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Optimal Staffing Model for NAVSUP Warehouse Operations

June 2025

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ABSTRACT

Our research explores the development of a staffing model for Naval Supply Systems Command (NAVSUP) warehouse operations. NAVSUP currently lacks formalized manpower staffing standards for key warehouse functions and instead relies on staffing decisions based on annual financial constraints, which results in ad hoc, potentially sub-optimal staffing levels. Our study develops a staffing model based on workload analyses and time studies for key warehouse operations such as receiving, stowing, picking, packing, shipping, and inventory management with the aim to establish clear workload standards and accurate staffing projections. The model can be used to refine current staffing practices at NAVSUP Fleet Logistics Centers (FLCs) as well as to identify opportunities for technology integration. Our research enables NAVSUP to establish accurate staffing levels to meet operational demands, improve efficiency, and support decision-making for future warehouse operations.

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ABOUT THE AUTHORS

LCDR Ryan Le graduated from the U.S. Naval Academy in Annapolis, MD, in 2015 with a degree in Engineering. Beginning his career as a Student Naval Flight Officer, he served temporary assignments of duty as the Assistant Supply Officer at Naval Aviation Schools Command and worked at NAVSUP FLC Jacksonville. Following his transition into the Supply Corps, he served onboard the USS *Annapolis* (SSN 760) as the ship's Supply Officer. His second operational tour was aboard the USS *Carl Vinson* (CVN 70) where he worked as the Materiel Division Officer and Stock Control Officer. In his free time, LCDR Le is an avid runner and coffee appreciator who has completed multiple marathons, all well-caffeinated. Following graduation, LCDR Le, along with his fiancé Aruna and ten-year old Chow, Gumbo, he will be reporting to the Office of the Chief of Naval Operations (OPNAV) Programming Office (N80) in the Pentagon.

LT Heidi Millay earned a Master of Science in Chemistry from Western Kentucky University in 2019, graduating with a 4.0 GPA. She was commissioned into the U.S. Navy as a Direct Input Officer (DIO) through the Nuclear Propulsion Officer Candidate (NUPOC) program and served as an instructor at Naval Nuclear Power Training Command (NNPTC) in Charleston, SC, until 2024, when she laterally transferred to the Human Resources community and was selected to pursue a Master of Science in Defense Financial Management at the Naval Postgraduate School. Following graduation, LT Millay will report to OPNAV N100 at the Naval Support Facility in Arlington, VA, where she will serve as a Program Analyst.

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LIST OF ACRONYMS AND ABBREVIATIONS

AOR	Area of Responsibility
BBD	Billet Based Distribution
BLA	Business Logistics Administration
BSO	Budget Supporting Offices
DD Form 1149	Requisition and Invoice/Shipping Document
DD Form 1348 1A	Issue Release/Receipt Document
DLA	Defense Logistics Agency
DLR	Depot Level Repairable
DoD	Department of Defense
DON	Department of the Navy
ERP	Enterprise Resource Planning
FACTS	Financial and Air Clearance Transportation System
FLC B	Fleet Logistics Center Bahrain
FLC HQ	Fleet Logistics Center Headquarters
FLC J	Fleet Logistics Center Jacksonville
FLC N	Fleet Logistics Center Norfolk
FLC PH	Fleet Logistics Center Pearl Harbor
FLC PS	Fleet Logistics Center Puget Sound
FLC SD	Fleet Logistics Center San Diego
FLC SI	Fleet Logistics Center Sigonella
FLC Y	Fleet Logistics Center Yokosuka
FLC	Fleet Logistics Center
GLS	Global Labor Standards
HAZMAT	Hazardous Material
HAZWASTE	Hazardous Waste
MEOU	Material Held as Excess, Obsolete, and Unserviceable
MHE	Material Handling Equipment
MHFFU	Material Held in Reserve for Future Use
MHFR	Material Held for Repair or Remanufacture
MHFU	Material Held for Use

NASEM	National Academies of Sciences, Engineering, and Medicine
NAVSUP	Naval Supply Systems Command
NEC	Navy Enlisted Classification
NIIN	National Item Identification Number
NWCF	Navy Working Capital Fund
OM&S	Operating, Materials & Supplies
PERS4	Navy Personnel Command for Career Management
QA	Quality Assurance
SHORECAL	Shorebased Coordinated Allowance List
SIT	Stock in Transit
SOP	Standard Operating Procedures
TYCOM	Type Commander
USTRANSCOM	United States Transportation Command
VLM	Vertical Lift Module

I. INTRODUCTION

Effective logistics is the backbone of military readiness, ensuring the timely delivery of supplies that are essential to mission success (Total Military Insight Editorial Team, 2024). Naval Supply Systems Command (NAVSUP) is the powerhouse of the United States Navy's logistics operations, playing a crucial role in enabling critical sustainment by directing complex supply chains that deliver vital material, services, and quality-of-life enhancements to the Navy's warfighters, their families, and joint and allied partners (Naval Supply Systems Command, n.d.a). With this mission to provide global logistics support, NAVSUP's warehouse operations are central to maintaining supply chain reliability. However, despite NAVSUP's continued growth in its warehouse management efforts, gaps remain in formalized manpower standards (e.g., time and motion studies) for traditional warehouse operations such as receiving, stowing, issuing, picking, packing, shipping, and inventory management.

Currently, due to the absence of formal documentation and processes, staffing (or "manpower") levels at NAVSUP Fleet Logistics Centers (FLCs) are somewhat arbitrarily determined based on historical staffing data and financial constraints, rather than on workload-informed analyses. The lack of a formal workload standard for basic work elements prevents the development of a manpower model that would tailor to real operational needs. As a result, NAVSUP faces resource allocation challenges, leading to potential inefficiencies that can affect its ability to meet the Navy's mission-critical demands. Without accurate and consistent manpower standards, operational readiness and flexibility suffer and limit NAVSUP's capacity to appropriately and adequately address emerging logistics challenges. Our study aims to develop a staffing model based on workload analyses and time studies for key warehouse operations to establish accurate workload standards and improve staffing projections.

The development of a manpower staffing model based on time and motion studies offers an opportunity to transform NAVSUP's workforce management approach. While time and motion studies have proven invaluable in other sectors, namely in manufacturing and healthcare (Roberts et al., 2018), there exists little literature focused specifically on warehouse manning, and none within the context of defense logistics. This gap in research creates a challenge for NAVSUP, as the availability of proven methodologies to guide manpower planning in its warehouses is severely limited. However, by adapting best practices from other industries and tailoring them to NAVSUP's unique needs, this thesis seeks to bridge that gap. The creation of a manpower staffing model that incorporates time studies will aid NAVSUP in the transition from arbitrary staffing decisions to data-driven, workload-informed decisions. This shift would enhance efficiency, address operational bottlenecks, and support NAVSUP's mission of providing reliable logistics support to the fleet.

In the following chapters we examine the current state of NAVSUP warehouse operations, analyze the best practices in manpower modeling, and propose a new staffing model. This thesis applies a time study approach to develop a workload-based staffing model tailored to NAVSUP FLCs. We observed four core warehouse functions—Receipt-to-Stow, Issue, Inventory, and Small Parcel Label Creation Using FACTS—at NAVSUP FLC Lemoore. These tasks were timed under ideal conditions, normalized for performance, and combined with throughput data to calculate monthly workload and corresponding staffing requirements. The resulting model provides minimum staffing estimates grounded in observed task durations and operational demand. This approach can offer a scalable, data-driven alternative to the current staffing practices and potentially improve efficiency and workforce planning across the NAVSUP enterprise.

II. BACKGROUND AND LITERATURE REVIEW

To best understand the complex and challenging nature of NAVSUP warehouse staffing, a brief review on warehousing operations provides context to the specialized objectives and dynamic nature of military logistics. In this chapter we explain the current state of NAVSUP warehousing and discuss best practices regarding manpower modeling. Understanding the present condition provides integral background knowledge for the reader to understand the numerous functions within military warehousing operations and provides context in the strengths and weaknesses of staffing models and simulations that we expand upon in this thesis.

A. CURRENT STATE OF NAVSUP WAREHOUSE OPERATIONS

NAVSUP performs over-the-horizon logistics support and operations through numerous regional FLCs, to include Bahrain (FLC B), Jacksonville (FLC J), Norfolk (FLC N), Pearl Harbor (FLC PH), Puget Sound (FLC PS), San Diego (FLC SD), Sigonella (FLC SI), and Yokosuka (FLC Y). These centers are centrally managed by NAVSUP Headquarters (FLC HQ) in Mechanicsburg per their official organizational chart (Naval Supply Systems Command, n.d.b). These sites host a mix of efforts supporting Navy Working Capital Fund (NWCF) inventory, other Budget Supporting Offices (BSOs) functions, and Operating, Materials & Supplies (OM&S). In charge of varying inventories and logistics functions, FLCs must adhere to a myriad of Department of Defense (DoD), component specific, and regionally conscious publications and regulations.

1. Navy Working Capital Fund

The component specific governing document regarding inventory management and administration is the NAVSUP P-723 Navy Inventory Integrity Standards, Revision 7. Initially released in April 2000, the NAVSUP P-723 has seen ten total changes, seven of which were full revisions. Eight of these changes, to include five formal revisions, occurred within the past five years (Naval Supply Systems Command, 2023, p. ii). NAVSUP, under scrutiny from congressional review of financial audit readiness, has taken steps to explicitly define roles and responsibilities for all individuals managing NWCF material and funding.

Per the NAVSUP P-723, FLCs are designated to provide supply and logistics support to naval units in their area of responsibility (AOR). These responsibilities are explicitly delineated to include inventory assessments, designating key positions, ensuring individuals are trained and qualified to meet the demands of those positions, monitoring management performance, and providing oversight of inventory accuracy (Naval Supply Systems Command, 2023, p. 2-2). The actions in which to manage NWCF material are further broken down into individual actions and categories. Receipt-to-Stow, Physical Inventory, Materiel in Repair, Reporting System Reconciliation, Stock in Transit (SIT) Management, Issue, Disposal, and Management Review Control represent the majority of actions in NAVSUP warehousing. Although the NAVSUP P-723 further elaborates on each of these actions, specific time requirements and manning associated with tasks are not mentioned. NAVSUP defines critical roles but fails to provide information on staffing needs to meet the overarching demand.

NWCF material inventory accuracy has direct influence on U.S. Navy operational success and the overall credibility of the DoD. Warehouse refusals, long customer wait times, backorders, and incorrect item information negatively contribute to efficiency and effectiveness. As evident from the frequent changes and revisions to the NAVSUP P-723 starting in June 2019, the DoD and its subsequent components emphasize optimization of warehouse operations. The focus on cost-effectiveness is echoed by the DoD-wide reform initiative on warehouse utilization (Reece, 2021).

2. Packaging and Shipping

Although NAVSUP FLC sites primarily service naval assets within their AOR, suppliers and intermediaries can vary across multiple military service components. Personnel working at FLCs must adhere to both external and internal instructions and publications. When preparing materiel for shipment, strict adherence to the MIL-STD-2073-1E DoD Standard Practice for Military Packaging requirements must be ensured. Navy specific standards, built upon the foundation of the MIL-STD-2073-1E, can be found in the NAVSUP P-700 Common Naval Packaging publication. The packing requirements outlined in these standards and publications explicitly detail the type of container to be used (e.g., wooden crate, corrugated cardboard, plastic case, or ceramic), the type of cushioning or protective material to be used (e.g., water resistant bound fiber, flexible polyurethane foam, chipboard sheets, or rigid foam), and testing standard to ensure a proper seal is in place (e.g., submersion, hot water, pneumatic pressure, or hot seal) (Department of Defense, 2024, pp. 129, 142, 147).

Separate from DoD-related transportation, the utilization of private sector shipping companies is an industry norm. NAVSUP FLC sites regularly receive and provide shipments to commercial providers like FEDEX, UPS, and DHL—each of which have their own packaging guidelines and transportation capabilities. Familiarity with, and training of personnel on, civilian shipping requirements is pertinent to the overall success of FLC warehousing operations.

3. Hazardous Material

The diverse geographic and regional regulations within the NAVSUP FLC umbrella provide a challenge in the transportation, storage, and subsequent disposal of hazardous materials. According to United States Transportation Command (2024), adherence to federal, state, and local government agencies regarding hazardous materials (HAZMAT) and hazardous waste (HAZWASTE) is required by all DoD personnel (military, civilians, and contractors) (p. II-204-1). This regulation is one of many which outlines the complex handling, disposal, and transportation of HAZMAT and HAZWASTE. Effective and continual training is required to ensure all personnel are aware of applicable local restrictions and annual policy updates.

4. Other Budget Supporting Offices and Operating, Materials & Supplies

According to the Naval Supply Systems Command (2023), FLCs may hold material from other BSOs for the purpose of "repair, staging, or positioning purposes" (pp. 2–4). The custody of this material requires designated personnel trained in standard business processes within warehousing. The management of this non-NAVSUP owned material presents unique challenges in inventory requirements and document retention. Beholden to out of organization reporting timelines, BSO material adds an additional layer of complexity in warehouse operations through requiring physical real estate and increased professional knowledge.

In support of both NAVSUP and other BSOs, FLC sites take on OM&S accountability and management. According to the Secretary of the Navy (2022), OM&S can be categorized as material held for use (MHFU), material held in reserve for future use (MHFFU), material held as excess, obsolete, and unserviceable (MEOU), and material held for repair or remanufacture (MHFR) (p. 2). The ability for FLCs to maintain accountability and custody of OM&S provides flexibility to space constrained naval assets and BSOs. The distinct inventories that FLCs must maintain are an obstacle in defining roles within the NAVSUP warehousing enterprise. With varying stowage, disposal, and inventory requirements; the proper segregation of material along with the requisite knowledge on management is significantly more challenging than individual naval asset or BSO equivalents.

5. Afloat Equivalence

Afloat NWCF assets operate in unique environments and are staffed primarily by the military force. Manning within the United States Navy was formalized under a new process through the Department of the Navy (DON) NAVADMIN 016/16 (2016) which established Billet Based Distribution (BBD) to sailor detailing (Department of the Navy, 2016). The BBD matches specific billets based on rating, paygrade, and navy enlisted classification codes (NEC). Sutton (2013), asked by the Navy Personnel Command for Career Management (PERS4), identified numerous areas for manning efficiency gains using various modeling and simulation theories. This in-depth analysis by an outside entity has not occurred for the ashore FLCs.

In addition to the lack of manpower or staffing analysis of the ashore civilian component of the NAVSUP enterprise, a lack of formalized throughput and workloads standards exists. Navy Afloat units reference the NAVSUP P-485 Volume I Revision 7, Operational Forces Supply (2024b) or Type Commander (TYCOM) specific guidance for standard wait times, shipping timelines, and performance benchmarks. However, the NAVSUP P-485 Volume I only applies to afloat operational units and does not have applicability or adherence requirements for ashore FLCs. There is currently no formalized consolidated standard for productivity norms or labor output.

6. Current Challenges

NAVSUP FLCs and the DoD as a whole face pressure to increase warehousing efficiency. As Steele (2022) reported, the NAVSUP enterprise is making strides to meet the modern needs and demands of its customer base through initiatives for efficient space allocation and technology integration by "participating in a Department of Defense reform initiative to improve warehouse utilization to 75 percent and save $575 million over five years" (para. 1). From a physical real estate and equipment perspective, Reece (2021) mentions the contracting of a third-party firm, Accenture Federal Services, who utilized advances in technology to improve data collection for space analysis (p. 1).

As more funding and effort is poured into technological research, the human element of FLC warehousing operations remains stagnant and antiquated. According to the Commander Naval Supply Systems Command (2024a) in the release of proposed topics for thesis/capstone projects, "staffing levels at NAVSUP FLCs are arbitrarily set based on historical staffing data and financial constraints" (p. 9). The need for formalized studies in manpower standards is ever more present as DoD-wide efforts to effectively employ warehousing operations continue. Basic work elements and workload standards require data collection to provide foundational analysis in which forecasting and a basic staffing model can be derived from.

B. BEST PRACTICES IN MANPOWER MODELING

According to Judge and Kammeyer-Mueller (2021), staffing is defined as "the process of acquiring, deploying, and retaining a workforce of sufficient quantity and quality to create positive impacts on the organization's effectiveness" (p. 9). It involves systematic management of human capital to ensure adequate quality and quantity of personnel exists to perform the necessary tasks and is the most essential function for organizational effectiveness (Judge & Kammeyer-Mueller, 2021, pp. 6–7). This critical function is not static in nature and requires continuous alignment with an organization's evolving mission and external challenges. For NAVSUP, the role of staffing the organization extends beyond basic human resource management; it is a strategic effort to ensure that their logistics operations meet the dynamic demands of the military.

Effective staffing is significant because it allows us to align human resources with organizational objectives to influence productivity, efficiency, and adaptability. Inadequate staffing can lead to operational bottlenecks, delayed service delivery, and compromised mission readiness. On the other hand, overstaffing drives unnecessary costs and labor costs frequently represent one of the largest expenses for organizations. Poor staffing decisions can have lasting operational and financial repercussions, while effective staffing can positively and directly impact profitability, customer satisfaction, and adaptability.

Roberts et al. (2018) demonstrated how time and motion studies in healthcare improved task allocation and identified inefficiencies to directly improve productivity. Similarly, Williams (2018) demonstrated that using data-driven models to enable evidence-based decision-making with respect to staffing resources in a high-intensity warehouse environment mitigated bottlenecks and enhanced service-level agreements. These studies highlight the importance of aligning manpower with workload demands to ensure uninterrupted operations and mission success.

Manpower modeling utilizes various analytical frameworks to predict and optimize staffing needs based on operational constraints and workload variability. Next, we discuss a handful of techniques; keeping in mind that some techniques will employ others.

1. Time and Motion Studies

Time studies, also known as work measurement studies, are employed to determine the standard time it takes an individual to perform a given task by observing specific activities' start and end times (Barnes, 1980, p. 7). Analysts can then use these times to determine average task durations and use this data to establish workload standards. This method allows organizations to forecast staffing needs based on the volume and frequency of tasks. Unfortunately, time studies on their own do does not account for how efficiently tasks are performed, as they do not capture wasted motion or ergonomic concerns.

Motion studies, also known as work methods design, are used to find the preferred method for doing work by examining the physical actions required to complete a task (Barnes, 1980, p. 7). Motion studies aim to streamline workflow by identifying unnecessary or inefficient movements, which may reduce fatigue and enhance productivity (Barnes, 1980, p. 17). Analysts often break down tasks into discrete motions to evaluate whether they can be simplified, eliminated, or re-sequenced for better performance (Barnes, 1980, p. 50). Motion studies are instrumental in environments where layout, equipment positioning, and physical repetition affect output.

Although each approach offers valuable insights, time and motion studies are typically performed together to understand work processes better. Time studies tell how long tasks take, while motion studies explain how those tasks are performed. When used in tandem, they help to optimize both staffing levels and operational efficiency. This integrated approach has proven especially useful in fields where precision and efficiency are critical.

Time and motion studies are frequently used in the medical field. Poulsen et al. (2020) conducted a time and motion study to evaluate the amount of time hospital personnel spent on drug-related tasks, such as searching, scanning, dispensing, and validating medications. Their study illustrates how timing methodologies can help to identify inefficiencies and inform process improvements. Furthermore, their study highlights the applicability of such approaches to logistics operations, such as picking, packing, and shipping. Time and motion analyses would offer NAVSUP a data-driven approach to forecast staffing needs accurately. However, this method requires extensive observation and data collection, making it time-intensive, which can make it less cost-effective over the long run. Additionally, it may not account for unexpected variations in task execution.

2. Data-Driven Deployment

Data-driven methods differ from time and motion studies by utilizing historical data and workload patterns instead of direct observation. Williams (2018) utilized this strategy to restructure staffing in library operations to address inefficiencies in resource-intensive tasks like the retrieval and reshelving of books. Similarly, NAVSUP could leverage this method to determine appropriate staffing levels and improve task allocation across all of its warehouses. Though the effectiveness of this method depends upon both the availability and accuracy of historical data, the latter of which may not adequately reflect future conditions or emerging trends, it can be extremely useful due to its scalability and efficiency; the model can be employed rapidly across multiple facilities without the need for extensive on-site observations.

3. Simulation-Based Approaches

Simulation methods are used to mimic real-world system behavior over time to evaluate performance under different conditions. They are often used when the system is too complex for a purely mathematical analysis, or when inputs such as demand patterns have a large degree of variability (e.g., non-stationary demand). A simulation most often utilizes computer software to run scenarios iteratively to represent a system's behavior in order to evaluate the outcomes under varying conditions. Simulation models allow organizations to test staffing scenarios in a virtual environment prior to implementation of changes. For example, He et al. (2016) utilized simulation-based methods to develop staffing algorithms in service systems with non-Poisson non-stationary arrivals. Similarly, Krishna and Prabhu (2017) employed simulation methods to analyze workforce capacity in distribution centers under different demand scenarios to reduce costs while maintaining quality of service. These two cases demonstrate the effectiveness of simulation in handling complex operational patterns and fluctuating demand. NAVSUP could use simulation to evaluate how varying transaction volumes and operational conditions impact requirements for staffing, enabling the optimization of staffing levels. However, the primary limitation of this method is the large degree of resource demands, such as the computational power and expertise required to use these models effectively.

4. Regression Analysis

Regression analysis is a statistical approach used to understand the relationship between variables (Tepkasetkul et al., 2023), which may assist in decision-making and forecasting future needs. This method is particularly useful for workforce planning, as it can help to identify key predictors of workload variability and manpower needs. For instance, using historical observational data, regression models can be used to analyze how changes in inventory levels or transaction volumes (independent variables) relate to manpower requirements (dependent variable). This method of approach would allow NAVSUP to uncover patterns in their logistics operations, to permit more precise staffing adjustments.

Unlike time and motion studies, which rely heavily on direct observation or simulation-based approaches to create virtual models of operations, regression analysis focuses on uncovering relationships within existing data. The primary strength of this method is the ability to quantify the effect(s) of multiple variables simultaneously, providing practical guidance for improving staffing efficiency. The struggle with any method is that the effectiveness of the analysis depends on the quality and relevance of the data used, the more significant struggle with this method is that it may not be able to account for non-linear relationships or unexpected shifts in operational demand. However, despite this limitation, regression analysis would provide a scalable and cost-effective tool for improving staffing efficiency within NAVSUP.

5. Queueing Models

A queueing model is a mathematical framework used to analyze systems in which entities such as people, products, or even tasks wait in line for a service. They are typically used for the prediction of performance metrics like wait times or queue lengths, or to optimize resource allocation by evaluating different service configurations, making them very useful in identifying appropriate levels of staff (Green, 2010). Although queueing models can be incorporated into a simulation model, as Krishna and Prabhu (2017) did, they can also be used as a standalone model; and unlike simulation models, queueing models offer a more static analytical approach. For example, a queueing model might calculate average wait times in a warehouse, while a simulation could model the entire operation, capturing the interdependence between processes, both of which can inform staffing decisions. Moreover, unlike simulation models, queueing models require little data and typically result in simple formulas for various performance measures, making them easier and cheaper to develop and use (Green, 2010). This makes queueing models a powerful tool for analyzing systems with well-defined arrival and service rates, however, they often rely on simplifying assumptions which may not accurately reflect real-world complexities. Nevertheless, this method could be used as a subset of broader simulation efforts to help analyze specific bottlenecks or resource allocation challenges within NAVSUP.

6. Stochastic Optimization

Differing in methodology and purpose from both simulation and queueing models (though it often utilizes simulation and may incorporate queueing theory), stochastic optimization focuses on decision-making under uncertainties and uses probabilistic methods to identify the best solution available given those uncertainties in key variables or outcomes. This focus provides for greater flexibility in workforce planning. Wruck et al. (2017) noted, “stochastic models are used most often for staffing problems to deal with uncertainty in labour demands” (p. 1). Their research explored multistage stochastic models to address staffing fluctuations in e-commerce warehouses. The ability for stochastic optimization to account for variability is the major advantage of this method and what makes it particularly effective for more complex manpower challenges. On the other hand, the method can be computationally intensive and requires extensive data inputs and sophisticated tools for proper implementation. This limits the accessibility and scalability of this method.

7. Desirable Characteristics of Effective Staffing Models

Now that we have discussed some staffing model options, let us look at some of the considerations when choosing a model according to the National Academies of Sciences, Engineering, and Medicine (NASEM). In their book on Facilities Staffing Requirements, they list several desirable characteristics of effective staffing models: adaptability, communicability, relevance, scalability, transparency, validity, validation and verification capability, usability, and utility (NASEM, 2019, pp. 33–37). We will address them in the order listed here, though that does not indicate their relative importance overall.

Adaptability refers to the model's ability to adjust for changing conditions, such as workload fluctuations, advancements in technology, or shifts in the organization's structure. This characteristic is particularly significant for NAVSUP, given the dynamic nature of military logistics and the large degree of variability in operational demands. Communicability emphasizes the need for models to be easily understood and interpreted by stakeholders so as to improve, rather than bias, decision-making (NASEM, 2019, p. 37). Relevance requires the model to address "the issues for which it is designed" (NASEM, 2019, p. 35). Scalability, also particularly significant for NAVSUP due to the need to scale this research across all of its warehouses, allows the model to adapt to a range of facilities and functions (NASEM, 2019, p. 35). Transparency is crucial for fostering stakeholder confidence, and is accomplished by making assumptions, inputs, and outputs clear and readily accessible. The most critical characteristic, validity, requires that the model be an accurate representation of the problem and therefore the results and recommendations based on the model are credible and applicable. Validation and verification capabilities bolster confidence in the model by ensuring it performs as intended. Usability highlights the importance of practical implementation, and lastly, utility focuses on delivering action items to improve the performance of the organization.

8. Proposed Model

Considering these models and characteristics, along with the fact that NAVSUP currently does not have historical data to work with, allows us to conclude that the method for determining the optimal staffing model for their warehouse operations is a time study. This method addresses NAVSUP's immediate need for a practical staffing solution, as it does not rely on pre-existing historical data but instead generates new task-specific data through direct observation. Time studies are also more user friendly than simulation or stochastic optimization, addressing the usability factor. Furthermore, this method can be easily adapted in the future, allowing for adjustments as NAVSUP's operations evolve. Lastly, time studies are both practical and scalable and permits

NAVSUP to establish a strong foundation for workforce planning to build upon and incorporate more sophisticated models in the future if desired.

III. METHODOLOGY

NAVSUP FLCs, like many other government entities, are under significant pressure to implement staffing efficiency initiatives. As noted in earlier chapters, historical data on core warehouse functions are lacking; therefore, NAVSUP has no ability to make informed decisions. Currently, NAVSUP FLC sites are decentralized from FLC HQ, operating independently of one another with leeway in standardized operating procedures (SOPs) based on warehouse floor configurations, types of materials, available personnel, and types of clienteles.

The initial focus for this study was to establish a baseline correlation between the completion time of various warehouse functions and associated staffing requirements. Process flowcharts provided by NAVSUP FLC supplied guidance and framework in the development of data collection methodology for each process. The timeframe for the development of collection plans was approximately two months. The timeframe was considered ample in providing a useful insight into the individual tasks applicable to the study. One author's prior experience as a Supply Corps Officer, with over ten years in logistics and warehouse operations, likely contributed to the efficiency of the planning process. This operational knowledge informed us of the development of effective and relevant data collection methods. Based on availability, a local site visit at NAVSUP FLC Lemoore occurred over four days; divided into a day of briefing and coordination, and three days of data collection. Prior to arrival on-site, NAVSUP FLC HQ selected four core warehouse functions to observe and focus efforts on: receipt-to-stow, issue, inventory, and small parcel label creation using the Financial and Air Clearance Transportation System (FACTS). The observations of these tasks were recorded utilizing a Real Instruments ZSD-009 digital stopwatch. The data collection methods conducted were created following discussions with both the sponsor and warehouse personnel. Observed processes were recorded under ideal operational scenarios to provide a baseline under favorable conditions. The ideal operations assumption exempts disruptions or exceptions within the process flow, which subsequently resulted in periodic pauses in recording.

A. RECEIPT-TO-STOW

For the purposes of this study, the Receipt-to-Stow function of NAVSUP FLC warehousing is defined in accordance with NAVSUP P-723 Chapter 3 Internal Control Aid 3 Receipt-to-Stow Line of Effort (Figure 1) and as follows:

1. Verifying National Item Identification Number (NIIN), quantity, document number, and condition code of items received by signing, dating, and legibly printing or stamping name
2. Verifying the materiel matches the shipping/receipt documentation
3. Reviewing shipping/receipt documentation and determining disposition
4. Determining if open due-in exists
5. Verifying or producing label(s) in accordance with the NAVSUP P-723 and local policy
6. Stowing materiel in designated location
7. Providing annotated shipping/receipt documentation to QA analyst
8. Verifying the shipping/receiving document is signed, dated, and legibly printed or stamped name. Posting the receipt information reflected on the shipping/receipt document to Navy Enterprise Resource Planning (ERP)

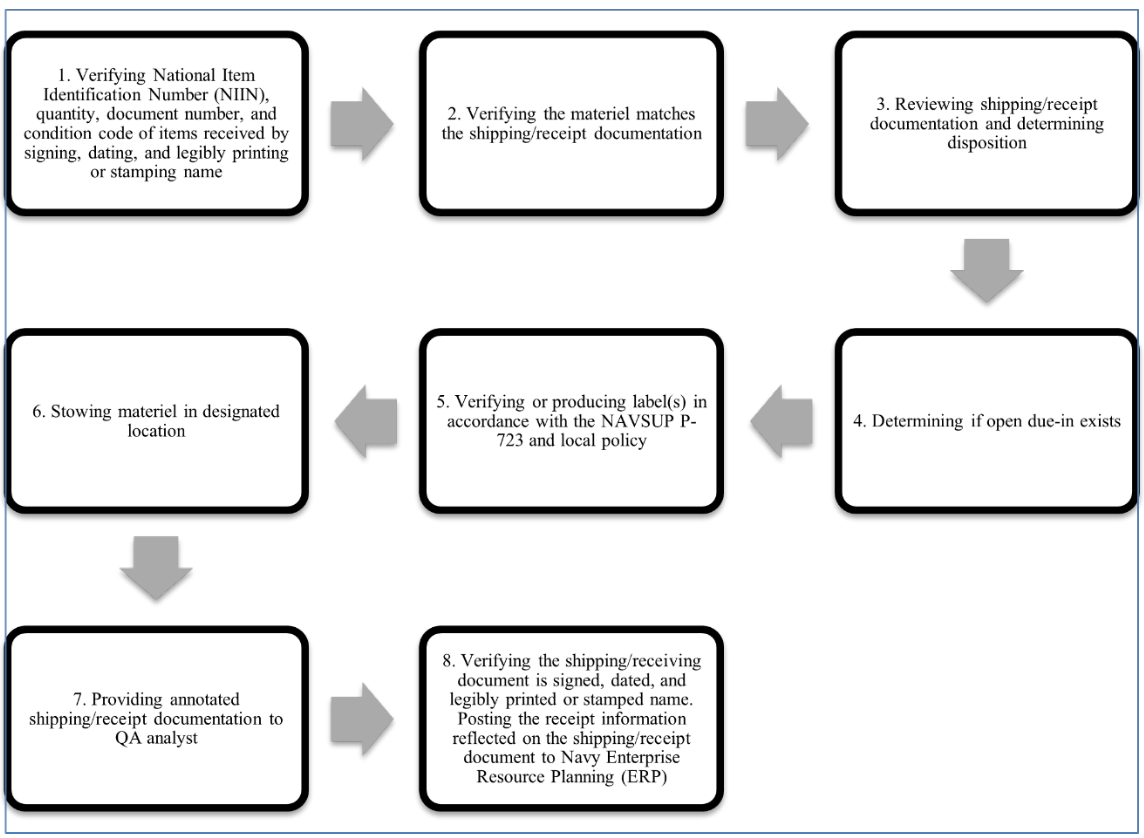

Figure 1. Process Flow for Receipt to Stow

Materiel was staged on pallets following truck delivery and sorting. Warehouse personnel were logged into workstations (both desktop and mobile tablet) with Navy ERP ready for input. Timing commenced upon the warehouse worker initiating step 1 of Figure 1 and concluded upon completion of step 8. Receipt-to-Stow was observed as a single worker task. A sample size of N = 30 was utilized with diverse materiel types and stow locations. Data recorders tracked sample number, worker identification, time elapsed, and stow type location (Rack, Shelf, Bin, Carousel, VLM, Cage, or Floor). Copies of materiel shipping/receiving documentation (DD Form 1348–1A) were retained with recorded information for future reference. Four separate warehouse personnel were observed to complete the Receipt-to-Stow process in its entirety.

B. ISSUE

For the purposes of this study, the Issue function of NAVSUP FLC warehousing is defined in accordance with NAVSUP P-723 Chapter 10 Internal Control Aid 10 Issue Line of Effort (Figure 2) and as follows:

1. Release request in Navy ERP/BLA and print picking ticket
2. Find materiel
3. Pull materiel identified on Picking Ticket from storage location for items to be issued by signing, dating, and legibly printing or stamping name on the issue document
4. Verify supported local customer (SHORECAL)
5. Deliver to or stage materiel for supported local customer (both Consumable and DLR)
6. Provide annotated Picking Ticket to QA Analyst
7. Expend Navy ERP/BLA asset balance
8. Post the issue information (NIIN, quantity, document number, and condition code) reflected on the picking ticket to Navy ERP/BLA

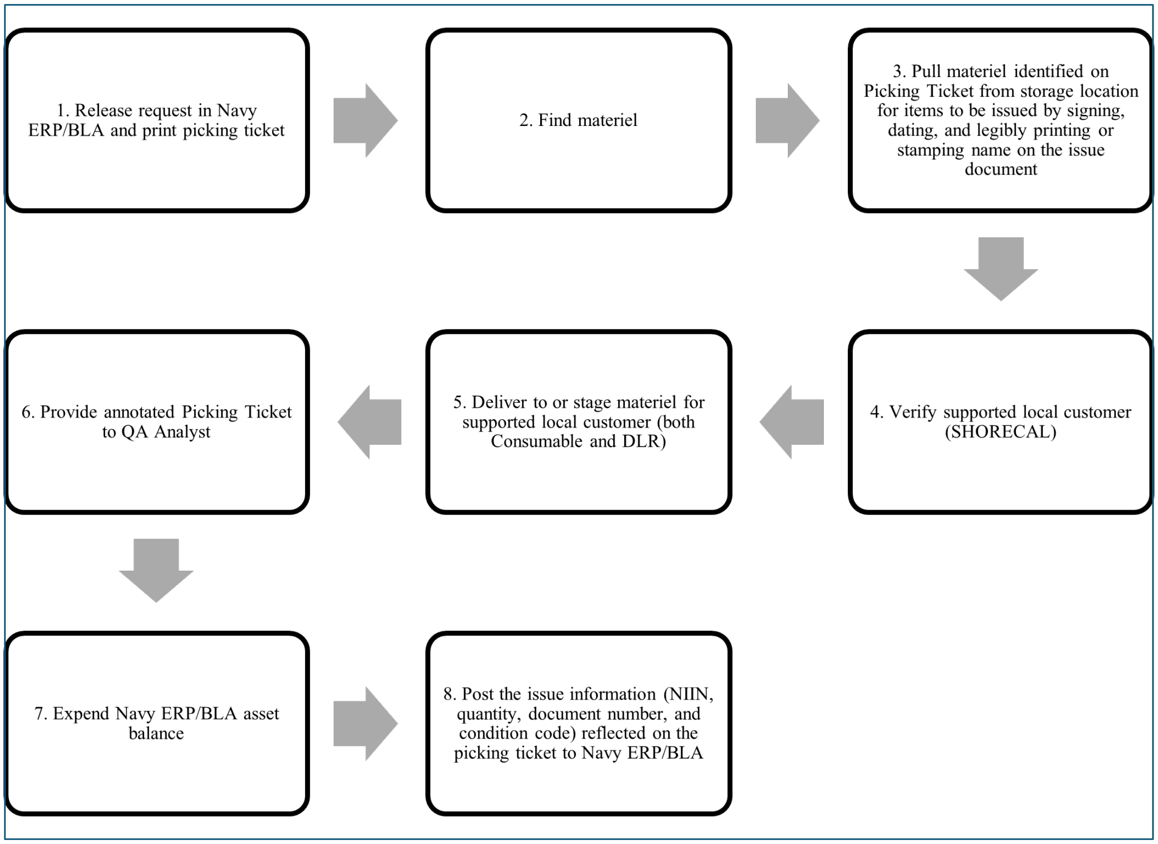

Figure 2. Process Flow for Issue

Within the scope of this study, picking ticket and issue documentation are interchangeable as both are DD Form 1348–1A. Picking tickets were printed and stacked in advance. Timing commenced upon a warehouse worker initiating step 1 of Figure 2 and concluded upon completion of step 8. Issue was observed as a two-person task. A sample size of N = 30 was utilized with diverse materiel types and stow locations. Data recorders tracked sample number, time elapsed, and stow type location (Rack, Shelf, Bin, Carousel, VLM, Cage, or Floor). Copies of issue documentation were retained with recorded information for future reference. The same two warehouse workers were observed for each sample.

C. INVENTORY

For the purposes of this study, the Inventory function of NAVSUP FLC warehousing is defined in accordance with NAVSUP P-723 Chapter 4 Internal Control Aid 4 Physical Inventory Line of Effort (Figure 3) and as follows:

1. Conduct a count for a NIIN, unit of issue, and annotate the quantity by condition code and location
2. Repeat step (1) for all materiel on the count sheet
3. Sign, date, and legibly print or stamp name on the first page of the count sheet. Turn into QA analyst

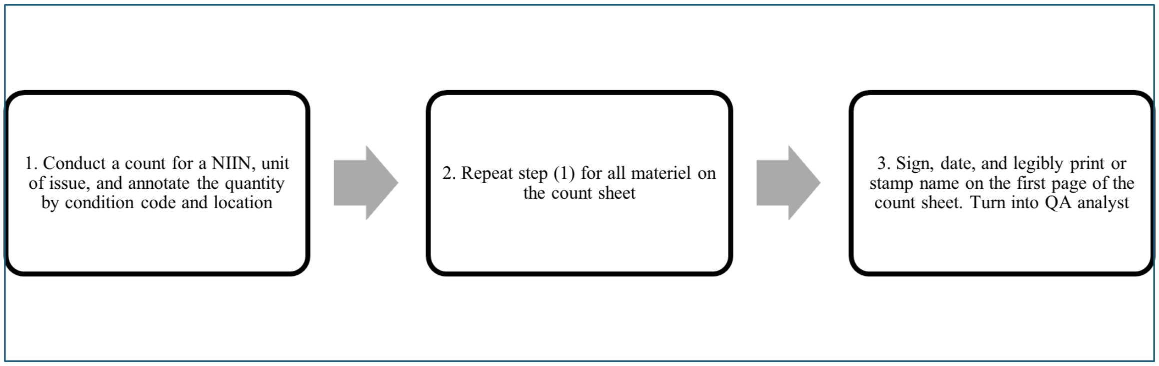

Figure 3. Process Flow for Inventory

Within the scope of this study, Inventory does not include preliminary preparation steps such as inventory generation within Navy ERP or the printing of count sheets. Time measurements commenced upon an inventory counter initiating step 1 of Figure 3 and concluded upon completion of the same step. Inventory was observed as a single-person task. An inventory of sample size N = 30 was generated, incorporating diverse materiel types and stow locations. Data recorders tracked sample number, time elapsed, and stow type location (Rack, Shelf, Bin, Carousel, VLM, Cage, or Floor). A copy of the completed inventory count sheet was retained for future reference. The same individual performed all inventory samples to control variation. Walking time between the completion of step 1 for one NIIN and the start of step 2 for the next NIIN was included in the time measurement for the following NIIN.

D. SMALL PARCEL LABEL CREATION USING FACTS

For the purposes of this study, the Small Parcel Label Creation Using FACTS function of NAVSUP FLC warehousing is defined in accordance with the NAVSUP FLC San Diego Global Labor Standards (GLS) Workbook deliverable under DLA Warehouse Utilization Contract No. SP3300-23-F-1082 (see Figure 4), and is described as follows:

1. Review the shipping document and scan information into FACTS
2. Complete the remaining required information fields in FACTS
3. Print the shipping label

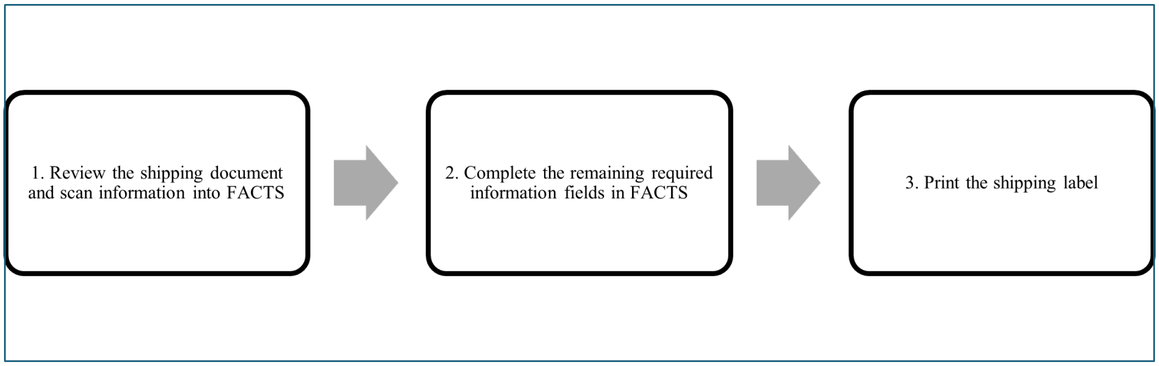

Figure 4. Process Flow for Small Parcel Label Creation Using FACTS

Within the scope of this study, shipping documents refer to either a DD Form 1348–1A or a DD Form 1149. The term "Small Parcel" applies to individual packages that do not require freight shipping. Sub-shipment types—including single parcel, multi-box, and multi-pack shipments—were treated uniformly under the umbrella of small parcel label creation. A sample size of N = 30 was generated based on available shipments. Sub-shipment type, destination, and material type were not used as selection criteria due to limited availability. Time measurements began when transportation personnel initiated step 1 and concluded upon completion of step 3. The Small Parcel Label Creation Using FACTS line of effort was observed as a single-person task. Data recorders documented the sample number, worker identification, time elapsed, shipment type (domestic vs. international), and the regulated or non-regulated status of the material. Additional notes were taken to distinguish between manually entered and scanned data fields. Although two individuals were available for observation, one, with 12 years of warehousing experience, was observed more extensively and completed 90% of the recorded samples. This was intended to establish a consistent operational baseline and reduce variation in task execution due to experience level.

IV. DATA ANALYSIS

This section outlines the individual steps taken to translate the raw time observations into normalized or performance-adjusted estimates suitable for use in a staffing model. The objective was to determine the total workload by process in order to determine the number of staff members needed to perform that workload. The data was cleaned to remove outliers, adjusted for individual worker performance, and applied to throughput data to calculate monthly workload values. These results serve as the foundation for developing a data-driven staffing model tailored to the NAVSUP FLC Lemoore warehouse.

A. OUTLIERS

The first step in data analysis involved removing statistical outliers to ensure that anomalies did not distort average performance time estimates. Outliers were removed by utilizing the standard deviation to find the lower and upper bounds as follows:

$$\begin{aligned} &Lower\ Bound = Mean - (2s) \\ &Upper\ Bound = Mean + (2s) \\ &Where: \\ &s = Standard\ Deviation \end{aligned} \qquad (1)$$

Since each process was broken down by inventory stow type location, the outlier removal process was performed for each stow type within a process. There was a single outlier of the Rack stow type for the Inventory Count process, one outlier of the Bin stow type for the Receipt-to-Stow process, one outlier of the Carousel type for the Issue process, and two outliers of the Domestic/Non-regulated type for the FACTS process. All of which were outside the upper bound except the Carousel type in the Issue process, which was below the lower bound.

B. NORMALIZING

To translate raw observation time data into a usable staffing model, the recorded observed times for each process were standardized by factoring in skill and effort ratings to obtain a normal performance time, that is, the time it would take an average individual to perform the given task. These ratings were drawn from the performance rating table in Ralph M. Barnes's book *Motion and Time Study: Design and Measurement of Work* (1980), illustrated in Table 1.

Table 1. Performance Rating Standards

Skill			Effort		
0.15	A1	Superskill	0.13	A1	Excessive
0.13	A2		0.12	A2	
0.11	B1	Excellent	0.1	B1	Excellent
0.08	B2		0.08	B2	
0.06	C1	Good	0.05	C1	Good
0.03	C2		0.02	C2	
0	D	Average	0	D	Average
-0.05	E1	Fair	-0.04	E1	Fair
-0.1	E2		-0.08	E2	
-0.16	F1	Poor	-0.12	F1	Poor
-0.22	F2		-0.17	F2	
Conditions			**Consistency**		
0.06	A	Ideal	0.04	A	Perfect
0.04	B	Excellent	0.03	B	Excellent
0.02	C	Good	0.01	C	Good
0	D	Average	0	D	Average
-0.03	E	Fair	-0.02	E	Fair
-0.07	F	Poor	-0.04	F	Poor

The standards, referred to as a four-factor system, were initially developed at Westinghouse in 1927 (Barnes, 1980). The numerical factors come from predefined rating scales based on expert judgment and historical observation of work behavior. The four factors—skill, effort, conditions, and consistency—represent a distinct aspect of worker performance and contribute to the overall performance rating.

- Skill reflects the worker's adherence to the proper method, coordination, and rhythm.
- Effort assesses how energetically the worker applies their skill.
- Conditions account for external influences such as lighting, temperature, and workspace layout that may ease or hinder performance.
- Consistency evaluates the worker's ability to repeat the task with minimal variation in time or quality.

These factors are scored and combined to adjust observed time, producing a fair standard time for the task. Table 2 provides our assessment of skill and effort for the nine different workers observed during data collection, note worker "C" appears twice.

The assessment of skill and effort involved an inherent degree of subjectivity, as it relied on qualitative observations rather than precise measurement tools. We evaluated each worker's performance based on factors such as their years of experience in their current role, working speed, and perceived familiarity with both the warehouse layout and the technology used during the task. Criteria that, while providing helpful context for assigning relative ratings, are interpretive by nature. For example, a worker who moved confidently and efficiently through the picking process was rated higher in skill. Similarly, effort was inferred from the observed pace and task engagement, though it could be influenced by temporary fatigue or environmental conditions not accounted for in the rating. To mitigate bias, we applied a consistent framework across all observations, but some variability in judgment remains unavoidable.

Table 2. Skill and Effort Assessment

Department	Process	Worker	Skill	Effort	PR	Standard PR
Admin	Inventory Count – NWCF	A	0.06	0	0.06	0.06
Admin	Inventory Management – Print/Review Inventory Count Report – NWCF	B	0	0	0	0
Inbound	Receipt to Stow – NWCF	C	0	0	0	0.0675
		D	-0.05	0.05	0	
		E	0.06	0.05	0.11	
Inbound	Receipt to Stow – NWCF	F	0.11	0.05	0.16	0.0675
Outbound	Issue – NWCF	C	0	0	0	0.055
		G	0.06	0.05	0.11	
Outbound	Transportation – Small Parcel Label Creation (FACTS)	H	-0.10	0	-0.10	-0.035
		I	0.03	0	0.03	

The performance ratings were then calculated utilizing the following equation, assuming Conditions and Consistency were always "average" and therefore equal to zero.

$$PR = Skill + Effort + Conditions + Consistency$$
$$\text{Where:}$$
$$PR = Performance\ Rating \quad (2)$$

The standard performance rating given in Table 2 is the average performance rating of all individuals observed for a given task. This was applied to the data provided by the stakeholders from previous data collection by the third-party consulting firm Accenture, discussed later in this section. The standard performance rating was also used for the two-person team for the Issue process.

Each observed time was adjusted using the appropriate performance rating to remove performance variation between workers. The adjusted time, referred to as the normal time, was calculated as follows:

$$\text{Normal Time} = (\text{Observed Time})(\text{Performance Factor})$$
$$\text{Where:}$$
$$\text{Performance Factor} = 1 + PR \qquad (3)$$

C. WORKLOAD CALCULATIONS

Once the normal times were determined, they were averaged by inventory type within a process to establish a standard time for that given category. The equation used for this was:

$$T_{avg} = \frac{\sum T_i}{N}$$
$$\text{Where:}$$
$$T_{avg} = \text{Average normal time per task item}$$
$$\sum T_i = \text{Sum of the time for all task line items}$$
$$N = \text{Total number of line items} \qquad (4)$$

These averages were then multiplied by monthly throughput values provided by the stakeholders, given in Table 3, to calculate the total workload by inventory type for each process. The equation used for this was:

$$W_t = (T_{avg})(P)$$
$$\text{Where:}$$
$$W_t = \text{Total Workload by Type}$$
$$P = \text{Throughput (number of tasks completed in a given time frame)} \qquad (5)$$

Table 3. Throughput Data – CY2024

Process	Type	Number of Line Items
Inventory Count – NWCF	Carousel	5571
	Floor	269
	Rack	1104
	Shelf	5480
	VLM	2308
	Total	14732
Issue – NWCF	Carousel	12353
	Floor	753
	Rack	12522
	Shelf	24178
	VLM	2671
	Total	52477
Receipt to Stow – NWCF	Carousel	7577
Receipt to Stow – NWCF	Floor	411
	Rack	3930
	Shelf	12457
	VLM	1599
	Total	25974
Transportation – Small Parcel Label Creation (FACTS)	Non-Regulated / Domestic	4803
	Non-Regulated / International	1562
	Regulated / Domestic	368
	Regulated / International	55
	Total	6788
Inventory Management – Print/ Review Inventory Count Report – NWCF	Total Line Items Inventoried – FY23	22921
	Total Line Items Inventoried – FY24	26809
	Total Inventories Conducted – FY23	1867
	Total Inventories Conducted – FY24	956

NAVSUP FLC HQ provided the throughput values shown in Table 3. These values represent actual historical workload volumes by inventory type and process and were not independently verified or adjusted in this study. While we did not assess their accuracy, they were treated as authoritative for the purposes of calculating total workload in conjunction with the normalized time estimates derived from our observations.

The results from the calculations utilizing Equations 4 and 5 are provided in Table 4.

Table 4. Total Workload Results

Process	Type	T_{avg} (min)	Throughput (per month)	W_t (min)
Inventory Count – NWCF	Cage	1.206	N/A	N/A
	Carousel	1.188	464.25	551.568
	Floor	0.106	22.417	2.376
Inventory Count – NWCF	Rack	0.691	92	63.551
	Shelf/Bin	0.590	456.667	269.383
Issue – NWCF	Carousel	4.818	1029.417	4960.101
	Rack	5.821	1043.5	6074.285
	Shelf/Bin	4.779	2014.833	9628.128
	VLM	4.634	222.583	1031.379
Receipt to Stow – NWCF	Cage	8.297	N/A	N/A
	Carousel	7.633	631.417	4819.767
	Rack	5.990	327.5	1961.575
	Shelf/Bin	5.552	1038.083	5763.216
Transportation – Small Parcel Label Creation (FACTS)	Non-Regulated / Domestic	1.813	400.25	725.584
	Non-Regulated / International	1.894	130.167	246.493
	Regulated / Domestic	9.318	30.667	285.736
	Regulated / International	None Observed		
Inventory Management – Print/Review Inventory Count Report – NWCF	N/A	1.702	2072.083	3527.146

The Cage type for both the Inventory Count and Receipt-to-Stow processes was not calculated because we only had one data point for each process, and the throughput data provided by stakeholders did not break the processes down into this subcategory. Additionally, Bin locations were not provided in the throughput values by the stakeholders either. As such, the line items that we classified as Bin, which were on shelves, are assumed here to be Shelf instead.

After calculating the workload for each subcategory within a process, the total monthly workload by process was determined using the following equation:

$$W_p = \sum W_{t_i}$$

Where:

$W_p = \text{Total Workload by Process}$

$$\sum W_{t_i} = \text{Sum of individual } W_t \qquad (6)$$

The total monthly workload by process was then used to determine staffing needs using the following two equations:

$$S = \frac{W_p}{H}$$

Where:

S = Baseline number of staff needed

H = Available work hours per employee per month (7)

Available work hours per employee per month were calculated assuming an 8-hour working day and an average of 253 working days per year (accounting for federal holidays and weekends), resulting in 2024 available work hours per year, or 10120 working minutes per month, for unit alignment.

$$S_{adj} = \frac{S}{U}$$

Where:

S_{adj} *= Adjusted Number of Staff Needed*

U = Utilization Rate (8)

The utilization rate applied was 60%, and the resulting numbers for workload by process and staff needed are provided in Table 5.

Table 5. Adjusted Staff Required, by Process

Process	W_p (min)	S	S_{adj}
Inventory Count – NWCF	886.878	0.088	0.146
Issue – NWCF	21693.893	2.144	3.573
Receipt to Stow – NWCF	12544.558	1.240	2.066
Transportation – Small Parcel Label Creation (FACTS)	1257.814	0.124	0.207
Inventory Management – Print/Review Inventory Count Report – NWCF	3527.146	0.349	0.581

Rounding the adjusted staff numbers, we get that the Inventory Count process requires one person, the Issue process requires four people, Receipt-to-Stow requires three people, FACTS requires one person, and Inventory Management requires one person. Since the same individuals carry out the Issue and Receipt-to-Stow processes, this department within the warehouse would require seven people, using the numbers from the previous sentence. Alternatively, if we add the adjusted staff numbers for these two processes prior to rounding, we get 5.6387; from this, we might suggest that the department only requires six people. However, it is important to note that this department has other responsibilities, so to say they only need six workers based on these two tasks would be an oversight. It would be better to say that in order to perform the Issue process duties at NAVSUP FLC Lemoore, they would minimally need four individuals.

D. UTILIZATION RATES

Given that the norm is for the company to set its own staff utilization rate(s), the 60% rate used in this study was the recommended value provided by NAVSUP FLC HQ. However, the following is an analysis of the actual observed utilization rate for both floor operations and FACTS computer work. The utilization rates were determined by first calculating the downtime for a given task line item per day, using:

$$D = \frac{\left(\frac{T_{avail} - T_{active}}{N}\right)(P)}{d}$$

Where:

D = Down time for task line item per day

T_{avail} *= Total (observed) available working time for task*

T_{active} *= Total time actively performing task*

d = Number of working days per year (9)

Outliers were retained in these calculations because they represented periods during which individuals were actively engaged in tasks. Once downtime was determined, using approximate T_{avail} numbers, it was input into the following equation:

$$U = 1 - \left(\frac{1 + D}{h}\right)$$

Where:

h = Number of hours in a working day (10)

The "1" in this equation accounts for one hour worth of breaks, to include lunch time. The observed utilization rate for the Receipt-to-Stow process was approximately 54.95%, and for the FACTS process, it was approximately 27.68%.

E. ACCENTURE COMPARISON

In 2023, as part of the Warehouse Utilization enhancement initiative under Contract No. SP3300-23-F-1082, the Defense Logistics Agency contracted the third-party consulting firm Accenture to:

1. Collaborate with FLC SD stakeholders to define key warehouse processes, identify relevant variables and conditions within those processes, and develop a prioritized list of processes for observation and labor standards.
2. Conduct visits to designated FLC SD warehouse sites to observe multiple process cycles. During these visits, Accenture was tasked to:
   a. Time each cycle
   b. Identify variables such as material type, material handling equipment (MHE) requirements, travel distance, and employee-related factors (e.g., effort level and expertise)
   c. Document each step within the process to formally define it
   d. Develop engineered labor standards for each site, and when applicable, create a consolidated "global standard" incorporating data and insights from all locations

While this effort likely provided valuable insights into individual process steps and site-specific factors, Accenture's resulting data set contains several limitations that hinder the development of a comprehensive staffing model and a meaningful comparison with our own findings. There were some instances of data unaccompanied by sample sizes and other instances with missing supporting documentation required for computation. Moreover, for similar observed processes, either the structure of Accenture's observations or the limited quantity of data points collected render a direct comparison invalid or incomplete.

For example, Accenture collected data on the Receipt-to-Stow process in two separate steps, one for Stow and one for Receipt. Their Receipt recording process started at "unloading material from truck" and ended at "process material in ERP and stage again for stow if small/bin or keep in place if heavy/oversized." Their Stow recording process started at "walk to printer" and ended at "stamp 101 with put-away confirmation." As such, no comparison can be made between our data and Accenture's for the Receipt-to-Stow process. Additionally, there is insufficient data available for comparison for the Inventory Management-Print/Review Inventory Count Report-NWCF process. Accenture provided two data points, indicating two reports of inventory line items were observed;

however, the number of line items per report was not recorded, again making comparison between the two data sets impossible. We are also unable to draw any conclusions from a comparison of our FACTS data collection process with their singular data point of unknown type. That said, for processes where methodology and scope aligned sufficiently, direct comparisons are shown in Table 6.

Table 6. Data Comparison

Process	Type	Number of Data Points	Accenture T_{avg} (min)	Our T_{avg} (min)
Inventory Count – NWCF	Carousel	6	0.3151	1.188
	Rack	1	41.340	0.691
	Shelf	10	0.623	0.590
Issue – NWCF	Bin	9	5.126	4.779

The results diverge significantly in these comparable areas. Given the small sample sizes, limited documentation, and lack of methodological transparency in the Accenture data, comparing the data tells us very little, except that the results presented in this study offer a more complete, standardized, and transparent basis for estimating warehouse staffing requirements.

V. DISCUSSION AND CONCLUSION

The methodology and subsequent analysis presented in this study represent an initial step toward quantifying labor requirements for NAVSUP FLC warehouse operations. While the model offers a structured and repeatable process for estimating manpower based on throughput, it is not all-encompassing. Variations in site location, warehouse layout, inventory types, and expected tasking—all play significant roles in the formulation of a throughput-based staffing estimate. The objective of the following section is to present a critical evaluation of the methodology, highlight key limitations, and outline the considerations necessary for informed interpretation and future application.

A. EVALUATION OF METHODOLOGY

This study utilized work measurement, or time, studies to quantify labor demands for core NAVSUP warehouse operations. The exclusion of motions studies a motion study was based on resource and time constraints as well as the immediate need to generate usable data for workforce planning. Time studies enabled the derivation of standardized task durations across diverse inventory types and processes. However, the absence of motion studies introduces limitations. Motion studies capture inefficiencies that stem from poor workstation design, layout challenges, or unnecessary physical movements. Without this analysis, the model remains descriptive rather than prescriptive—it reflects how current operations are performed, not how they could be optimized. The goal was to assess staffing needs based on existing workflows, not to redesign them for maximum efficiency. As such, the model serves as a baseline for current labor requirements rather than a tool for productivity optimization.

Our methodology relied on observing warehouse operations under ideal conditions to establish baseline task durations. The assumption of ideal operations excludes process interruptions, administrative delays, and unexpected complications. Consequently, the staffing estimates derived from this study should be considered minimum requirements, likely to underestimate actual labor demand under routine, imperfect conditions. Any application of the model should account for these variances through buffer staffing, adjusted utilization rates, or dynamic scheduling mechanisms.

B. DATA CATEGORIZATION LIMITATIONS

Accurate workload modeling depends on detailed throughput data aligned with task categories. A key limitation of this study was the lack of complete categorization for inventory types. For example, throughput data did not include disaggregated volumes for Cage and Bin locations. As a result, these subcategories had to be absorbed (when not excluded due to a single data point, like those of the Cage type) into other subcategories, such as Shelf, creating a risk of distortion in workload calculations. This limitation hinders our ability to model task-level staffing needs precisely. Standardizing throughput reporting across FLCs to include all relevant subcategories and ensuring consistency in labeling and classification would significantly improve future staffing models.

C. WORKFORCE APPLICATION CONSIDERATIONS

Although our calculations treat each process in isolation, warehouse staffing is not so neatly divided. In practice, personnel rotate across multiple tasks within a department. For instance, the same workers may perform both Issue and Receipt-to-Stow operations and may also support ad hoc tasks. This fluid distribution of labor makes it difficult to map process-level staffing estimates directly into workforce planning.

Our model offers a baseline for the minimum staffing required to perform each process under favorable conditions, and guides task-level scheduling to ensure core functions are adequately covered. However, actual departmental staffing must also reflect broader responsibilities, cross-functional support, and unplanned demands. As such, our findings reinforce the need for dynamic scheduling and adaptable manpower structures within warehouse operations.

D. TASK INCLUSION AND HOLISTIC OPERATIONS

For this study, we focused on four primary warehouse functions: Issue, Inventory, Issue, Receipt-to-Stow, and Small Parcel Label Creation Using FACTS. While these represent key operational activities within NAVSUP FLCs, they comprise only a portion of the full task set performed in the warehouse. Numerous other core functions of comparable scales—such as re-warehousing, shipping, and the duplicate functions of those we observed for other types of materiel, such as F-35 and Hazardous—were excluded due to scope limitations. In addition, essential tasks such as QA verification, inventory discrepancy resolution, administrative documentation, and supervisory oversight were omitted. While these activities consume time and require skilled labor, they are often under-documented, vary in execution, and are not consistently captured in formal task tracking systems, which makes them more difficult to standardize within a time study framework.

As a result, the staffing recommendations derived from this study are conservative and represent only a partial view of actual labor requirements. A truly comprehensive model should incorporate all recurring operational functions, both routine and exceptional. Future efforts should expand the task inventory, assign standard times or frequencies to these activities, and integrate them into the staffing framework to ensure the model reflects the complete scope of warehouse operations.

E. UTILIZATION RATE CONSIDERATIONS

Our staffing calculations applied a 60% utilization rate based on NAVSUP FLC HQ guidance. Utilization rates are a multiplier that adjusts gross available labor time to reflect realistic productivity, accounting for breaks, non-productive time, meetings, and informal downtime. Observed utilization rates diverged from this benchmark. For example, we calculated approximately 54.95% utilization for Receipt-to-Stow and 27.68% for FACTS processing. This suggests that either observed tasks include additional disruptions not captured by standard assumptions or that the benchmark does not reflect operational conditions.

Applying an inaccurate utilization rate can skew staffing estimates. Overestimating productivity will understate staffing needs, leading to worker overload and reduced throughput, and underestimating productivity will overstate staffing needs, leading to excess labor, inefficient resource allocation, and unjustified personnel costs. We recommend that NAVSUP FLC HQ establish utilization benchmarks, perhaps site-specific, and implement continuous performance monitoring to ensure staffing models reflect actual operating conditions.

F. DEVELOPMENT OF STANDARD OPERATING PROCEDURES (SOPS)

Another barrier to effective workload modeling is the lack of consistent and/or accurate SOPs across NAVSUP FLCs. SOPs provide the foundation for repeatable observations, consistent classification, and task segmentation, but without clear SOPs, observations risk variability due to personal interpretation and training differences. Ensuring adequate and accurate SOPs for each major warehouse process, ideally standardized across the NAVSUP enterprise, would improve future data collection, increase the validity of performance benchmarks, and support training and onboarding. SOPs also lay the groundwork for integrating motion study elements and further automation of task timing.

G. CONCLUSION

This study introduces a task-level staffing model tailored to NAVSUP FLC warehouse operations. Our approach, despite the limitations discussed here, provides a scalable method for estimating labor requirements. With further refinement, this approach can serve as a central component of NAVSUP's workforce planning strategy.

By establishing baseline task durations, the model offers a minimum staffing requirement to meet operational demands. Although it does not capture the full complexity of warehouse activities, the use of time studies provides a transparent and repeatable methodology that supports future iterations and expansion.

The methodology and resulting staffing model are not intended as a definitive solution but rather as a framework for ongoing assessment of the relationship between throughput and manpower. The processes used to calculate staffing estimates enable NAVSUP FLC HQ and its regional sites to move from anecdotal decision-making to a quantitative, data-driven foundation for enhanced performance visibility, operational planning, and resource allocation.

VI. FUTURE WORK

While the previously discussed methodology and analysis establish a foundational framework for throughput-based staffing within NAVSUP FLC warehouse operations, further research is required to enhance the model's accuracy, scalability, and overall utility. The purpose of this chapter is to discuss those further research objectives.

A. INTEGRATION OF MOTION STUDIES

Future studies on NAVSUP warehousing efforts should incorporate motion studies to complement the time-based observations conducted here. Motion studies assess task execution from the perspective of physical efficiency and evaluate factors like workstation layout, unnecessary movements, and repetitive strain. This is especially relevant for the physically demanding operations across NAVSUP FLCs.

Motion studies could shed light on inefficiencies such as extended walking distances or poorly sequenced tasks. For example, queueing a carousel allows personnel to initiate a retrieval cycle and then complete other tasks while the system rotates—an efficient use of time that may appear idle or delayed in a standard time study. Mapping such task interdependencies and physical flows would provide a more complete picture of how space, movement, and equipment use affect overall labor efficiency.

Moreover, recent technological changes, specifically the adoption of mobile tablets for data entry, have begun to alter how certain tasks are performed within NAVSUP FLCs. For example, instead of walking to a fixed workstation to input data, personnel can now complete this step on the move, reducing travel time and increasing workflow continuity. Motion studies can help quantify the labor savings and efficiency gains associated with this change and support future decisions about equipment upgrades or broader implementation across sites.

B. MULTI-SITE STUDY AND MODEL ADAPTATION

This study was limited to NAVSUP FLC Lemoore, and although this site shares many characteristics with other FLCs, there are differences in warehouse size, layout, tasks, and regional practices, which limit the generalizability of the model introduced here. Expanding the study to include multiple sites would serve two purposes: validation and scalability. Validation ensures that observed time standards hold across different contexts. If significant deviations are found, they may be attributed to layout, process variability, or operational tempo. Scalability enables NAVSUP HQ to deploy consistent staffing models across the entire enterprise. Multi-site data would also enable the construction of a "global standard" model that is useful for policy planning and workforce management.

C. DYNAMIC MODELING

Our model is deterministic and static, meaning it relies on fixed inputs to produce staffing outputs and does not account for randomness or variability. Warehouse operations are subject to many uncertainties, such as fluctuating demand and process disruptions, and transitioning to a dynamic modeling framework would improve resilience and flexibility.

One option for dynamic modeling is the use of simulation models. This approach can test how staffing levels perform under varying conditions by simulating variables like peaks in demand, unexpected disruptions, or layout changes. Another option for the transition to dynamic modeling is to use regression models, which could help identify workload drivers based on historical data in order to predict staffing needs as a function of variables like incoming line items or process complexity.

Both of these models have the potential to provide immense value, but it is important to note that they also require more advanced data handling and technical capability. Nevertheless, once the baseline performance data from this study is expanded and validated, dynamic modeling would enable NAVSUP to forecast staffing needs proactively and optimize personnel deployment under real-world constraints.

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