air transportation, surface transportation, and forward staged assets. There were 1,391 data points that had a blank in the shipment method column, so these items were excluded from one of the three categories because there is no way for us to determine the actual mode of shipment for these items. In addition, there were two reserved categories that could not be directly linked to a particular shipment method, so those requisitions were excluded from a category assignment. Table 2 shows the frequency for each of the three categories. Over 52 percent of the Fifth Fleet requisitions were filled by air transportation, followed by 25 percent filled by sea transportation, and finally 23 percent filled by NIINs forward staged.

Table 2. Frequency of PSL Shipment Methods (after NAVSUP, 2014)

	Frequency	% of Total
Filled by Air Transportation	14,657	52.44%
Filled by Surface Transportation	6,989	25.01%
Filled by Forward Staged Assets	6,303	22.55%
Total	27,949	

We graphed the percentage of depot level repairables (DLR) that were designated as a PSL item and demanded in the last two years. Figure 11 shows that of all the PSL

items requisitioned only three percent made up the total. Of that three percent, 76 percent were labeled as a 7H COG. All of the listed COGs are associated with shipboard DLRs.

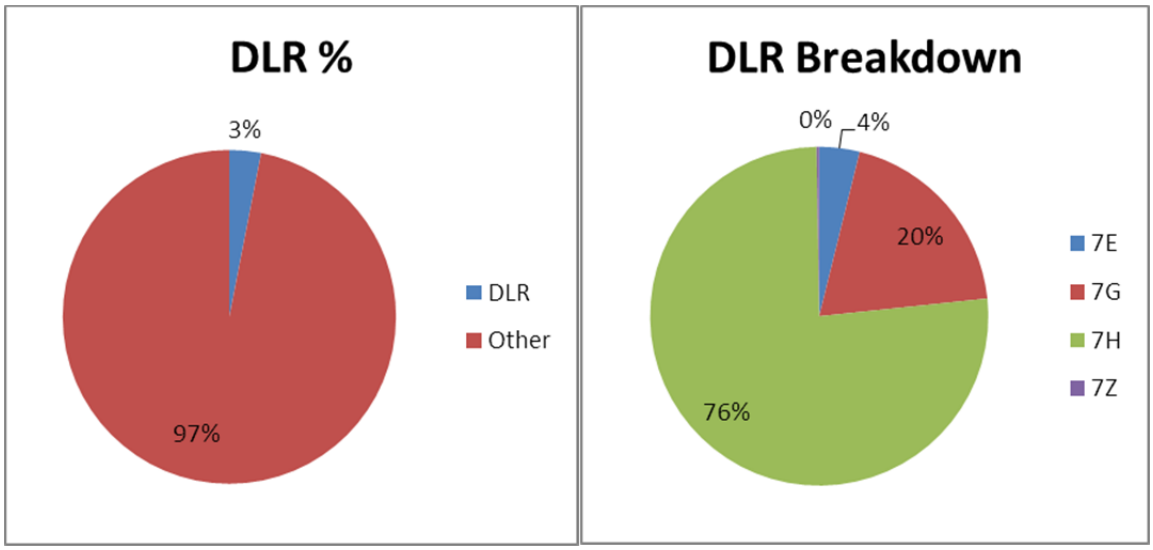

Figure 11. DLR Percentage and Breakdown (after NAVSUP, 2014)

Looking at the demand data as a whole, there are 11 requisitions that were received before the items were ordered. This could be because of an error in inputting the requisition or if the item was ordered offline. In addition, there were 119 requisitions submitted but not received. Thirty-six requisitions were backordered, and 77 were cancelled. The shortest lead time from the date an item was ordered to the date it was received was less than one day. The longest lead time was 720 days. The average lead time of the data set was 38.71 days. The frequency of the lead times from when the requisition was placed to when the NIIN was received for the entire data set were graphed in Figure 12. A small portion of the NIINs were shipped and received within five days. Most of the lead times were between six to 40 days. The frequency of leads times greater than 182 days was relatively minimal.

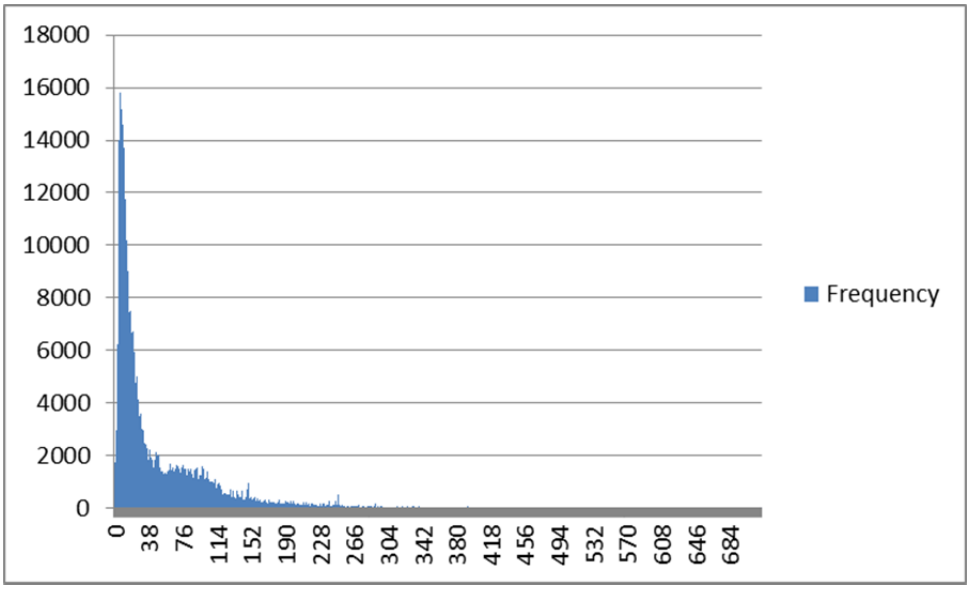

Figure 12. Frequency of Lead Times in Days for Full Data Set (after NAVSUP, 2014)

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III. COST ANALYSIS

In this chapter, we report findings of a cost analysis conducted on the forward staging process at DDNB. The data was analyzed in various stages, starting with the DLA air and surface shipments. This data was analyzed for only NIINs listed on the PSLs, and then the analysis was conducted on the entire data set. A cost analysis was conducted on the Fifth Fleet demand history for only NIINs listed on the PSLs and then for the entire data set. Requisition numbers are not listed in the DLA data, so there was no way for us to combine the two data sets. It is possible that some of the shipments in the DLA data are also in the two-year demand data; however, because we had no means to connect the two data sets we analyzed them separately. This analysis provides NAVSUP a quantitative analysis of the methods used to fill customer demand in relation to the forward staging efforts.

A. ASSUMPTIONS

We had the following assumptions when developing and using our cost analysis equation.

1. The surface shipping rates will only change at the beginning of a new fiscal year. This assumption facilitates using only one rate per fiscal year.

2. Items listed on the Bahrain PSL that were air shipped were done so because the items were not in stock at the DDNB warehouse.

3. Items shipped via air transportation were done to meet the customers' required delivery dates, and therefore could not be shipped by surface transportation.

4. The holding cost does not include any financial opportunity costs.

5. We ignore any special handling or cube cost and use NIIN weight as the only factor when calculating costs.

6. Requisitions with a mode of shipment code 2, 5, G, M, V, and Z will be considered to have been shipped via surface shipment.

7. Requisitions with a mode of shipment code of 4, 6, and F will be considered to have been shipped via military air shipment.

8. Requisitions with a mode of shipment code of 7, H, J, and Q will be considered to have been shipped via commercial air shipment.

9. Requisitions with a mode of shipment code of 9, A, B, D, E, I, S, and X will be considered to have been issued from Bahrain.

B. GENERAL EQUATION

The general equation used in our cost analysis is as follows:

$$Cost_{Type} = \sum_{i=1}^{N} Surface_i^{[DataSource]} + \sum_{i=1}^{N} Hold_i^{[DataSource]} + \sum_{i=1}^{N} Air_i^{[DataSource]}$$

where:

Type=

$$\left\{\begin{array}{l} Best\ case\ (DLA) = The\ cost\ if\ all\ NIINs\ that\ were\ selected\ for\ forward\ staging\ in\ the\ DLA\ datasets\ were\ shipped\ via\ surface \\ Actual\ (DLA) = The\ cost\ that\ actually\ occurred\ using\ the\ DLA\ datasets \\ Difference\ (DLA) = The\ difference\ between\ forward\ staging\ PSL\ NIINs\ versus\ not\ forward\ staging\ them\ using\ the\ DLA\ data\ sets \\ Opportunity\ (DLA) = The\ target\ of\ opportunity\ for\ non-PSL\ NIINs\ in\ the\ DLA\ dataset \\ Best\ case\ (2YrDmd) = The\ cost\ if\ all\ NIINs\ that\ were\ selected\ for\ forward\ staging\ in\ the\ 5^{th}\ demand\ dataset\ were\ shipped\ via\ surface \\ Actual\ (2YrDmd) = The\ cost\ that\ actually\ occurred\ using\ the\ 5^{th}\ fleet\ demand\ dataset \\ Difference\ (2YrDmd) = The\ difference\ between\ forward\ staging\ PSL\ NIINs\ versus\ not\ forward\ staging\ them\ using\ the\ 5^{th}\ fleet\ demand\ dataset \\ Opportunity\ (2YrDmd) = The\ target\ of\ opportunity\ for\ non-PSL\ NIINs\ in\ the\ 5^{th}\ fleet\ demand\ dataset \end{array}\right\}$$

$Cost_{Type}$ = Cost of forward staging material. Subscript denotes what type of cost is being calculated.

i = The ith data point

Data source =

$$\left\{\begin{array}{l}(DLA)\ PSL\ Surface\ =\ The\ DLA\ surface\ shipment\ data\ set\ for\ PSL\ NIINs\\(DLA)\ PSL\ Air\ =\ The\ DLA\ air\ shipment\ data\ set\ for\ PSL\ NIINs\\(DLA)\ NonPSL\ Air\ =\ The\ DLA\ air\ shipment\ data\ set\ for\ non-PSL\ NIINs\\(DLA)\ Holding\ Costs\ =\ The\ DLA\ holding\ cost\ data\ set\\(2\ YrDmd)\ PSL\ Surface\ =\ The\ 5^{th}\ fleet\ demand\ data\ set\ for\ surface\ shipped\ PSL\ NIINs\\(2\ YrDmd)\ PSL\ Local\ =\ The\ 5^{th}\ fleet\ demand\ data\ set\ for\ locally\ issued\ PSL\ NIINs\\(2\ YrDmd)\ PSL\ Air\ =\ The\ 5^{th}\ fleet\ demand\ data\ set\ for\ air\ shipped\ PSL\ NIINs\\(2\ YrDmd)\ NonPSL\ Air\ =\ The\ 5^{th}\ fleet\ demand\ data\ set\ for\ air\ shipped\ non-PSL\ NIINs\end{array}\right\}$$

$Surface_i^{[DataSource]}$ = Surface shipping costs. Superscript denotes what data source was used to calculate the surface shipment cost.

$Hold_i^{[DataSource]}$ = Navy holding cost for DDNB warehouse. Superscript denotes what data source was used to calculate the holding cost.

$Air_i^{[DataSource]}$ = Air shipment costs. Superscript denotes what data source was used to calculate the air shipment cost.

This equation calculates the aggregate cost of forward positioning material. The equation is flexible in that it can be used to calculate the historic cost or what the cost would have been given a set of selected NIINs. In addition, it can be modified to calculate the cost difference between shipping items via surface shipping and paying a holding cost less the cost of shipping items via air shipment.

C. CALCULATIONS AND ANALYSIS

1. DLA Air and Surface Shipments Analysis with Only PSL NIINs

First, we wanted to see how much DLA has charged the Navy for forward positioning material from March 2012 to February 2014. To do this, we filtered the DLA surface shipment data for only those NIINs that were listed on the DDNB PSLs. We then multiplied the filtered NIIN weights by the yearly surface shipment rates and summed the values. This gave us how much DLA has charged the Navy for sending NIINs selected for forward staging via surface transportation which was $1,781,827.97. We ensured the NIIN weights were multiplied by the appropriate fiscal year shipping rate. In addition, we

omitted ten data points because their weights dictated that they would have to be shipped via surface transportation regardless of forward staging efforts and should be excluded from our calculations. A NIIN was omitted if it exceeded 45,000 pounds, which is the maximum payload capacity of a C-130 aircraft.

We then filtered the DLA air shipment data for only those NIINs that were listed on the DDNB PSLs. We summed the individual air shipment charges for the filtered data, which totaled $481,110.05. This is the amount the Navy was charged by DLA for shipping NIINs on the PSLs to Bahrain via air transportation. Finally, we added the surface and air transportation totals to the DDNB holding cost. The total forward staging cost charged to the Navy by DLA is $2,662,424.61. Below is the equation we used for our calculation.

$$Cost_{Actual\,(DLA)} = \sum_{i=1}^{5,930} Surface_i^{[(DLA)\,PSLSurface]} + \sum_{i=1}^{24} Hold_i^{[(DLA)\,HoldCost]} + \sum_{i=1}^{6,664} Air_i^{[(DLA)\,PSLAir]}$$

where:

$$\sum_{i=1}^{5,930} Surface_i^{[(DLA)\,PSLSurface]} = \$1,781,827.97$$

$$\sum_{i=1}^{24} Hold_i^{[(DLA)\,HoldCost]} = \$399,486.59$$

$$\sum_{i=1}^{6,664} Air_i^{[(DLA)\,PSLAir]} = \$481,110.05$$

$$Cost_{Actual\,(DLA)} = \$1,781,827.97 + \$399,486.59 + \$481,110.05 = \$2,662,424.61$$

Next, we wanted to see what it should have cost if all PSL NIINs were shipped via surface transportation. This is the best case scenario and is the situation the forward positioning effort is aiming to achieve because surface shipping costs are significantly lower than air transportation costs. To calculate what it would have cost to ship NIINs via surface transportation that were actually shipped via air transportation, we used the filtered list we made for the air shipment data and then multiplied the NIIN weights by the appropriate surface shipping rate. The summed charges came out to $97,614.35. This is the amount it would have cost to ship the PSL NIINs in the air shipment data by surface transportation. We added the previous surface shipping cost and the holding cost to this amount and came out with a total of $2,278,928.91. This is the lowest cost the Navy could have incurred from DLA for forward positioning material in the Fifth Fleet

AOR based off the PSL NIINs shipped. Below is the equation we used for our calculation.

$$Cost_{BestCase(DLA)} = \sum_{i=1}^{6,664} Surface_i^{[(DLA)PSLAir]} + \sum_{i=1}^{5,930} Surface_i^{[(DLA)PSLSurface]} + \sum_{i=1}^{24} Hold_i^{[(DLA)HoldCost]}$$

where:

$$\sum_{i=1}^{6,664} Surface_i^{[(DLA)PSLAir]} = \$97,614.35$$

$$\sum_{i=1}^{5,930} Surface_i^{[(DLA)PSLSurface]} = \$1,781,827.97$$

$$\sum_{i=1}^{24} Hold_i^{[(DLA)HoldCost]} = \$399,486.59$$

$$Cost_{BestCase(DLA)} = \$97,614.35 + \$1,781,827.97 + \$399,486.59 = \$2,278,928.91$$

The difference between Cost $_{Actual(DLA)}$ and Cost $_{BestCase(DLA)}$ is $383,495.70, which is the premium the Navy paid to have material expedited via air transportation to meet customer needs. The Navy would have saved a fair amount of money if the NIINs in the DLA air shipment data were in stock at the DDNB warehouse and had been sent via surface shipping instead of air shipped. Typically the items were air shipped because they were out of stock in the DDNB warehouse and were required immediately; or the items were listed on the PSL, but not yet stocked at the warehouse.

The actual air shipment costs and the best case cost were graphed side by side for comparison purposes, see Figure 13. The difference between the two columns is equal to $383,495.70. DLA chose to air ship a significant amount of material rather than send it by surface for items that should have been stocked at DDNB. The material shipped was a combination of NIINs to fill the COCO warehouse and NIINs to fill immediate customer demand. The air shipments costs were paid for by the Navy.

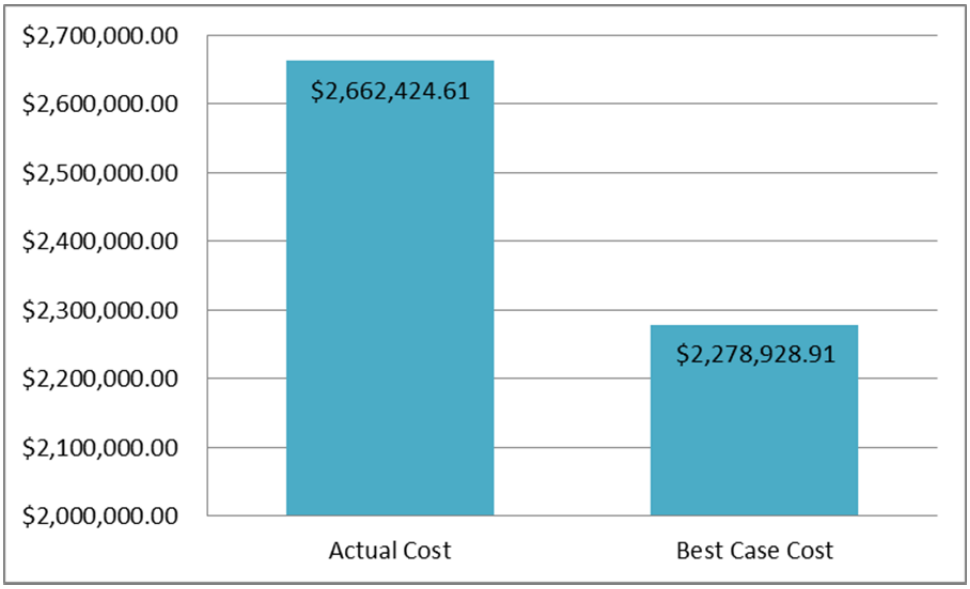

Figure 13. Actual Cost versus Best Case Cost (after DLA, 2014)

Next, we calculated what the charges would be for forward staging the PSL NIINs, best case scenario, versus shipping all PSL NIINs via air transportation and not forward staging. To calculate what it would have cost to ship the PSL NIINs in the DLA surface shipment data by air transportation, we filtered the DLA surface shipment data for only PSL NIINs and then multiplied the NIIN weights by the average yearly air shipping rate. The shipping rates were calculated using the DLA air shipment data. The cube sizes of the NIINs were not used in calculating the average rate. The data suggests that NIIN weight is the primary driver of the air transportation costs. To verify this, we conducted a regression on the air shipment charges using weight as an independent variable. The probability value of the test statistic is zero, and the coefficient of determination was .82. These two factors verify that using weight alone to calculate a shipping rate is satisfactory. Below is the equation we used to calculate the cost difference.

$$Cost_{Difference(DLA)} = \left(\sum_{i=1}^{6,664} Surface_i^{[(DLA)PSLAir]} + \sum_{i=1}^{5,930} Surface_i^{[(DLA)PSLSurface]} + \sum_{i=1}^{24} Hold_i^{[(DLA)HoldCost]}\right)$$
$$-\left(\sum_{i=1}^{6,664} Air_i^{[(DLA)PSLAir]} + \sum_{i=1}^{5,930} Air_i^{[(DLA)PSLSurface]}\right)$$

where:

$$\sum_{i=1}^{6,664} Surface_i^{[(DLA)PSLAir]} = \$97,614.35$$

$$\sum_{i=1}^{5,930} Surface_i^{[(DLA)PSLSurface]} = \$1,781,827.97$$

$$\sum_{i=1}^{24} Hold_i^{[(DLA)HoldCost]} = \$399,486.59$$

$$\sum_{i=1}^{6,664} Air_i^{[(DLA)PSLAir]} = \$481,110.05$$

$$\sum_{i=1}^{5,930} Air_i^{[(DLA)PSLSurface]} = \$11,617,573.45$$

$$Cost_{Difference(DLA)} = (\$97,614.35 + \$1,781,827.97 + \$399,486.59)$$

$$-(\$481,110.05 + 11,617,573.45) = -\$9,819,754.59$$

Based off the above calculation, theoretically if the Navy had shipped the items listed on the PSL via air shipment, it would have cost the Navy $9,819,754.59 more than if the NIINs were sent via surface transportation and forward positioned. By forward positioning material, it is saving the Navy a significant amount of money and improves NIIN lead times. The ability to issue directly from the warehouse saves two to three days in air transportation time. The saved time will decrease equipment down time and improve mission readiness.

The cost to expedite all PSL NIINs via air transportation and the cost to forward position the material were graphed side by side to get a visual comparison, see Figure 14. The cost to expedite all PSL NIINs and not forward position material is significantly higher than the cost to forward position the material and ship via surface transportation.

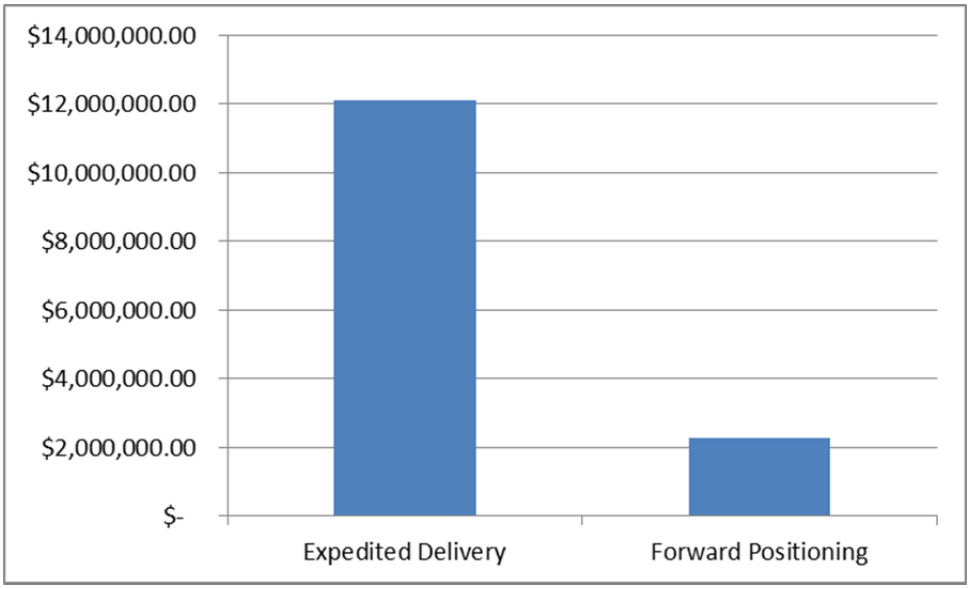

Figure 14. Expedited Delivery versus Forward Positioning, DLA Data Set (after DLA, 2014)

2. DLA Air and Surface Shipment Analysis with Non-PSL NIINs

We also analyzed all non-PSL NIINs shipped from DLA to identify a target of opportunity for the Navy to save on transportation costs for NIINs shipped by DLA that were not selected for forward positioning. We filtered the DLA air shipment data for only non-PSL NIINs and multiplied the weights by the surface shipping charge rate. We then summed the values and subtracted the total air charges for non-PSL NIINs, which came out to -$8,660,942.61. We used the below equation in our calculation.

$$Cost_{Opportunity(DLA)} = \sum_{i=1}^{218,456} Surface_i^{[(DLA)\,\mathrm{NonPSLAir}]} - \sum_{i=1}^{218,456} Air_i^{[(DLA)\,\mathrm{NonPSLAir}]}$$

where:

$$\sum_{i=1}^{218,456} Surface_i^{[(DLA)\,\mathrm{NonPSLAir}]} = \$2,069,629.58$$

$$\sum_{i=1}^{218,456} Air_i^{[(DLA)\,\mathrm{NonPSLAir}]} = \$10,730,572.19$$

$$Cost_{Opportunity(DLA)} = \$2,069,629.58 - \$10,730,572.19 = (\$8,660,942.61)$$

Over the course of two years, the Navy paid an additional $8,660,942.61 to have required non-PSL NIINs shipped to Bahrain through DLA. This is the premium that the Navy paid to meet customer demand on time and support mission readiness and

operational commits. We graphed the monthly cost of the air shipments and the monthly cost of the calculated surface shipping cost over time. Figure 15 shows the additional amount paid to expedite orders and meet customer demand. The light blue area represents the target of opportunity for the Navy to save money in transportation charges.

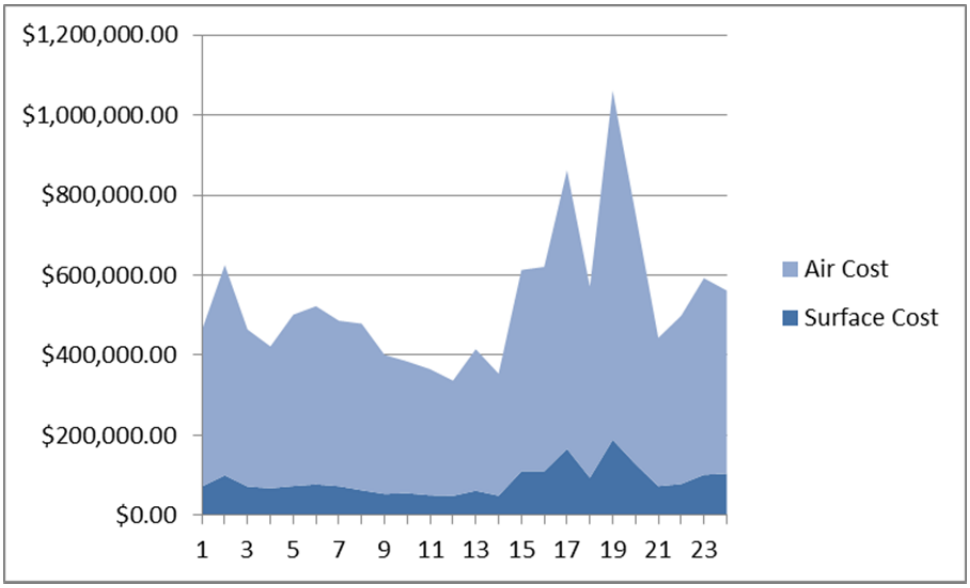

Figure 15. Actual Air Costs versus Calculated Surface Transportation Costs for Non-PSL NIINs (after DLA, 2014)

Additionally, we calculated what percentage of the total air shipment data was attributed to items that were listed on DDNB PSL. The results indicate that only a small fraction of the items shipped, four percent, were items designated for forward staging and most of the air shipment costs were attributed to items that were ordered to fill customer requirements that did not qualify the NIIN to become a part of the PSL. Figure 16 is visual representation of the percentage of PSL air transportation costs in relation to the total air transportation costs.

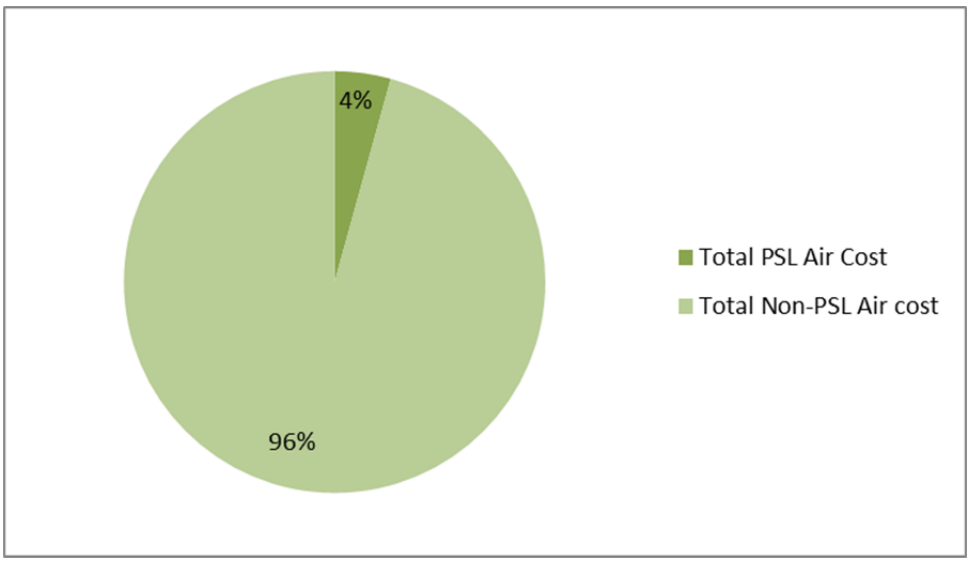

Figure 16. PSL Versus Non-PSL Air Transportation Costs (after DLA, 2014)

Although the forward staging effort is saving the Navy money, the fact that there are 22 times more NIINs being shipped by air transportation than the amount of items designated for forward staging means there is significant target of opportunity for increasing forward staging efforts.

3. Fifth Fleet Demand Data Analysis with Only PSL Items

Utilizing the second set of data provided, we conducted a cost analysis based off all customer demand in the Fifth Fleet AOR for any NIIN on the DDNB PSL. The data set contained all NIINs requisitioned so we filtered the data for only those NIINs that were listed on a DDNB PSL for the last 24 months. In theory, these items should have been issued from the DDNB warehouse and not shipped via air transportation. As we saw earlier, only 25 percent of the requisitions ordered were filled by forward staged supplies. To calculate the total cost associated with PSL NIINs listed on the demand data, we used the following equation.

$$Cost_{Actual(2YrDmd)} = \sum_{i=1}^{6,086} Surface_i^{[(2\,YrDmd)\,PSLSurface]} + \sum_{i=1}^{5,173} Surface_i^{[(2\,YrDmd)\,PSL\,Local]} + \sum_{i=1}^{24} Hold_i^{[(DLA)\,HoldCost]} + \sum_{i=1}^{14,657} Air_i^{[(2\,YrDmd)\,PSLAir]}$$

where:

$$\sum_{i=1}^{6,086} Surface_i^{[(2\,YrDmd)\,PSLSurface]} = \$43,547.51$$

$$\sum_{i=1}^{5,173} Surface_i^{[(2\,YrDmd)\,PSL\,Local]} = \$35,421.36$$

$$\sum_{i=1}^{24} Hold_i^{[(DLA)\,HoldCost]} = \$399,486.59$$

$$\sum_{i=1}^{14,657} Air_i^{[(2\,YrDmd)\,PSLAir]} = \$543,172.07$$

$$Cost_{Actual(2YrDmd)} = \$43,547.51 + \$35,421.36 + \$399,486.59 + 543,172.07$$

$$= \$1,021,627.53$$

The total shipping and forward staging cost of NIINs listed on the Bahrain DDNB PSL is $1,021,627.53, using the two-year demand data set and holding cost data set. The holding costs make up 41 percent of the total cost, see Figure 17.

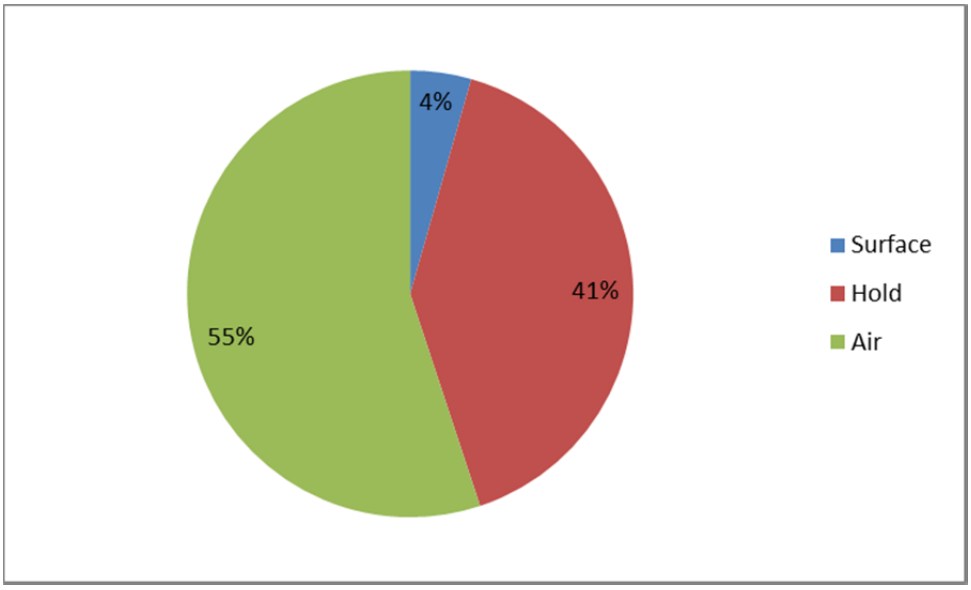

Figure 17. PSL Cost Breakdown (after NAVSUP, 2014)

To find out what the theoretical cost savings would be using only the PSL demand data, we first multiplied the PSL NIINs by the average yearly shipping rates for air and surface transportation. These values represent what transportation cost would have been if all the PSL NIINs were shipped by air and if they were all shipped by surface. We used the following equation to calculate the savings.

$$Cost_{BestCase(2YrDmd)} = \sum_{i=1}^{6,086} Surface_i^{[(2\,\mathrm{YrDmd})\,\mathrm{PSL}\,Surface]} + \sum_{i=1}^{14,657} Surface_i^{[(2\,\mathrm{YrDmd})\,\mathrm{PSL}\,Air]}$$
$$+ \sum_{i=1}^{5,173} Surface_i^{[(2\,\mathrm{YrDmd})\,\mathrm{PSL}\,Local]} + \sum_{i=1}^{24} Hold_i^{[(DLA)\,HoldCost]}$$

where:

$$\sum_{i=1}^{6,086} Surface_i^{[(2\,\mathrm{YrDmd})\,\mathrm{PSL}\,Surface]} = \$34,181.76$$

$$\sum_{i=1}^{14,657} Surface_i^{[(2\,\mathrm{YrDmd})\,\mathrm{PSL}\,Air]} = \$64,046.27$$

$$\sum_{i=1}^{5,173} Surface_i^{[(2\,\mathrm{YrDmd})\,\mathrm{PSL}\,Local]} = \$35,421.36$$

$$\sum_{i=1}^{24} Hold_i^{[(DLA)\,HoldCost]} = \$399,486.59$$

$$Cost_{BestCase(2YrDmd)} = \$34,181.76 + \$64,046.27 + \$35,421.36 + \$399,486.59$$
$$= \$533,135.98$$

If all the PSL NIINs listed in the two-year demand data were shipped via surface transportation and forward positioned as originally intended, the cost would be $533,135.98. This is the best case scenario for the Navy and would have been the approximate cost if the PSL NIINs were in stock at the DDNB warehouse. Unfortunately, 14,657 PSL NIINs were shipped by air transportation because they were out of stock in the DDNB warehouse and required immediately or the items were listed on the PSL, but not yet stocked at the warehouse. The difference between $Cost_{Actual(2YrDmd)}$ and $Cost_{BestCase(2YrDmd)}$ is $488,491.55. This is the premium the Navy paid over two years to get items that should have been forward staged air shipped from CONUS to meet immediate customer demands. The premium is 49 percent of the actual forward staging cost.

Finally, we calculated what it would have cost to ship all the PSL NIINs listed in the two-year demand data set by air transportation and not forward position material in Bahrain. We used the below equation.

$$Cost_{Difference(2YrDmd)} = (\sum_{i=1}^{14,657} Surface_i^{[(2\,YrDmd)\,PSLAir]} + \sum_{i=1}^{6,086} Surface_i^{[(2\,YrDmd)\,PSLSurface]} + \sum_{i=1}^{5,173} Surface_i^{[(2\,YrDmd)\,PSLLocal]} + \sum_{i=1}^{24} Hold_i^{[(DLA)\,HoldCost]}) - (\sum_{i=1}^{14,657} Air_i^{[(2\,YrDmd)\,PSLAir]} + \sum_{i=1}^{6,086} Air_i^{[(2\,YrDmd)\,PSLSurface]} + \sum_{i=1}^{5,173} Air_i^{[(2\,YrDmd)\,PSLLocal]})$$

where:

$$\sum_{i=1}^{14,657} Surface_i^{[(2\,YrDmd)\,PSLAir]} = \$64,046.27$$

$$\sum_{i=1}^{6,086} Surface_i^{[(2\,YrDmd)\,PSLSurface]} = \$34,181.76$$

$$\sum_{i=1}^{5,173} Surface_i^{[(2\,YrDmd)\,PSLLocal]} = \$35,421.36$$

$$\sum_{i=1}^{24} Hold_i^{[(DLA)\,HoldCost]} = \$399,486.59$$

$$\sum_{i=1}^{14,657} Air_i^{[(2\,YrDmd)\,PSLAir]} = \$543,172.07$$

$$\sum_{i=1}^{6,086} Air_i^{[(2\,YrDmd)\,PSLSurface]} = \$293,166.80$$

$$\sum_{i=1}^{5,173} Air_i^{[(2\,YrDmd)\,PSLLocal]} = \$302,061.39$$

$$Cost_{Difference(2YrDmd)} = (\$64,046.27 + \$34,181.76 + \$35,421.36 + \$399,486.59) - (\$543,172.07 + \$293,166.80 + \$302,061.39) = -\$605,264.28$$

Theoretically, the forward positioning of material in the Fifth Fleet AOR would save the Navy $605,264.28 over the course of two years based of the demand data. This is a substantial amount of money; however, it is not as large of a savings as that calculated using the DLA shipment data. The primary cause of the difference between the two values is the average weight of the NIINs shipped in the DLA data is significantly higher than the average weight of the NIINs in the two-year demand data.

The cost to expedite all PSL NIINs via air transportation and the cost to forward position all PSL NIINs were graphed side by side to get a visual comparison, see Figure 18. The cost to expedite all PSL NIINs and not forward position material is significantly higher than the cost to forward position all PSL NIINs and ship via surface transportation.

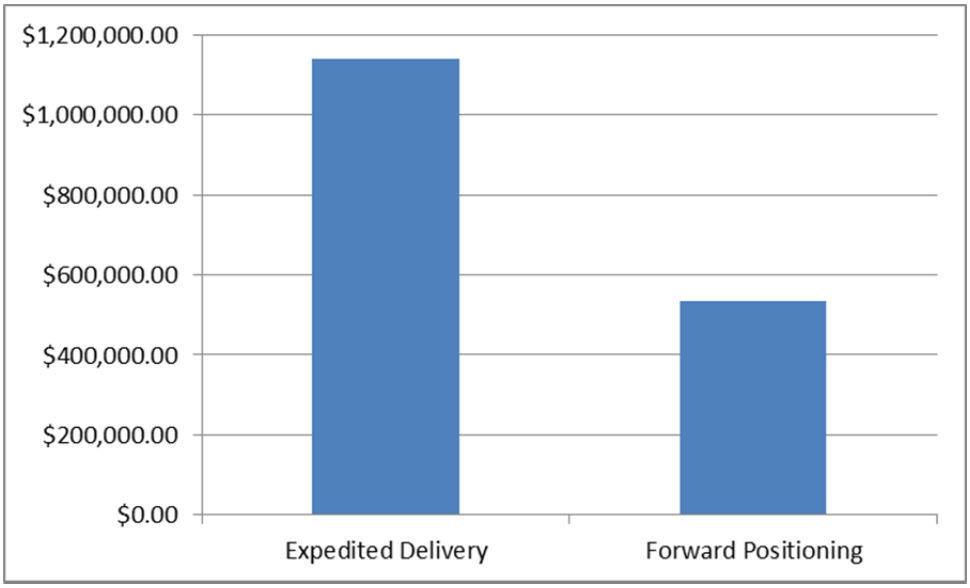

Figure 18. Expedited Delivery versus Forward Positioning, Two-Year Demand Data Set (after NAVSUP, 2014)

4. Fifth Fleet Demand Data Analysis with Non-PSL NIINs

Finally, we wanted to see what the target of opportunity was for forward positioning NIINs that were not previously selected by the EMQ and SRC process in the two-year demand data set. We filtered the data to only include non-PSL NIINs and then multiplied the NIIN weights by the surface shipping rate and then for the air shipping rate. We summed the surface shipping costs and the air shipping costs and then subtracted the air cost from the surface cost. The equation we used is as follows.

$$Cost_{Opportunity(2YrDmd)} = \sum_{i=1}^{221,319} Surface_i^{[(2\,YrDmd)\,NonPSLAir]} - \sum_{i=1}^{221,319} Air_i^{[(2\,YrDmd)\,NonPSLAir]}$$

where:

$$\sum_{i=1}^{235,976} Surface_i^{[(2\,YrDmd)\,NonPSLAir]} = \$973,009.48$$

$$\sum_{i=1}^{235,976} Air_i^{[(2\,YrDmd)\,NonPSLAir]} = \$8,756,916.24$$

$$Cost_{Opportunity(2YrDmd)} = \$973,009.48 - \$8,756,916.24 = -\$7,783,906.76$$

Over the course of two years, the Navy has paid a premium of $7,783,906.76 to have NIINs not selected for forward staging to be shipped via air transportation in order to meet customer demands. This is a large opportunity to save the Navy money by increasing forward staging efforts. We graphed the cost to ship PSL and non-PSL NIINs via air transportation for comparison purposes, see Figure 19. The PSL air transportation cost only makes up six percent of the total air transportation cost in the Bahrain data, which is a sign that forward staging efforts are working but should be better enforced. The remaining 94 percent represents the target of opportunity for the Navy to save on transportation costs by increasing the amount of NIINs that are forward positioned. There is a delicate balance to ensure the maximum amount of material is forward staged while not significantly reducing the availability of material available CONUS and in other AORs.

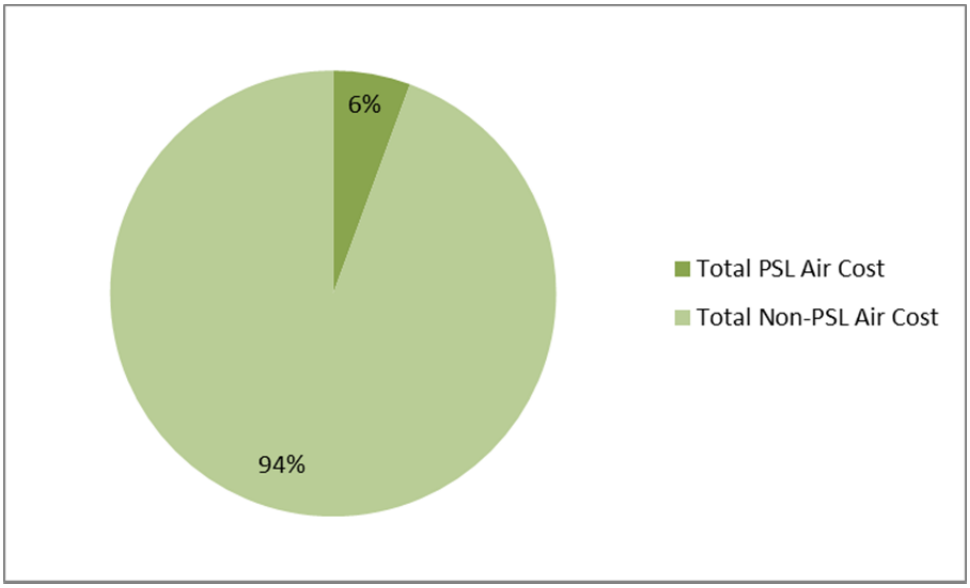

Figure 19. PSL Versus Non-PSL Air Transportation Costs (after NAVSUP, 2014)

D. ANALYSIS SUMMARY

The analysis shows that the Navy paid a premium of $399,486 to have items that were listed on the PSL shipped via air transportation that should have been issued from the DDNB if it were fully stocked. The premium is relatively small compared to the total forward staging cost savings of $9,819,754 associated with DLA shipped items. When the two-year demand data set is used to calculate the cost savings it comes out to a savings of $605,264 which is significantly lower than when the DLA data sets are used. The primary driver of this cause is that the DLA surface shipping data set contains NIINs that are much heavier and as a result when their weights are multiplied by the air shipping rate the total cost comes out much higher. In either case the current forward staging efforts are saving the Navy funding. In addition, both data sets show there is a significant target of opportunity for NIINs not listed on the PSL.

IV. LEAD TIME ANALYSIS

In the previous chapter, we discussed the financial impacts of the forward staging process. In this chapter, we will analyze the savings in time, specifically lead time. For the purpose of this study, we consider lead time to be the number of days in between the date of initial order and the date the item was received, or in other words, customer wait time after placing a requisition. It should be noted that some of the days in between initial order and receipt are caused by administrative delays rather than merely shipping, but the lead time we used is all inclusive in order to capture the reality of the process from the customer point of view.

In order to study the effects of the forward staging policy in the Fifth Fleet with regard to the DDNB COCO warehouse, we looked at two time periods: first, a time period prior to the standup of the COCO warehouse, and next, a relatively equal timeframe after the PSL build up and the availability of the COCO warehouse at DDNB. Of note, at the time of this study, the DDNB has not yet been fully stocked with all PSL items and allowances. For this reason, we highly recommended this study be performed again after the warehouse has been fully stocked and functional for at least six months. However, we will show this data are already showing a significant reduction in lead time.

We have determined three ways in which to study the overall impact of forward staging on the Fifth Fleet customers. First, we will look at overall lead time during the two time periods. Next, we will analyze differences in lead time length categories. Finally, we will analyze differences in lead time caused by seasonality of fiscal quarters.

A. DATA SELECTION

We used the same Fifth Fleet demand data from April 2012 through March 2014, obtained from NAVSUP GLS, as discussed for the financial impact study in Chapter III (NAVSUP, 2014). However, for the lead time analysis, we are only concerned with the items that will be stocked as part of the PSL in support of the forward staging effort. It should be noted that the PSL is frequently updated and modified according to demand by

the DLA EMQ model and the Navy's SRC process (Defense Logistics Agency, 2013). This study was conducted using the PSL as of March 2014, which contains 75,577 requisitions from the Fifth Fleet.

In order to more closely examine the effects of forward staging the PSL, we further classified the data into two categories: (1) before and (2) after initial DDNB PSL implementation. We wanted to capture demand data during the same general time of year, in order to prevent any possible seasonality differences. We also wanted to capture the most recent effects, so we used the latest PSL demand information within our data set. Lastly, we wanted the data from the two categories to have the same number of requisitions, so that even though our date ranges are not identical, our sample sizes are. Similar sample sizes over different time periods could possibly confound the study results due to a greater workload during one period, which would theoretically increase lead time due to capacity constraints; however, we negate that confound in our workload comparison. For these reasons, our first category, pre-DDNB PSL, consists of 3,919 requisitions between February 1, 2013 and March 31, 2013; the second category, after the initial PSL build up and COCO warehouse standup, consists of 3,919 requisitions between January 15, 2014 to March 31, 2014.

B. OVERALL LEAD TIME IMPACT

In the past two years, requisition lead time in the Fifth Fleet has significantly decreased, by 29–41 percent depending on how it is measured. The average lead time of the PSL items during the entire two years of demand data is 31.5 days. For the three months of data we have available for 2014, the requisition lead times dropped to 12.89 days on average, which is the 41 percent decrease.

A comparison of identical sample sizes produces a more conservative, but still impressive, 29 percent savings in average lead time. This data comes from the previously described sample timeframe categories consisting of 3,919 requisitions during the periods of February 1 to March 31, 2013, pre-DDNB COCO warehouse forward positioning, compared to the same number of requisitions taken from January 15 to March 31, 2014, post-initial PSL build-up. The former time period had an average 44.12-day lead time

compared to the later period's 12.89-day average. These differences are statistically significant (T-stat= 34.15, P-value<0.000).

Figure 20 visually depicts the reduction in PSL lead times over the course of only one year during which the DDNB began forward staging efforts.

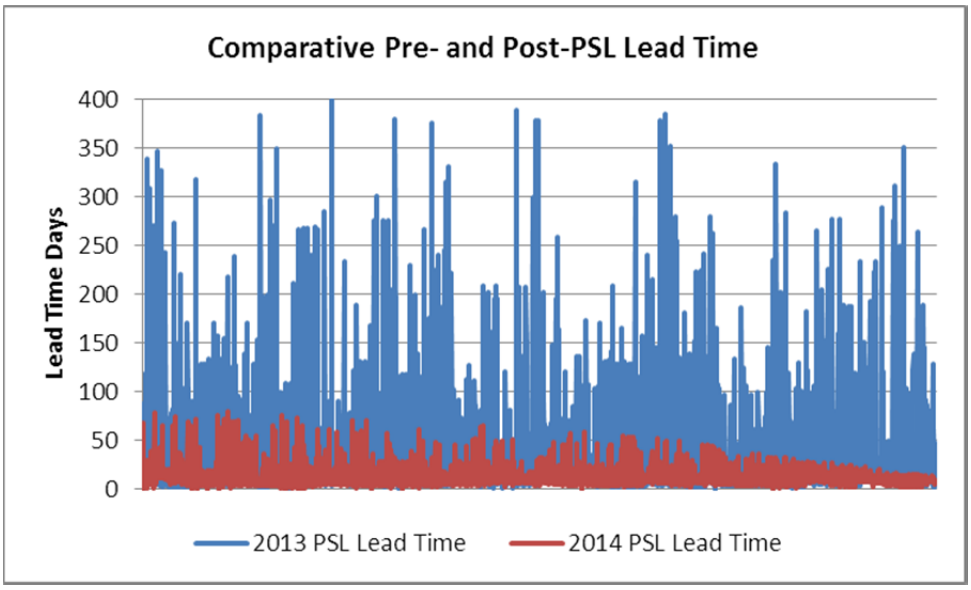

Figure 20. Comparative PSL Lead Times 2013 and 2014 Periods (after NAVSUP, 2014)

In order to provide a more useful analysis, we also studied the frequency of which the lead times occur. In order to do so, we divided the data into eight logical lead time categories. The categories we created range from greater than one year down to less than one week. We calculated the frequency of occurrences in each category for both the 2013 PSL data set (Figure 21) and the 2014 PSL data set (Figure 22), and then we overlapped the two data sets for comparison (Figure 23). See charts and key points below.

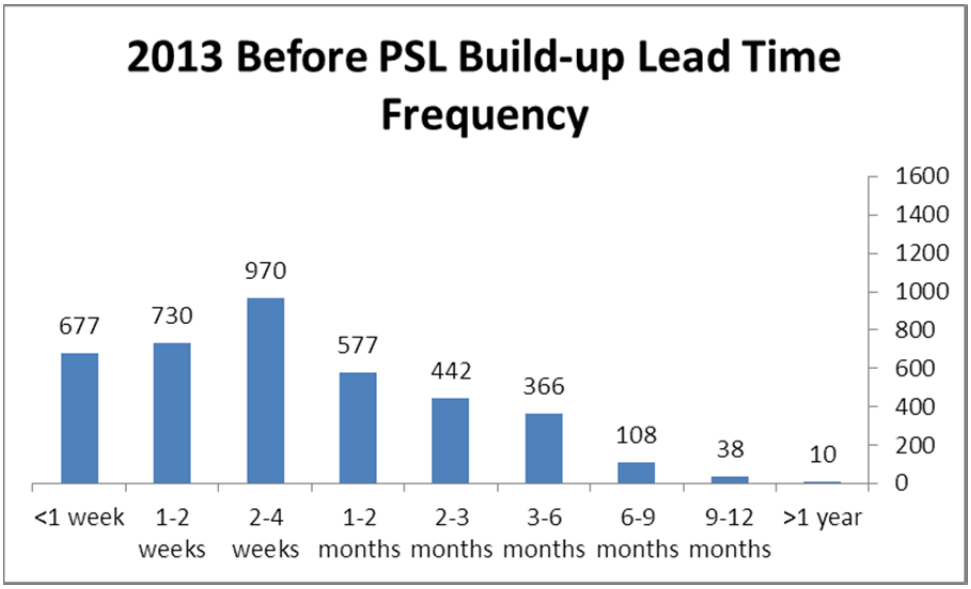

Figure 21. 2013 Before PSL Lead Time Frequency (after NAVSUP,2014)

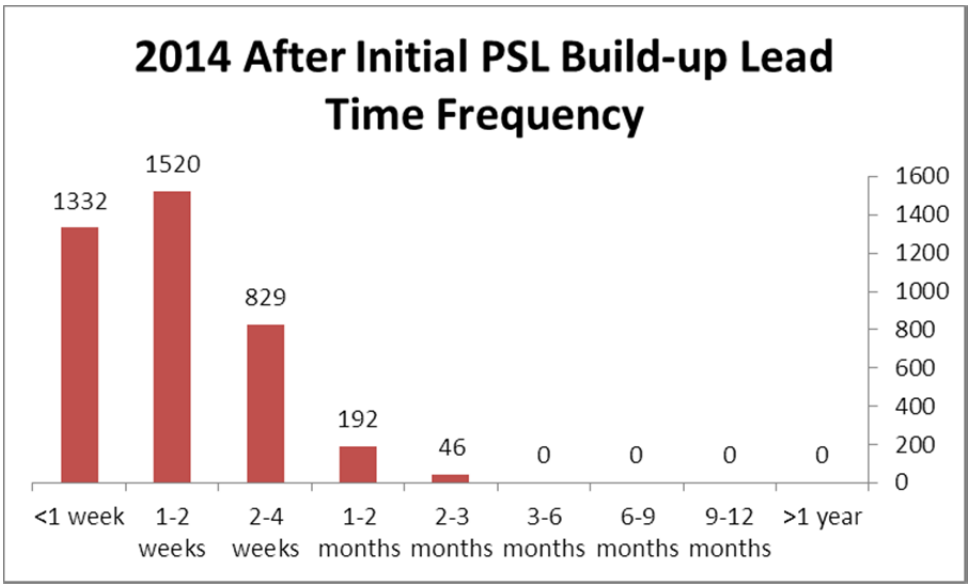

Figure 22. 2014 After Initial PSL Lead Time Frequency (after NAVSUP,2014)

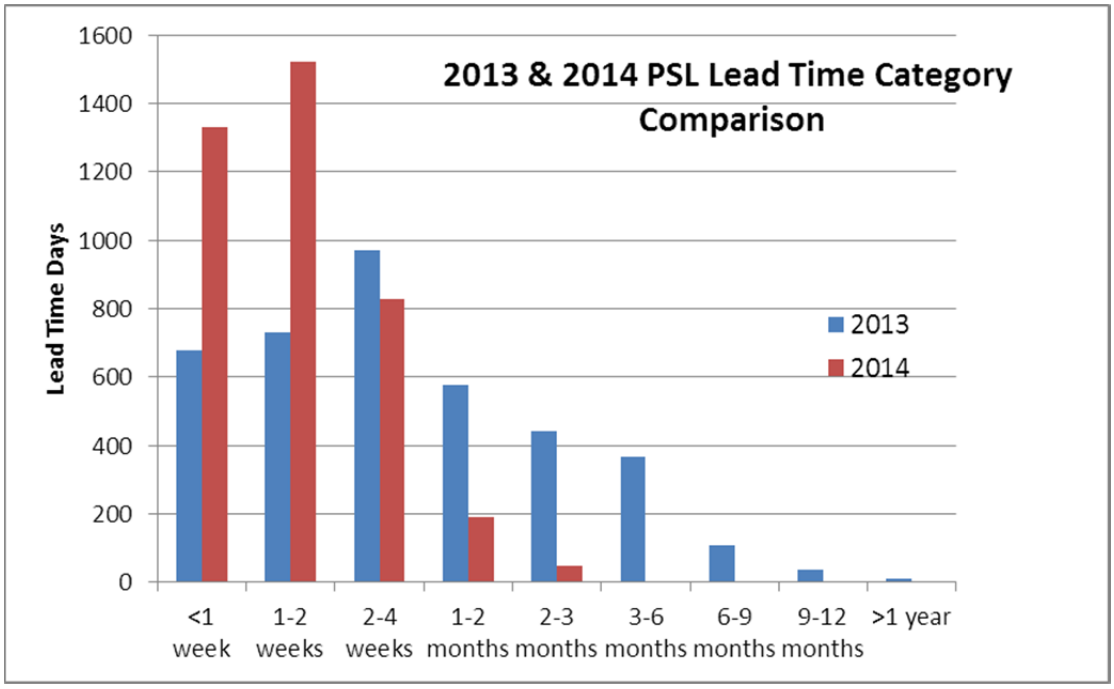

Figure 23. 2013 and 2014 PSL Lead Time Comparison (after NAVSUP, 2014)

As Figure 23 shows with the side-by-side comparison, lead times were significantly improved in the 2014 data set. Lead times greater than three months were completely eliminated. Lead times less than one and two weeks increased by a combined 91 percent, which shows that shorter lead times were more prevalent in the post-PSL build-up time period. A summary of improvement highlights are listed in Table 3.

Table 3. Key Points from 2013 and 2014 Lead Time Comparison (after NAVSUP, 2014)

Key Points	01Feb-31Mar 2013	15Jan-31Mar 2014	Improvements
Longest lead time	399 days	80 days	319 days
Lead time occurences >1 year	10	0	10
Lead time occurences >3 months	522	0	522
% lead times >2 months	25%	6%	19%
% lead times <2 weeks	19%	93%	74%
% lead times <1 week	17%	34%	17%

C. WORKLOAD COMPARISON

In order to rule out the lead time reductions as a result of heavier workload, which generally tends to increase lead time, we isolated a single week during the 2013 data set and compared it to a single week in the 2014 set with nearly identical numbers of requisitions, 328 and 329 respectively. We then calculated the frequency of lead time category occurrences to ensure that workload was not a factor in the lead time reductions. As Figure 24 demonstrates, workload did not contribute to the decreased lead times; if workload had been a factor, we would have seen similar lead time category occurrences in the two periods.

However, all lead time categories greater than two months were eliminated. There was a 62 percent decrease in the one- to two-month lead time category and a 66-percent decrease in the two-week to one-month category. There was an increase of 285 percent of lead times in the 1–2 week category and a 233 percent increase in the >1 week category. These differences are statistically significant (Chi Squared= 1,538, P-value<0.000). Therefore, the data indicates the same lead time reduction patterns as previously found in the larger time period differences, eliminating workload as a contributing factor.

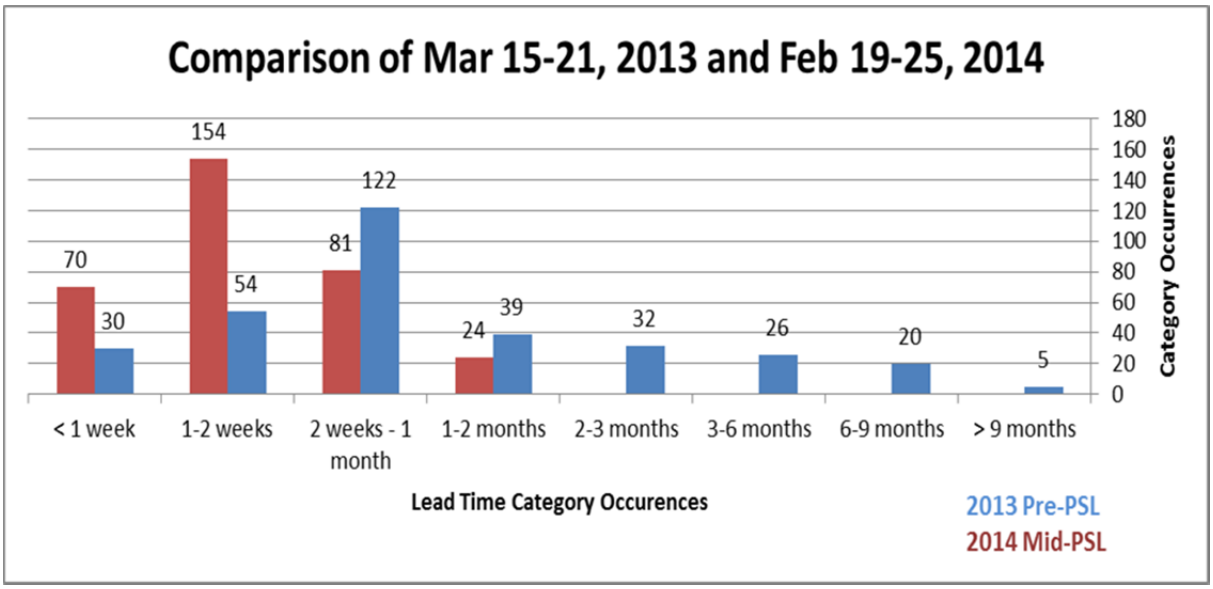

Figure 24. Comparison of 15–21 Mar, 2013, and 19–25 Feb, 2014 (after NAVSUP, 2014)

D. FISCAL QUARTER COMPARISONS

We deduced from the one-week comparisons that workload was not a factor in lead time reduction. Our next concern was seasonality, specifically the pattern of lead time effects during fiscal quarters (FQ). In order to study the FQ impact, we divided the demand data into four FQs for comparison: FY12 Quarter 4, FY13 Quarter 1, FY13 Quarter 4, and FY14 Quarter 1. We chose these quarters because 1st and 4th fiscal quarters have the highest budgetary impacts, which could cause longer lead times due to increase or lack of funding for parts and transportation. This comparison will show the differences in lead times across fiscal quarters as well as the pre- and post-PSL implementation time periods.

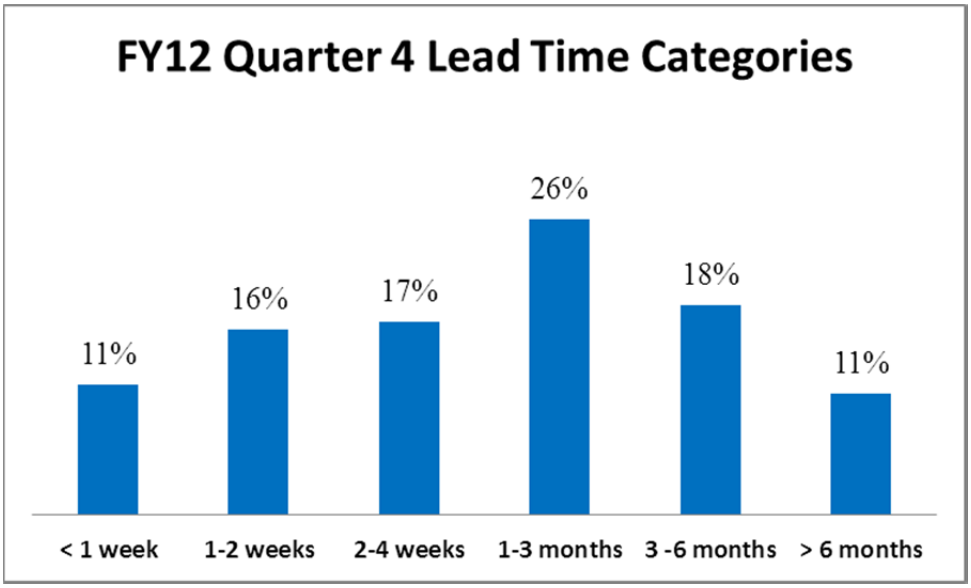

Figure 25. FY12 4th Quarter Lead Time Categories (after NAVSUP, 2014)

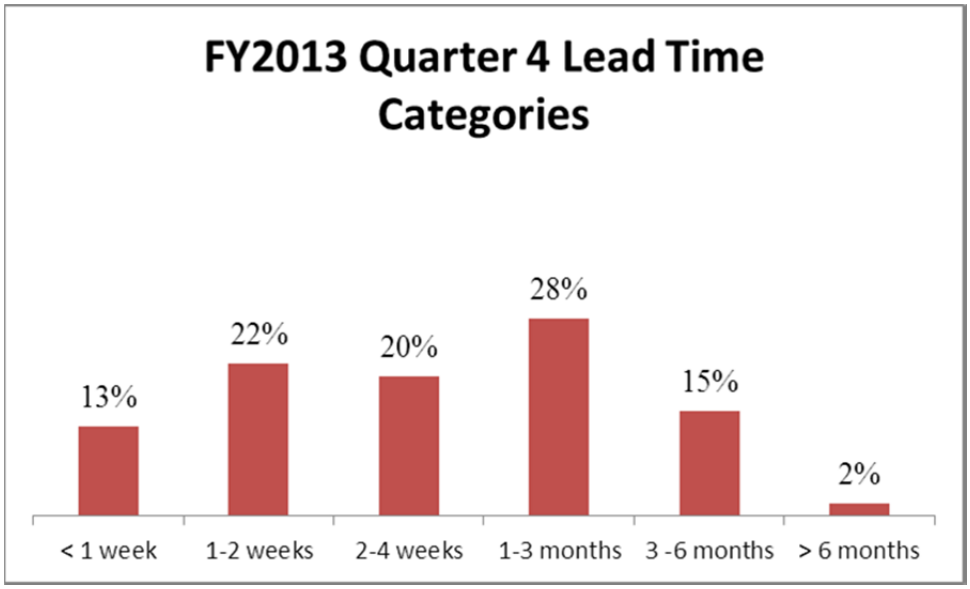

Figure 26. FY13 4th Quarter Lead Time Categories (after NAVSUP, 2014)

The last FQ of each year is generally when there is the least amount of funding available for both parts and transportation. It naturally follows that lead times will be the longest during these time periods, and our analysis confirms this. However, even when comparing FY12 4th Quarter (Pre-PSL build-up) with FY13 4th Quarter (Post-Initial PSL Build-up), the lead time reductions still occur. The analysis shows 1,570 fewer lead time occurrences greater than six months and 1,232 fewer instances of lead times between three and six months.

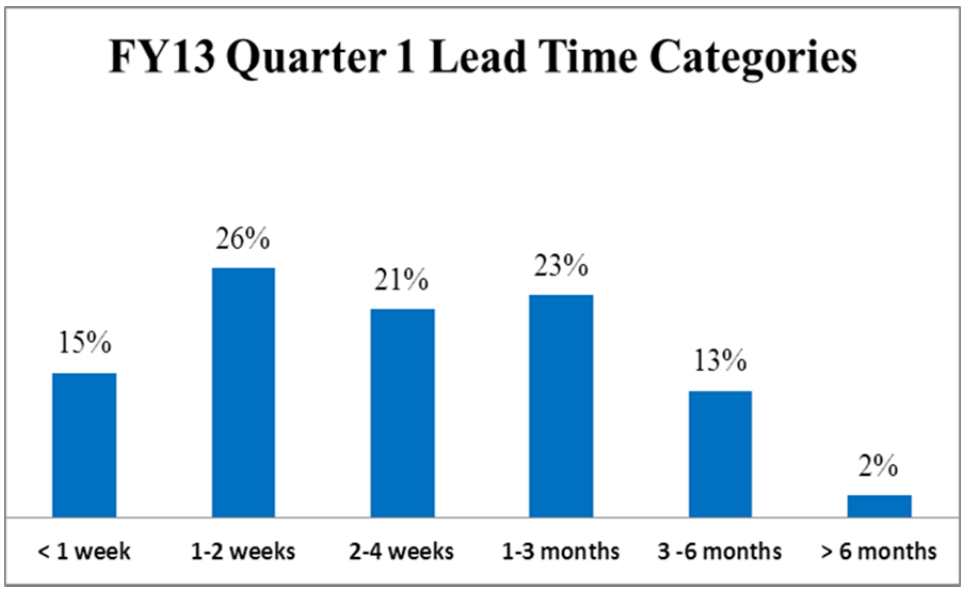

Figure 27. FY13 1st Quarter Lead Time Categories (after NAVSUP, 2014)

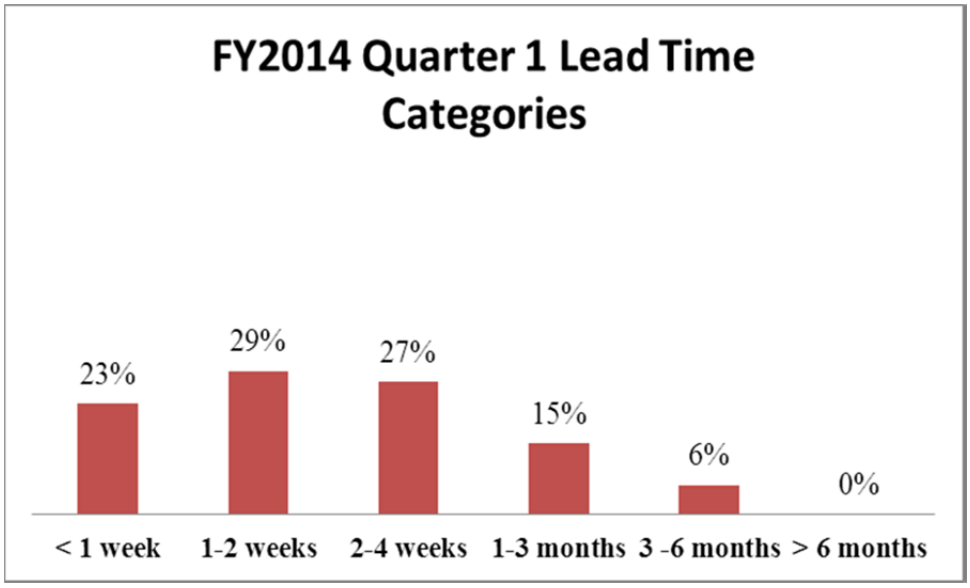

Figure 28. FY14 1st Quarter Lead Time Categories (after NAVSUP, 2014)

The first FQ of each year is when the new fiscal year's budget is available; therefore, lead times tend to be shorter due to the funding availability. Again, our data supports this generality with lead times showing improvement. When we studied the 1st FQ lead times of the before and after PSL build-up periods, Figures 27 and 28, the lead

time reductions across like quarters is still apparent. The longest lead time category, greater than six months, was eliminated. The 3- to 6-month lead time category was reduced by 804 occurrences; the one- to three-month category was reduced by 1,133 instances.

This analysis shows that fiscal seasonality does play a role in lead times. Both 4th quarter time periods show longer lead times compared with both of the 1st quarter time periods. Conversely, the 1st quarters show lead time reductions in both instances from the previous quarter. Even though lead time lengths seem to follow a fiscal-seasonal pattern, lead times were still reduced overall. Lead time occurrences over six months were reduced over the quarters and then eliminated. Table 4 summarizes the lead time category frequencies shown in Figures 25–28.

Table 4. Fiscal Quarter Lead Time Category Frequency
(after NAVSUP, 2014)

Lead Time Category	FY12 Q4	FY13 Q4	FY13 Q1	FY14 Q1
>6 months	11%	2%	2%	0%
3-6 months	18%	15%	13%	6%
1-3 months	26%	28%	23%	15%
2-4 weeks	17%	20%	21%	27%
1-2 weeks	16%	22%	26%	29%
<1 week	11%	13%	15%	23%

V. CONCLUSION AND RECOMMENDATIONS

Admiral Greenert has made operating forward and maintaining a strategic presence one of his three primary tenants. In order to meet this requirement, the Navy has forward staged mission-critical material to meet immediate customer demand and lower equipment downtime. NAVSUP has been assigned the primary responsibility for developing and managing forward staging policies and procedures. They leveraged DLA to develop an EOQ variant model to identify key material to be staged in the Fifth Fleet AOR. In addition, NAVSUP developed a SRC selection process to compliment the EOQ variant model, which gives them the ability to set their own parameters for selecting forward staged NIINs that are Navy specific. The aim of this research project was to determine the cost effectiveness of forward positioning material in the Fifth Fleet AOR and determine if the efforts have saved the Navy money. In addition, the project analyzes the impact to lead time before and after the standup of the COCO warehouse in Bahrain.

Even though the portion of NIINs on the Bahrain PSL only makes up a small percentage of the total NIINs requisitioned, there is still a strong argument for continuing to increase forward staging efforts. The first reason is that the current forward staging efforts in the Fifth Fleet in aggregate are saving the Navy approximately $605K to $4.9M yearly depending on which data set is analyzed. The funding saved from forward staging efforts can be used for other critical programs and initiatives. The Navy's share of the holding cost is relatively small when compared to how much money is saved by shipping NIINs via surface transportation instead of by expedited air.

The second reason is the customer wait time is decreased by 29 percent when the item is pulled directly off the shelf and can be immediately issued to a unit in-port or quickly flown to a unit operating in the AOR. Typically air shipments take between two to three days to have an item flown from CONUS to Bahrain while surface shipments can take several months. Critical parts need to be available for immediate issue to the requesting unit in order to maintain a high level of readiness. There are several situations in which shipping a NIIN via air from CONUS is too slow and the unit requires the part to be forward staged and issued immediately to meet mission requirements.

Having NIINs forward staged gives logistics readiness officers more options and a greater flexibility to get the item to the requesting unit at the specific time they need it. Twenty-five percent of the time, the DDNB was able to fill a requisition with forward staged NIINs. This is a low fill rate; however, because of the large forward staging efforts, we anticipate this figure to increase dramatically over the next few years as more and more PSL NIINs arrive at the DDNB warehouse.

The main results from the cost analysis are:

1. Over the course of two years the Navy paid an additional $8,660,942.61 to have required non-PSL NIINs shipped to Bahrain through DLA.

2. Only a small fraction of the items shipped in the DLA data set, 4 percent, were items designated for forward staging, and most of the air shipment costs were attributed to items that were ordered to fill customer requirements that did not qualify the NIIN to become a part of the PSL.

3. The total shipping and forward staging cost of NIINs listed on the Bahrain DDNB PSL based on the Bahrain demand data is $1,021,627.53.

4. The Navy paid a $488,491.55 premium, over two years, to get items that should have been forward staged air shipped from CONUS to meet immediate customer demands.

5. Over the course of two years, the Navy has paid a premium of $7,783,906.76 to have NIINs not selected for forward staging to be shipped via air transportation in order to meet customer demands.

6. If the NIINs in the DLA data set had been in stock and issued from the DDNB warehouse, the Navy would have saved $383,495.70 over the course of two years

7. Theoretically, if the Navy had shipped the items listed on the PSL via surface shipment and paid the monthly holding cost fee in aggregate the forward staging process would have saved the Navy $9,819,754.59, compared to just shipping everything via air transportation based off the DLA data set.

8. Theoretically, the forward positioning of material in the Fifth Fleet AOR would save the Navy $605,264.28 based off the Bahrain two year demand data.

The lead time analysis shows substantial savings in lead time days and even greater improvement in lead time categories. We believe the 29 percent reduction in

overall lead time averages and the lead time category improvements are a direct result of the forward staging efforts in the Fifth Fleet at the DDNB warehouse. We conclude that these reductions in lead time and improvement in lead time categories will continue to improve as the DDNB warehouse finishes stocking the PSL. We recommend a further study be conducted in 18 months to test these assumptions and monitor future lead times to validate the sustained improvements.

The main results from the lead time analyses are:

1. The DDNB PSL build-up shows a 29 percent improvement in lead time with the average lead time reduction of 31.23 days between 2013 and 2014 time periods studied.

2. Although overall number of requisitions decreased from 2013 to 2014, we confirmed that workload was not a factor in the lead time reduction.

3. Lead times greater than 3 months have been completely eliminated. The improvement in longest lead time was a reduction of 319 days; the longest lead time in our post-PSL build-up data set was 80 days.

4. Lead time in all categories greater than 1 month have been reduced, and lead times less than 1 and 2 weeks have a combined increase of 91%.

5. Lead times are a function of fiscal quarter seasonality; however, overall improvements from quarter-to-quarter and during like-quarter comparisons support the trend of lead time savings due to the PSL implementation.

The March 2014 PSL containing 75,577 items comprised only 18 percent of the total Fifth Fleet demand between April 2012 and March 2014. As the PSL is continuously updated through DLA's EMQ model and the Navy's SRC process, we also predict that the PSL will grow more robust, thereby incorporating a larger portion of Fifth Fleet demand in the future and providing shorter lead times in general across the AOR.

A. RECOMMENDATIONS FOR FUTURE RESEARCH

The efforts to forward position material in the Fifth Fleet AOR are working by meeting the CNO's guidance and saving the Navy money while lowering associated lead times to the war fighter. The Navy has considered several other options to forward stage

material in the Fifth Fleet AOR resulting in improved lead times and higher material availability, and our analysis can aid in deciding among courses of action (COA). There is a significant amount of room to expand the forward staging efforts in Bahrain by incorporating a greater number of NIIN's in the DDNB COCO warehouse or by following one of the COAs mentioned above. The concern with expanding too much is that there is a possibility that parts availability might start to become restricted for units operating CONUS or in other AORs because selected NIINs will be positioned forward. The right balance of forward positioned NIINs needs to be attained that is not only cost efficient but also supports each COCOM needs without having to buy additional stock.

We recommend that another analysis be conducted in 12 to 18 months on the forward staging efforts in the Fifth Fleet AOR. This would allow ample time for the COCO warehouse to be fully stocked; therefore, the analysis could encompass a greater span of time. In addition, we recommend that the other AORs be similarly analyzed to verify their cost effectiveness and improvements in lead times.

Finally, although not reported here, during our research we discovered that backorder rates as well as backorder lead times have also been significantly reduced during this time period, with an overall reduction of approximately 10 percent from 2013 to 2014. Because backorders are theoretically not increased or reduced by forward staging, we were not able to further analyze this improvement and stay within the scope of this thesis. There are several possible causal factors that we identified but could not isolate, including but not limited to: the off-loading of the USS *Ponce* material, an initiative to increase asset visibility, or any number of new policies affecting the naval supply system. We recommend that further analysis be conducted to study and possibly further improve the number, rate, and lead times of backorders.

APPENDIX A. MAP OF NAVAL FORCES CENTRAL COMMAND

(from United States Central Command, 2014)

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APPENDIX B. SELECTED ACQUISITION ADVICE CODE DEFINITIONS

C - Service/Agency regulated. These NIINs have no special restrictions affecting their issue, shipment, or transfer other than those imposed by the agency policy.

D–DOD integrated material managed, stocked, and issued. These NIINs have no special restrictions affecting their issue, shipment, or transfer other than those imposed by Integrated Material Management (IMM) or the agency policy.

J–Not stocked but centrally managed by IMM. Once the requisition is received the procurement will be initiated.

V–Terminal item. The NIIN is currently in inventory but further procurement is denied.

Z–Insurance/numeric stockage objective item. These NIINs are ordered infrequently but a small quantity must be stocked because either the NIIN has a long lead time or is considered essential material.

(Naval Supply Systems Command, 1997, p. App 23)

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APPENDIX C. ASSUMPTIONS, DEFINITIONS AND OTHER CALCULATIONS

Other Calculations, Definitions, and Assumptions

- **SKU:** An Item (NIIN) at a location.
- **SKU Build:** This is the term DLA uses to encompass the overall process of how DLA Stock Positioning determines whether or not to create a SKU at a location. At this level, it applies to both CONUS and OCONUS depots.
- **Economic Movement Quantity (EMQ):** This was a model that DLA created to introduce economics into the forward positioning decision-making process. It was based on Wilson's Economic Order Quantity (EOQ) and was customized to focus on the handling, holding, transportation, and other costs associated
- **Demand** is defined as the Sales or Order Requests ("Hits") made for an item, whether or not that order was filled. In EBS it is the forecast which includes any manual collaborative adjustments. It is not the number issues.
- **Planned Stock List (PSL)** this is PLAN that EBS has calculated. In simple terms, it's the Economic Items + SRC Items. Please note that this is not an actual physical list that is readily available. Rather, it's a term used to refer to those items that are activated or remain activated as a result of the production run; from which a list can be generated by query if required.
- **Constraints to the economic model: Any level calculated that would result in more inventory being forward positioned than is forecasted for** greater than 365 days (CovDur), that DRP CovDur is changed and set at 365 days
- Assumes customers'' alignments are correct and not changeable, along with taking into consideration where mobile units were targeted for replenishment throughout their history, vs. where they are currently located.
- As of this document date, C&T forward positioning decisions are not determined using this process.
- Assumes all Item data, NIIN, CIIC, HCC, Cube, Weight, Price, UOM, etc., are correct.
- Assumes that all required statistics and data were pulled and calculated prior to beginning the Economic Calculations
- **Mean Standard Error (MSE)** will be calculated by EBS to track variability and be used by EBS to
  calculate safety stock.
- **Costs/Rates:**
- All Handling Costs are DLA Distribution Net Landed Cost (NLC) Rates with the exception of the ALOC rates. These are blended rates provided by DLA Distribution J8; not depot specific handling costs.
- **Holding Costs** is assumed to be a blended 18%. Again, it is not depot specific.
- Blended (cost/lb.) **Transportation Rates** by lane by shipment mode are provided by USTRANSCOM
- Assumes all Restrictions are correct and will be honored.
- Average Inventory is: $AvgInv = (EMQ \div 2) + SS$

(Defense Logistics Agency, 2013)

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APPENDIX D. SHIPMENT MODES AND FREQUENCY

Code Explanation	Shipment Mode	Frequency
Includes trailer on container/flatcar (excluding SEAVAN)	1	0
Government watercraft, barge/lighter	2	14
Roll on/roll off service	3	0
Defense Courier Service	4	3
Surface Small Package Carrier	5	2692
Military Official Mail (MOM)	6	16
Express Mail	7	1
Pipeline	8	0
Local delivery	9	4324
Motor, truckload	A	761
Motor, less than truckload	B	334
Van (unpacked, uncrated, personal and/or government property)	C	0
Driveaway, truckaway, towaway	D	18
Bus	E	138
Air Mobility Command (AMC) Channel and Special Assignment Airlift Mission	F	4627
Surface parcel post	G	602
Air parcel post	H	1502
Government truck, for shipment outside local delivery area	I	1
Air Small Package Carrier	J	8482
Rail, carload	K	0
Rail, less carload	L	109
Surface - Freight Forwarder	M	18
LOGAIR	N	1
Organic military air (including aircraft of foreign governments)	O	0
Through Government Bill of Lading	P	0
Commercial air freight	Q	26
European Distribution System (EDS) or Pacific Distribution System (PDS)	R	0
Scheduled Truck Service (applies to contract carriage, guaranteed traffic routings and/or scheduled service)	S	702
Air freight forwarder	T	2
SEAVAN	V	3370
Water, river, lake, coastal (commercial)	W	0
Bearer Walk-Through (customer pick-up of material)	X	25
Reserved	Y	0
Military Sealift Command (MSC); controlled, contract, or arranged space	Z	292
	Blank	1391

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