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Inventory Funding Methods on Navy Ships: NWCF vs. End-Use

30 May 2013

LCDR Bradley C. Carroll, USN

LCDR Tanya K. Cormier, USN

Advisors: Dr. Geraldo Ferrer, Associate Professor,

Philip Candreva, Senior Lecturer, and

Dr. Michael Dixon, Assistant Professor

Graduate School of Business and Public Policy

Naval Postgraduate School

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ABSTRACT

The purpose of this research is to determine the applicability of Navy Working Capital Fund (NWCF) repairable inventory on small combatant platforms. The majority of these platforms are funded, as of June 2013, using appropriated Operating Target funds. This project analyzes NWCF versus end-use funded inventories using data from the pilot project launched by Commander, Naval Surface Force East, on USS *Normandy* (CG 60) in 2008. We use supply effectiveness and financial data to identify whether there is an inventory readiness gap between the two sources of funding and compare and contrast performance with other CNSF Guided Missile Cruiser and Amphibious Assault class ships. From this analysis, we identify the advantages and disadvantages of both NWCF and end-use inventories and provide an impact matrix for the three major stakeholders: the ship, the Type Commander, and the Navy. We also provide a recommendation to Naval Supply Systems Command on the future implementation of these methods for existing and future classes of small combatants, specifically, *Zumwalt*-class destroyers.

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ABOUT THE AUTHORS

Lieutenant Commander Bradley Carroll is a native of Belton, TX. He graduated from Baylor University in Waco, TX, in 2000 with a Bachelor of Business Administration in Marketing and International Business. He received his commission in 2001 through the Naval Officer Candidate School in Pensacola, FL. His first tour was with Naval Mobile Construction Battalion (NMCB) One of Gulfport, MS, as assistant supply officer and air detachment supply officer during their deployment to Kuwait and Iraq. He then reported to USS *Buffalo* (SSN 715) of Pearl Harbor, HI, as supply officer. After completing a submarine deployment to the Western Pacific, he reported to Naval Air Weapons Station (NAWS) China Lake, CA, as Aviation Support Division (ASD) officer and site director for Fleet and Industrial Supply Center (FISC) San Diego. He subsequently reported to Second Marine Aircraft Wing (2D MAW) of Cherry Point, NC, as aviation contract manager and Navy liaison. After graduating from the Naval Postgraduate School, he will report to USS *Harry S. Truman* (CVN 75) as the assistant supply officer.

Lieutenant Commander Tanya Cormier is a graduate of San Diego State University with a Bachelor of Arts in political science and economics. She received her commission from Officer Candidate School in September 2002. LCDR Cormier has successfully completed three afloat tours to include disbursing and food service officer on USS *Lake Champlain* (CG 57) from 2003–2005, supply officer on HSV 2 *Swift* (Gold Crew) from 2005–2007, and stock control and material officer on USS *Abraham Lincoln* (CVN 72) from 2009–2011. Her shore duty assignment was staff supply and diversity officer, Commander Patrol and Reconnaissance Group (COMPATRECONGRU), responsible for P-3/EP-3 *Orion* aircraft material support. After graduation in June 2013, she will report to the Fleet Logistics Center Pearl Harbor, HI.

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LIST OF ACRONYMS AND ABBREVIATIONS

3-M	Maintenance and Material Management
AEL	Allowance Equipage List
APL	Allowance Parts List
AT	Allowance Type
BOR	Budget OPTAR Report
BP	Budget Project
CBO	Congressional Budget Office
CG	Guided Missile Cruiser
CMP	Continuous Monitoring Program
CNAF	Commander, Naval Air Force
CNSF	Commander, Naval Surface Force
CNSF–East	Commander, Naval Surface Force, U.S. Atlantic Fleet
CNSF–West	Commander, Naval Surface Force, U.S. Pacific Fleet
CONUS	Continental United States
COSAL	Coordinated Shipboard Allowance List
CVN	Aircraft Carrier
D-Level	Depot Level
DBI	Demand-Based Item
DBOF	Defense Business Operating Fund
DDG	Guided Missile Destroyer
DEF-To-RO	Deficiency To Requisitioning Objective
DFAS	Defense Finance and Accounting Service
DLA	Defense Logistics Agency
DLR	Depot-Level Repairable
DoD	Department of Defense
DoN	Department of the Navy
DTO	Direct Turnover

EMRM	Equipment Maintenance Related Material
ERP	Enterprise Resource Planning
FLC	Fleet Logistics Center
FLR	Field Level Repairable
GAO	General Accounting Office
I-Level	Intermediate Level
IT	Information Technology
LCL	Lower Control Limit
LHD	Amphibious Assault Ship
LS	Logistics Specialist
LST	Logistics Support Team
MF	Mission Fund
MFCS	Material Financial Control System
NAVSUP	Naval Supply Systems Command
NWCF	Navy Working Capital Fund
O-Level	Organizational Level
O&MN	Operation & Maintenance, Navy
OFC	OPTAR Fund Category
OPTAR	Operating Target
OSO	Other Supply Officer
POM	Pre/Post-Overseas Movement
R-Supply	Relational Supply
RoR	Reorder Review
SAC	Service Application Code
S&E	Supplies and Equipage
SIM	Selected Item Management
SMC	Supply Management Certification
SOM	Supply Operations Manual
TL	Transmittal
TYCOM	Type Commander

UCL	Upper Control Limit
WSS	Weapon Systems Support

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I. INTRODUCTION

A. OVERVIEW

This project reviews the two different funding methods for spare parts support on U.S. Navy ships, Navy Working Capital Fund (NWCF) and end-use funding. As Navy supply officers, we entered into this project with experience managing both types of inventories on multiple classes of ships. Our professional knowledge and experience shaped the development of our hypotheses and guided us in the selection of data we used to analyze this complex issue. The question of whether the Navy should use one funding method over another has deeply rooted cultural and organizational ideologies that will compel decision-makers to identify their inventory measures of success. As the Navy acquires and resources new classes of ships, develops IT systems, and faces fiscal challenges, we assert that shipboard inventory management metrics will require a broader view.

B. BACKGROUND

The United States Navy employs two funding methods to provision and replenish spare parts inventories onboard ships: NWCF and end-use funding. Traditionally, the class of ship has determined the type of inventory funding method used. For example, NWCF inventory is placed aboard large ships, such as aircraft carriers (CVNs) and amphibious assault ships (LHDs). Conversely, inventories on small combatants, such as guided missile cruisers (CGs) and guided missile destroyers (DDGs), are end-use funded. Our research looks at these two inventory funding methods and their impact on a ship's supply readiness, repairable parts funding, and inventory management.

1. Inventory—Wholesale vs. Retail

The wholesale-versus-retail concept is similar in form for both commercial and military environments but differs significantly in performance expectations. Wherein the objective of commercial inventory is swift turnover resulting in high profits, military objectives focus on the operational availability of the weapons system supported by the inventory.

Textbook definitions of commercial and retail wholesale inventories are as follows:

> [Wholesale:] The wholesaler purchases large quantities from manufacturers and sells small quantities to retailers in order to provide retail customers with assorted merchandise from different manufacturers in smaller quantities. (Ailawadi, 2005, p. 73)

> [Retail:] Retailer purchases a wide variety of products and in relatively smaller quantities and assumes a substantial risk in [the] marketing process. Retailer inventory risk is wide but not deep. Emphasis is more on inventory turnover. (Ailawadi, 2005, p. 73)

Military wholesale, retail, and consumer inventories are described by the Department of the Navy (DoN) as follows:

> <u>Wholesale Level Inventory.</u> The highest level of organized DoD [Department of Defense] supply, and as such, procures, repairs, and maintains stocks to resupply the retail levels of supply. Inventory for which the designated inventory manager has asset visibility at the national level and exercises unrestricted asset control to meet worldwide inventory management responsibilities. (Chief of Naval Operations [CNO], 2012, p. 9)

> <u>Retail Level Inventory.</u> Inventory, regardless of the funding source, held below the wholesale level. The retail level is made up of intermediate and consumer level inventory. (CNO, 2012, p. 9)

> <u>Consumer Level Inventory.</u> The part of the retail inventory, regardless of funding source, usually of limited supply distribution for the sole purpose of internal consumption or utilization. (CNO, 2012, p. 9)

Small combatants such as CGs and DDGs carry and own a consumer retail inventory. LHDs and CVNs also carry a retail inventory, with the caveat that the inventory is retained and utilized by the ship but owned by the wholesale organization until the ship purchases the spare part for use. The CG's inventory is managed by end-use funding, while the LHD's inventory is managed by NWCF.

2. NWCF vs. End-Use Funding

The Navy has been using capital funding, in the form of stock funds, for materiel procurement since the late 1800s. Today's NWCF descends from the 1947 National Security Act, which called for the use of revolving funds as the business model for commercial-type activities, such as materiel procurement for Navy customers (Department of the Navy, Office of the Comptroller, 2001). The purpose of a revolving fund is two-fold, to promote total cost visibility and to control those costs. "The basic tenet of the revolving fund structure is to provide a customer–provider relationship between the military operating units and support organizations" (Defense Finance and Accounting Service, 2011). The flow of funding for the NWCF begins at the fund's inception with an initial appropriation from Congress. Revolving funds are intended to be self-sustaining and operate on a breakeven basis, as opposed to for-profit. This makes them useful tools to both government entities and non-profit organizations, which are providing goods and services at the taxpayer or donor's expense (Department of the Navy, Office of Financial Management and Budget, 2010). For example, Congress may appropriate $1 million to the NWCF. Ten types of widgets are purchased with NWCF money and warehoused by the Navy. The Navy sets the retail price of the widget to include the cost of the part plus overhead, such as storage, transportation, and handling. A ship orders the part, and the NWCF is reimbursed; overhead costs are paid, and a new part is ordered for the warehouse. The intent is to break even, and any gains or losses in the system are recovered by adjusting the retail price. Figure 1 provides a basic representation of the NWCF process and the flow of funding and materiel.

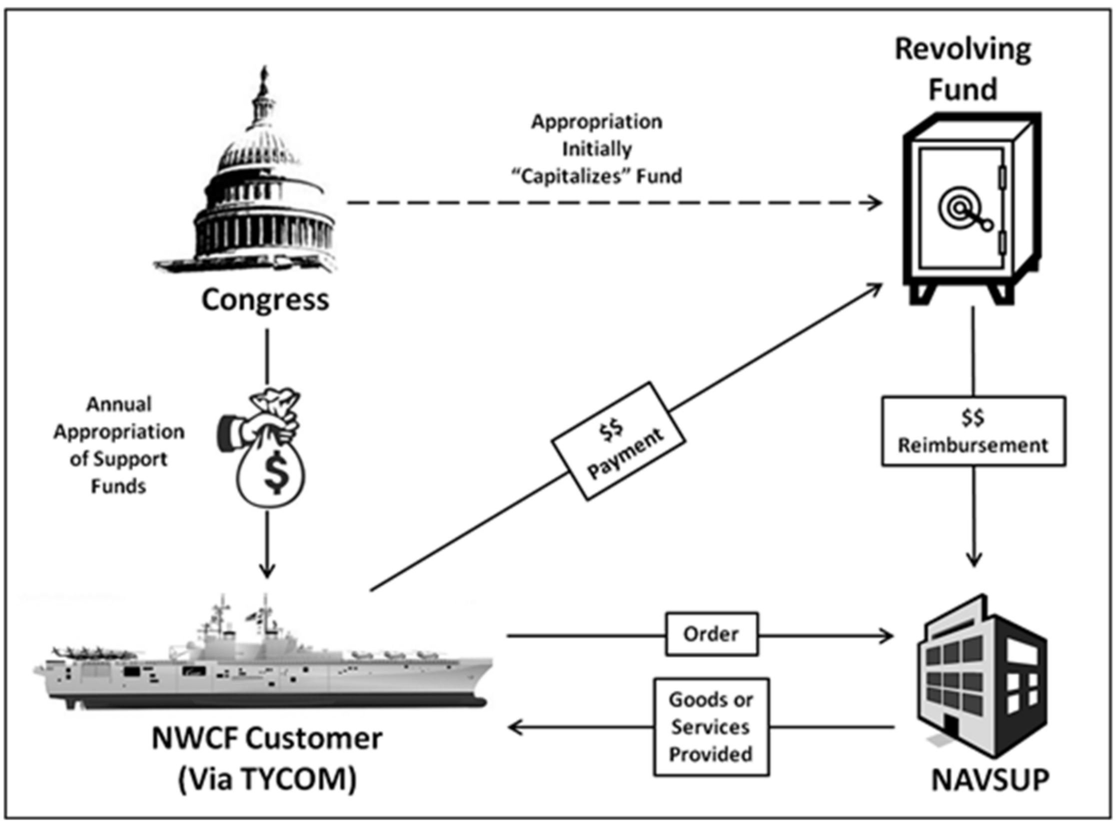

Figure 1. Process Diagram: Defense Working Capital Funds

(DAU, 2011)

NWCF assets include cash and physical assets, such as parts. CVN and LHD inventories, for example, are assets of the NWCF. In essence, each of these ships is a floating supply depot for the Navy; the majority of stock is not owned by the individual ships and is not available for a ship's use until its Operating Target (OPTAR) funds are available and obligated. Each ship maintains its own OPTAR "to obtain the material and services necessary for day-to-day operations" (Commander, Naval Supply Systems Command [NAVSUP], 1997, § 9000). The OPTAR represents the necessary fiscal year funding authority granted from the type commander (TYCOM) by way of the fleet commander, Navy comptroller, and ultimately, Congress, as a result of the annual federal budget process. The NWCF is reimbursed by the ship's OPTAR funding when the customer (i.e., shipboard supply department) requisitions the inventory item from the storeroom. At that point, the ship owns the part and may use it for the requisite repairs.

Conversely, the availability of OPTAR funding (end-use) is required upfront to replenish inventories on smaller combatants such as CGs and DDGs. Spare parts are paid for as they are ordered from the Navy supply system. Again, Figure 2 provides an abbreviated representation of the end-use process and the flow of funding and materiel. Unlike the NWCF process described in Figure 1, the ship does not pay into a revolving fund. Instead, the ship provides the payment in the form of an obligation to the Defense Finance and Accounting Service (DFAS). DFAS then plays the role of banker by matching and reconciling the customers' obligations with the providers' expenditures.

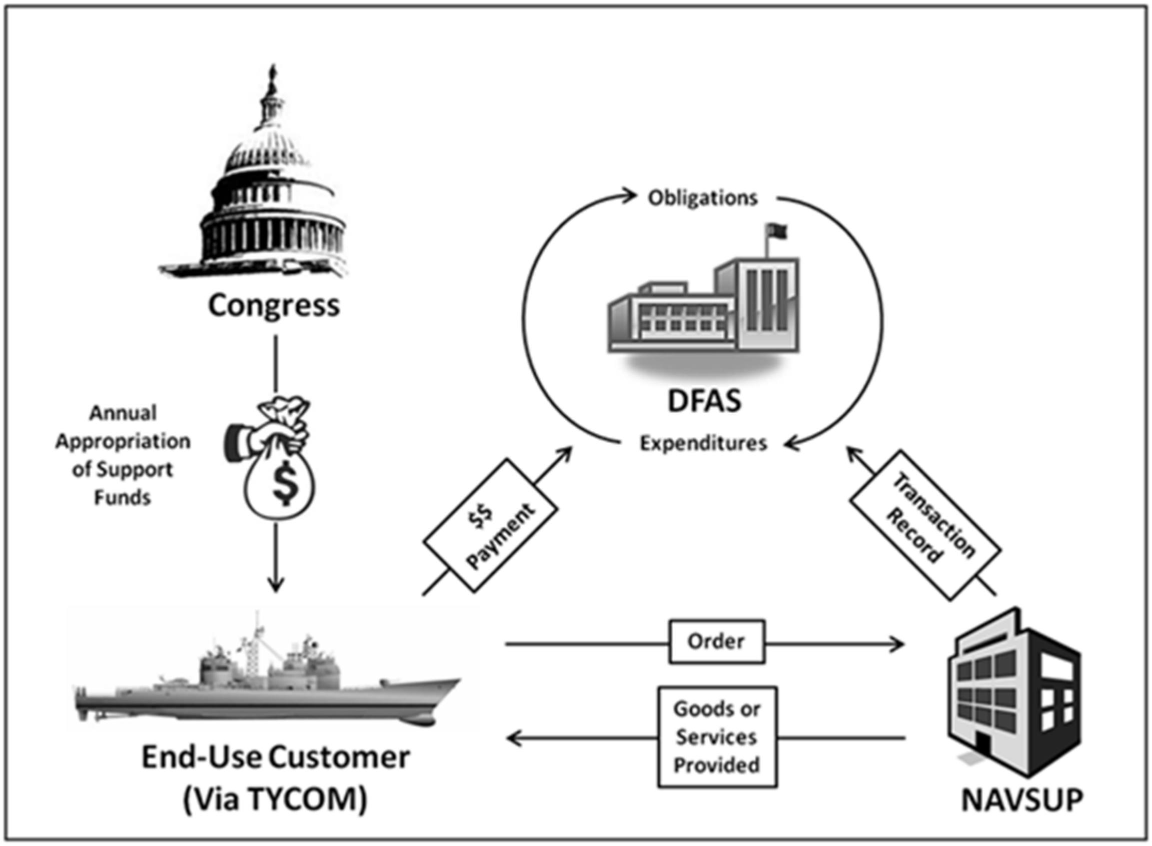

Figure 2. Process Diagram: End-Use Funds

The process begins when a ship's stock control division submits a requisition to the Fleet Logistics Center (FLC), a shore-based primary contact point for materiel support. There are FLCs in fleet concentration areas worldwide that maintain inventories of stock items. If the regional FLC is unable to fill the customer order, they refer the requisition to Naval Supply Systems Command (NAVSUP) Weapons Systems Support (WSS) in Mechanicsburg, PA. Here, personnel called item managers, who are assigned to particular stock items, identify a location where the part is available and refer the requisition to be filled (NAVSUP, 1997, § 1072). Once the part arrives, it is received into the ship's inventory for future use. The ship owns the part, and it is considered an asset of the ship's TYCOM.

Therefore, NWCF inventories are often perceived to provide an advantage to the end-user by allowing immediate stock replenishment for the storeroom regardless of available OPTAR funding from the TYCOM.

3. Supply Readiness

Spare parts inventories on Navy ships vary with respect to the size of the ship and the number and type of weapons systems maintained onboard. For example, a CG may have approximately 12,000 inventory line items, while an LHD may have approximately 25,000 inventory line items. The Navy uses a measurement, called supply effectiveness, to evaluate the supply department's ability to satisfy materiel requests from its onboard stock. As such, supply effectiveness is an indicator of supply department readiness and a critical input into the ship's overall readiness. Regardless of whether the stock is funded through the NWCF or end-use funding method, the measurement requirement is the same. Therefore, we use supply effectiveness to show whether there is a readiness advantage gained by the use of one funding method over the other.

C. PURPOSE

In August 2008, Commander, Naval Surface Force, U.S. Atlantic Fleet (CNSF–East), launched an inventory pilot project on a Norfolk-based guided missile cruiser, USS *Normandy* (CG 60), to test the feasibility of NWCF inventory on small combatants. CNSF–East is the TYCOM for all naval surface ships based on the East Coast. In partnership with Commander, Naval Surface Force, U.S. Pacific Fleet (CNSF–West), the TYCOM controls and provides resources to ships during the training cycles prior to deployment (U.S. Navy, 2009). The pilot project transitioned the funding method of *Normandy's* repair parts inventory from end-use ownership to NWCF. That is, NAVSUP assumed ownership of *Normandy's* inventory from CNSF–East. To illustrate this concept, consider an auto parts supplier that provides Acme Auto Repair Shop with spare parts the supplier knows Acme will most likely use for its business. Acme pays for the parts as they are used for auto repairs, while the supplier retains ownership of the stock. In this case, *Normandy* is Acme, and the supplier is NAVSUP.

In late 2012, NAVSUP requested that supply readiness and financial data from *Normandy's* pilot project be evaluated. The results of the project would be used as a factor in determining the inventory sourcing method for the new *Zumwalt*-class destroyers (DDG 1000). We surmised that the results could also be used to determine a future course of action for existing classes of ships that utilize the end-use inventory funding method.

The purpose of this research is to analyze the supply effectiveness and OPTAR data of *Normandy* and compare the data to a sample of ships to address the following research questions:

- Does a readiness or financial benefit exist when using an NWCF inventory method instead of an end-use inventory method? How does it affect the Navy, TYCOM, and individual unit?
- Should current end-use inventory platforms change to the NWCF inventory method?
- Is the NWCF inventory method a better option to use on future platforms that would traditionally fit the end-use funding method?

D. SCOPE, LIMITATIONS, AND ASSUMPTIONS

The scope of this project is limited to the evaluation of supply effectiveness and OPTAR data provided by CNSF for *Normandy*, CGs, and LHDs with the following parameters:

- Supply effectiveness measurements of Normandy both before and after the NWCF pilot project.
- Supply effectiveness measurements of all CGs and East Coast LHDs.
- OPTAR obligations of all CGs and all LHDs during the NWCF period. Financial obligations prior to 2008 were not available.

This project does not evaluate *Normandy* or the other ships used in the research for total materiel readiness, which would include data on shipboard maintenance and weapons system status, both of which are classified. It does not measure the quality of the inventory (i.e., spares that could be carried in the inventory based on recorded demand but are not). We present the supply effectiveness data reported by the ships to the TYCOM as an accurate reflection of their supply readiness for the reporting period. However, we accept that these numbers are vulnerable to manipulation by shipboard personnel in an effort to report higher effectiveness numbers, though we acknowledge this practice is the exception, not the rule. Last, we use repairable OPTAR obligations in lieu of total OPTAR obligations that contain operating expenses and purchases that do not apply to this research.

E. ORGANIZATION

In this chapter, we provided an overview of NWCF and end-use inventory funding methods, as well as introduced the *Normandy* pilot project as the genesis of our research.

Chapter II examines prior research of the NWCF versus end-use question. It provides a literary foundation for commercial inventory practices and measurement techniques that parallel the Navy's. Chapter III defines the data sources and measurements used in the analysis. The methodology of the research, which focuses on inventory effectiveness and financial measurement, is detailed in Chapter IV. Additionally, that chapter describes the hypothesis tests used in the data analysis chapter and discusses our assumptions. Chapter V analyzes the CNSF data for *Normandy*, along with the research population of ships, and illustrates the results. The final chapter comprises the findings, conclusions, and recommendations of the research.

II. LITERATURE REVIEW

For this research, we used a broad range of resources to bring the reader into the conversation of inventory funding methods. In the following sections, we provide an overview of the resources that provided insight on working capital and direct appropriation methods and inventory performance measures, as well as the existing comparative analysis of these two funding methods. We close this section by highlighting the data and supplemental documents we received for *Normandy's* pilot project.

A. REVOLVING FUNDS

There is extensive reference material available on the topic of revolving funds. *Merriam-Webster* defines revolving funds as those "set up for specified purposes with the proviso that repayments to the fund may be used again for these purposes" ("Revolving Fund," n.d.). These funds are commonly used for environmental initiatives, prescription drug funds, historical or preservation societies, and government agencies.

Our first resource provided a recent and succinct overview of revolving funds and their characteristics, one of the most significant being that "all income is derived from the activity's operations and is available to finance continuing operations without a fiscal year limitation" (Jones, Candreva, & DeVore, 2012, p. 265). This concept is integral as we discuss the advantages and disadvantages of the funding methods. A working capital fund model discourages the acquire-and-spend ("use it or lose it") mentality that is encouraged in an end-use model (Jones et al., 2012). The resource also addressed the customer–provider relationship, a theme consistently reiterated throughout the research literature and relevant to this research topic.

In 1991, the Department of Defense (DoD) combined all of its stock and industrial funds into one fund called the Defense Business Operating Fund (DBOF), the precursor to today's working capital funds. Patricia E. Byrnes (1993) discussed the origination, purpose, and evolution of those working capital funds, of which the DBOF was an integral part. In one section, she described the types of funding used to finance repairable parts inventory before and after revolving funds. Before revolving funds, repairable parts were purchased with supplier appropriation funding, wherein after revolving funds, customer operation and maintenance money was used (Byrnes, 1993). She also described the differences that exist in managing these funds and the supplier–customer relationships that result, presenting the parallel of the DBOF to the commercial sector:

> DBOF is intended to improve the operation of stock-funded, industrial funded, and some support activities through improved customer–supplier relationships. On the customer (buyer) side the focus of DBOF is to ensure that the customer drives the requirements. This is accomplished by shifting all funding to the customer. In addition, pricing will be established based on the cost of delivery of the service. … On the provider (seller) side the goals of DBOF are to ensure that prices reflect performance and are stable (e.g., unit cost pricing), funding is based on customer demand, and that costs are managed through established performance objectives. (Byrnes, 1993, p. 10)

Practical Financial Management: A Handbook for the Defense Department Financial Manager (Potvin, 2012) described both the federal and DoD budget process, resource allocation of funds, funding mechanisms such as reimbursable and revolving funds, and the flow of appropriations to the end-user. Here, the source of what this research refers to as end-use funding was explained in detail, from the originating bill in Congress to the Navy's operations and maintenance (O&MN) funding that is allocated to a ship's commanding officer and managed by the shipboard supply officer. The author, like Byrnes, reminded us of one of the primary principles of the working capital fund: the customer–provider relationship—in this case as it relates to budget formulation. "Customers discuss their projected workload with providers, and the providers project estimated rates based on the projected workload" (Potvin, 2012, p. 122). The operating portion of the working capital budget consists of direct, indirect, and administrative costs, while the capital portion of the budget provides for capital investments and improvements of $250,000 or greater and a useful life of two years or greater. While the financial composition of the NWCF is not a primary focus point in our research, this concept is discussed as a cost consideration of capitalizing the spare parts inventory on existing and future naval vessels.

B. INVENTORY MANAGEMENT & PERFORMANCE MEASUREMENT

This research examines the correlation between inventory management and performance measurement on Navy ships. Previous research on inventory management for the DoD and the DoN has been limited and mainly focused on the size and efficiency of service-wide or fleet inventory levels and their associated performance measurements. Conversely, a great deal of research has been performed in the area of commercial inventory models and sustainment practices. There are multiple supply chain and inventory management textbooks, websites, and research papers that discuss the basic principles of inventory. This research narrows the conversation down to the concept of wholesale and retail inventory management, wherein the following publications were used to provide a foundation and guide the conversation of funding shipboard inventories.

The primary references for wholesale and retail inventory definitions and shipboard inventory effectiveness measurements are the *DoD Supply Chain Materiel Management Regulation* (Department of Defense [DoD], 2003) and the DoN's *Retail Supply Support of Naval Activities and Operating Forces* (CNO, 2012). These publications lay the foundation for NAVSUP and TYCOM inventory and funding guidance used by shipboard supply departments. Detailed descriptions of these publications are provided in Appendix B. These references are the roadmap to defining the fleet's inventory management procedures, measurement, and performance goals. Like travelers embarking on a quest, we began our evaluation of shipboard inventory management by studying this map.

The General Accounting Office (GAO) report *Defense Inventory: Opportunities Exist to Improve Spare Parts Support aboard Deployed Navy Ships* (2003) provided a comprehensive review of supply effectiveness for six battle groups deployed to the Atlantic and Pacific in 1999 and 2000. It examined "(1) the extent to which the Navy is meeting its spare parts supply goals, (2) the reasons for any unmet supply goals, and (3) the effects of spare parts supply problems on ship operations, mission readiness, and costs" (GAO, 2003, p. 1). The makeup of the carrier battle group in 1999 and 2000 was typically one aircraft carrier, one auxiliary supply ship, two cruisers, two destroyers, and one frigate. The aircraft carrier and the auxiliary ship inventories were NWCF; the remainder of the ships retained an end-use funded inventory. The data for total supply effectiveness, which they measured as the percentage of requisitions filled from onboard inventories, ranged from 51 to 61% for the different battle groups. This amounted to an average of 54% for all six groups, falling below the Navy's goal of 65% (GAO, 2003). The report also analyzed data for Pacific Fleet amphibious readiness groups, whose composition included an LHD with an NWCF inventory and smaller support ships with end-use inventories. The average supply effectiveness rate of these ships was also 54 % for the same time period (GAO, 2003). Though the data for this report were collected in 1999 and 2000, the following excerpt reveals that this issue has a long history:

> These supply rates for the deployed battle groups are consistent with fleetwide historical data available from Navy reports. These data show that from 1982 to 2000 Navy ships in both deployed and nondeployed status, were, on average, able to fill 55 percent of their parts requisitions from onboard inventories. These rates have not varied much over the past 20 years, indicating that little overall progress has been made in meeting the Navy's 65 percent goal. (GAO, 2003, p. 7)

Although this report did not correlate the funding method of the inventory to the effectiveness measurement, it establishes a significant baseline for supply effectiveness rates onboard a variety of surface ships that utilize both types of funding. The study cited inaccurate ship configuration records and incomplete, erroneous, or outdated historical demand data as key contributors to the low effectiveness rates. To date, this is the most comprehensive published study measuring spare parts support and availability on multiple classes of surface ships.

Thorne examined the impact of performance measures and material availability (1999). He found that high inventory levels were the result of outdated performance measures and they created an incentive for users to overstate readiness measurements for their superiors. This may lead to inventory levels that are not reflective of the ship's actual requirements but rather a stockpiling of some material and a deficiency in others. Likewise, this project discusses the concept of inventory levels in relation to supply effectiveness measurements and seeks to answer the question, "Do different types of inventory buy a higher level of performance?"

Another aspect of inventory management is the relationship between its associated performance measurements (supply effectiveness) and the reporting culture and incentives placed on these measurements. The aforementioned GAO report (2003) inadvertently highlighted the shipboard supply system's vulnerability to manipulation. In a table illustrating the percentage of requisitions filled by onboard stocks for six ships in the Lincoln Battle Group, the following footnote was made for one of the CGs:

> The [CG] data overstate the number of onboard requisitions filled because the ship filed 452 individual requisitions for bulk issue items (light bulbs) that

> should have been included on a smaller number of requisitions for larger quantities, according to type command supply officials. (GAO, 2003, p. 17)

The cultural desire to reach the requisite readiness goals has made this a fairly common practice on Navy ships. CNSF's supply procedures publication also illustrates the vulnerability of the system and provides stern guidance on this type of practice:

> There are times when a CMP pulse point area will be yellow or red, even though the ship has taken all appropriate action. Further action to manipulate data (i.e., "Gaming") to make a CMP pulse point green will not be tolerated and may negatively impact the ship's departmental award (i.e., Blue E) and/or SMC grade. For example … issuing light bulbs one at a time to improve effectiveness numbers [is an example] of gaming. (Commander, Naval Surface Force [CNSF], 2008, § 17501.h)

In his thesis, Thorne (1999) also spoke to culture and the pressure on commands to ensure the highest level of weapons systems readiness. He examined the impact of performance measures and material availability. He found that high inventory levels were the result of outdated performance measures, which in turn created an incentive for users to overstate readiness measurements for their superiors. This may lead to inventory levels that are not reflective of the ship's actual requirements but rather a stockpiling of certain material. Likewise, this project discussed the concept of inventory in relation to supply effectiveness measurements.

C. COMPARATIVE WORK

There are no current academic or professional publications analyzing the specific issue of inventory funding methods on Navy ships. The most recent research addresses the industrial fund component of the NWCF, as opposed to the stock fund, and compares and contrasts the use of NWCF versus end-use funding to operate naval shipyards. The two applicable works we reviewed were an MBA thesis from the Naval Postgraduate School written in 2006 and a Congressional Budget Office (CBO) report published in 2007.

The thesis *Comparison of the Navy Working Capital Fund and Mission Funding as Applied to Navy Shipyards* (Cain, 2006) evaluated the Navy's decision to transition the four naval shipyards from NWCF to end-use funding (referred to as *mission funding* in the author's research). The thesis analyzed the "advantages and disadvantages each financial system provides shipyards, the operating differences that occur due to the funding change, and the future financial consequences of funding Navy shipyards using direct appropriations" (Cain, 2006, p. V). The factors used to evaluate the strengths and weaknesses of the funding method were cost visibility and flexibility—both operational and financial. Similarly, our research looks at inventory funding from the flexibility viewpoint. We do not address cost visibility since it was not of concern in addressing the question of whether one inventory method provides a higher level of supply readiness. However, flexibility provided by one inventory method over another was a key concept to answering this question.

Cain determined that in the area of operational and financial flexibility, there was no overwhelming advantage or disadvantage provided by the mission-funded model versus the NWCF model, therefore making it a draw. He determined that in the area of operational flexibility, "mission funded shipyards have more financial flexibility when schedule changes and emergent operations occur" (Cain, 2006, p. 55). He conversely argued that overall, "NWCF shipyards, in and of themselves, maintain significant financial freedom compared to MF [mission funded]. They are bound by none of the fiscal year requirements MF organizations must adhere to, and face no spending uncertainty during appropriations delays" (Cain, 2006, p. 56). While it would seem by this statement that NWCF won the point, the author minimized this advantage in his conclusion. The overall analysis provides that there are several variables, aside from funding, that determine the effectiveness of operations at naval shipyards. This statement can also be made of the funding method of shipboard inventories, wherein our research also highlights the additional variables that make an impact on supply readiness. The author's final recommendation found mission funding to be overall more advantageous with few drawbacks and supported the continued use of mission funding at Pearl Harbor and Puget Sound naval shipyards, as well as the planned conversion of Norfolk and Portsmouth naval shipyards.

The CBO paper *Comparing Working-Capital Funding and Mission Funding for Naval Shipyards* (2007) took a deeper look at the problem, utilizing additional metrics from Cain's (2006) analysis to determine a difference in capital expenditures and operational performance (CBO, 2007). With regard to operational flexibility, both authors concurred that mission funding (end-use) provided an overall advantage in workforce and workload, because the Navy has more control in a mission-funded environment to align the shipyard's workload to its own requirements (CBO, 2007). As a result of the conversion from NWCF to mission funding, the shipyard fell under the authority of the yard's primary customer (the fleet), rather than the organization that had technical cognizance over the repairs and modernization. The comparison we can draw from this funding method used on Navy ships is the following: the end-use funded ship "owns" the onboard spares inventory, which ultimately belongs to the TYCOM, who provides the OPTAR. Because the NWCF inventory is owned by NAVSUP while it is in the storeroom, permission is required to transfer the asset to a non-NWCF command. Therefore, the end-use funded ship has more control over its onboard inventory.

Another area both the CBO paper and our research explored was operational performance measures. CBO chose a set of existing measurements that they believed would provide an objective comparison of the shipyard's performance both before and after the transition from NWCF to mission (end-use) funding. These measurements were schedule adherence, total annual costs, cost per ship availability, burdened labor rate, and administrative efficiency. These metrics were inconclusive in providing a link between a shipyard's funding mechanism and its operational performance (CBO, 2007). Our research uses gross and net supply effectiveness, deficiency to requisitioning objective, and repairable financial expenditure metrics to compare the two funding methods. In the end, the CBO report was not able to make a succinct determination of which of the two funding methods was superior. They highlighted strengths and weaknesses of both, but did not support or challenge the Navy's decision to convert the four naval shipyards from NWCF to mission funding.

D. USS *NORMANDY* PILOT PROJECT

In addition to the supply effectiveness and financial data provided by CNSF for *Normandy's* pilot project, we also had access to CNSF point papers that outlined conversion details both before and after the pilot project. We reviewed lessons learned provided by CNSF–East and those shipboard supply officers assigned to *Normandy* before, during, and after conversion. We used these documents as supplemental information to interpret the data and develop our conclusions and recommendations for further research.

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III. DATA

A. BACKGROUND

Before describing our data sources and collection process, we first provide background on spare parts and allowances, supply effectiveness measures, and operating funds.

1. Spare Parts and Allowances

a. Repairables

Repair parts are those components that due to their complexity, cost, or scarcity must be returned to the depot for repair once the part fails; therefore, they are referred to as depot-level repairables (DLR). Field-level repairables (FLR) are a lesser variant of the DLR. It is economically more feasible for the Navy to repair these assets rather than pay the full replacement cost. The DLR program is funded through the NWCF as a stock fund activity. Unlike the NWCF's industrial fund that requires the customer to obligate funding before the activity can incur expenses, the stock fund permits the Defense Logistics Agency (DLA) and NAVSUP WSS to "incur obligations in anticipation of customer demand based on engineering, life cycle management, and fleet usage" (Jones et al., 2012, p. 268), and sell the DLRs "at the cost of goods plus a surcharge to cover their operating expenses" (Jones et al., 2012, p. 268).

b. Consumables

Consumables, on the other hand, require no turn-in. They are intended as single-use assets, although they can vary widely in cost. The Navy's policy is to stock only those consumables in support of the net selected item management (SIM)/demand-based item (DBI) program or where supply department storage space allows for any consumable that does not qualify for SIM/DBI (NAVSUP, 1997, § 6170). Certain consumables are also included in the ship's allowance lists if they are critical components to engineering or weapons systems. Otherwise, consumables are intended to be ordered as direct turnover (DTO) items (i.e., ordered as necessary by the requesting division and delivered via the supply department upon receipt).

c. Allowance Lists

Allowance lists identify each ship's mix of repairables, consumables, and special tools necessary for normal sustained operations with their assigned onboard quantities. Allowance lists can be either unique to a specific ship or common to the class of ship and serve as the baseline allowance. For example, a ship's allowances are tailored to its particular weapons and engineering systems as each ship receives update packages or undergoes overhaul. Each ship's allowances are collected and documented in a unified Coordinated Shipboard Allowance List (COSAL). The COSAL serves a dual role as both a supply document and a technical document. As a supply document, the COSAL contains all the qualitative and quantitative information used to build the ship's allowances to ensure the ship can achieve self-supported operations for an established period of time—set as 75 days for all surface ships (NAVSUP, 1997, § 6003). As a technical document, the COSAL establishes the ship's operating characteristics and provides a means to research technical manuals and equipment, component, and part breakdowns (NAVSUP, 1997, § 2090).

The COSAL categorizes the allowances as either Allowance Parts Lists (APLs) or Allowance Equipage Lists (AELs). APLs are specific to the individual equipment and associated onboard components (i.e., the package of necessary repair parts for each unique weapons system). AELs, on the other hand, are common to multiple systems; they include the special tools, consumables, and occasional repair parts necessary to maintain and operate a variety of mechanical, electrical, electronic, and ordnance systems (NAVSUP, 1997, § 2093).

2. Supply Effectiveness

The Navy uses supply effectiveness to evaluate the supply department's ability to satisfy materiel requests from its onboard stock. As such, supply effectiveness is an indicator of supply department readiness and a critical input into the ship's overall readiness. Supply effectiveness is subdivided into four measurements: gross effectiveness, net effectiveness, SIM/DBI effectiveness, and the not carried rate.

a. Gross Effectiveness

Gross effectiveness measures the ship's ability to satisfy organic demand for all parts and is calculated as

$$\text{(\# of ship's requirements satisfied from storeroom stock)} \div \text{(\# total demand)} \quad (1)$$

Gross effectiveness is the primary indicator of a ship's allowance range; higher gross effectiveness is preferred. Low gross effectiveness is often the consequence of incomplete or inaccurate allowance lists, resulting in a lack of support for installed equipment or weapons systems (NAVSUP, 1997, § 6860). The goal for gross effectiveness varies by ship type and TYCOM, but Naval Publication 485 (P-485; NAVSUP, 1997) establishes a benchmark of no less than 65%.

b. Net Effectiveness

Net effectiveness is a measure of the ship's ability to satisfy organic demand from its allowance and is calculated as

$$\text{(\# of ship's requirements satisfied from storeroom stock)} \div \text{(\# demands with an allowance)} \quad (2)$$

Net effectiveness is the primary indicator of a ship's allowance depth and reflects the supply department's ability to quickly replenish its stock; higher net effectiveness is preferred. Low net effectiveness is often the consequence of infrequent or inadequate stock replenishments (NAVSUP, 1997, § 6860). The goal for net effectiveness varies by ship type and TYCOM, but the P-485 (NAVSUP, 1997) establishes a benchmark of no less than 85%.

The time frame for gross and net effectiveness can vary, but they are commonly used as monthly metrics. Figure 3 illustrates the calculations for gross and net effectiveness. Each numbered shape on the bottom row (below the horizontal dotted line) represents a single demand for a part—the requisition. Out of 12 total demands, six were storeroom allowance items captured in the ship's COSAL, and five were satisfied from storeroom stock. Thus, gross effectiveness was 41.6% (5 issues ÷ 12 total demands), and net effectiveness was 83.3% (5 issues ÷ 6 storeroom allowance items).

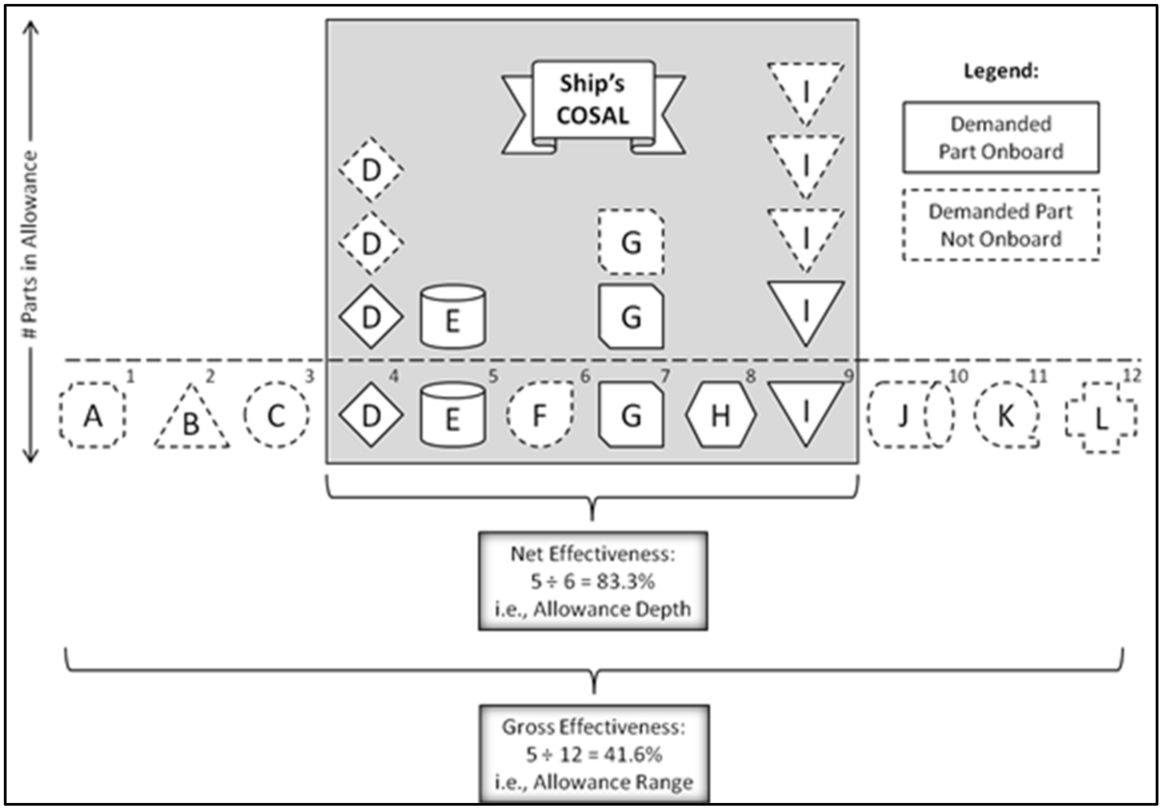

Figure 3. Gross and Net Effectiveness Calculations

The two remaining supply effectiveness measures are SIM/DBI effectiveness and the not carried rate. The SIM/DBI concept identifies the concentration of high-demand items from a relatively small proportion of inventory, with the intent to ensure greater replenishment visibility, more frequent inventory, and higher supply readiness (NAVSUP, 1997, § 6236). The SIM/DBI process allows the ship's supply department to increase or decrease its allowances based on real-time demand. However, repair parts are assigned a set allowance that cannot be altered without formal approval from higher echelons (i.e., the TYCOM and NAVSUP WSS). As such, the SIM/DBI program is not applicable to repair parts, and net SIM/DBI effectiveness was not evaluated for this research project.

The not carried rate measures the percentage of total demand for which there is no allowance. The not carried rate indicates the ability and effectiveness of shipboard allowances to support installed equipment and weapons systems (NAVSUP, 1997, § 6236). This measure evaluates the appropriateness of a ship's COSAL with no regard for whether the ship is NWCF or end-use. Therefore, we did not evaluate the not carried rate for this research project.

3. Operating Funds

a. OPTAR

Of the various types of OPTARs, the only OPTAR fund category (OFC) germane to this research project is OFC-20, supplies and equipage (S&E). OFC-20 is comprised of two subcategories: Equipment Maintenance Related Material (EMRM) and Other. A ship's OPTAR is funded from the same appropriation that funds fuel, port visit costs, pier services, and some TYCOM overhead expenses; only the portion controlled by the ship to buy parts is relevant to this study. EMRM includes all repair parts and those repair-related consumables necessary for corrective and preventive organizational-level maintenance. As such, all EMRM DTO requirements or issues from stock must refer to an associated APL or AEL. EMRM is also used to replenish repair parts to their allowance level on end-use funded ships. OFC-20 Other is used for all remaining obligations that do not qualify for EMRM; they do not have an associated APL or AEL. Common applications of Other are medical or dental supplies and services, damage control, lifesaving and personnel safety, force protection, general purpose consumables, and habitability.

b. NWCF

The Navy provides NWCF ships with five unique budget project (BP) accounts and associated OPTAR grants in order to conduct reorders and replenish NWCF stock to their allowance levels. Because these BPs are NWCF stock funds, any charges incurred to replenish stock allowances are offset by the revenue gained by selling the parts, in that "the NWCF is reimbursed when material is issued" (NAVSUP, 1997, § 9400). The five BPs are as follows:

- BP 14: surface consumables
- BP 28: DLA-furnished consumables
- BP 34: aviation consumables
- BP 81: surface DLRs
- BP 85: aviation DLRs

The gross and net effectiveness diagram in Figure 3 reinforces an important distinction between end-use and NWCF ships. The end-use funded ship spends its EMRM funding not only to fill its inventory allowances (the shaded area representing the COSAL) but also to purchase those assets that are not carried or not in stock (the dotted shapes in the requisition line). The NWCF ship, on the other hand, spends its EMRM funding only when the assets are demanded (i.e., those requisitions below the horizontal dotted line). The revolving BP accounts are used in lieu of EMRM funds to fill the NWCF ship's inventory allowances within the COSAL.

B. DATA SOURCES

1. Continuous Monitoring Program

To facilitate internal and external monitoring of supply effectiveness, CNSF implemented the Continuous Monitoring Program (CMP) onboard all surface ships in 2003. The CMP allows the supply department to extract the most critical supply department pulse points from a variety of databases and disseminate them to the TYCOMs. Likewise, the CMP is a valuable tool that allows the supply department to monitor "their day-to-day operations and take action to investigate and correct business processes that effect [*sic*] CMP pulse point areas" (CNSF, 2008, § 17501). Pulse points are color coded for at-a-glance assessment using a stoplight scale based on acceptable metrics values. The CMP extracts and collects data for four distinct supply department functions: S1 Stock Control (extractor program), S2 Food Service (extractor program), S3 Retail Operations (built-in extractor), and S4 Disbursing (manual website entry). Data frequency for S1, S2, and S3 are monthly, while S4 requires weekly and monthly inputs into the CMP database.

For the purposes of this project, we focused on S1 Stock Control, which includes gross effectiveness, net effectiveness, reorder review dollar values, and reorder review counts. Under end-use funding, the ship reorders repair parts to replenish its allowances. The reorder review represents those EMRM allowance deficiencies that must be replenished using the ship's OPTAR.

2. NWCF Reports

The TYCOM maintains two reports specific to NWCF ships that collect S1 Stock Control data comparable to the end-use ships' CMP reports.

The first report is the NWCF COSAL Effectiveness Metrics report, providing a monthly snapshot of gross effectiveness and net effectiveness for NWCF ships. The second is the Deficiency To Requisitioning Objective (DEF-To-RO) report. The calculation of reorder values differs between NWCF and end-use funded ships. The DEF-To-RO report provides a breakdown of all allowance deficiencies by BP (14, 28, 34, 81, and 85) and Allowance Type (AT) code (1, 2, 3, 4, 5, and 6). For the purposes of this project, we focused on the following BP/AT combinations:

- BP 28/AT 1: DLA-furnished consumables listed as COSAL items
- BP 81/AT 1: surface DLRs listed as COSAL items
- BP 81/AT 4: non-COSAL surface DLRs stocked based on demand

These three DEF-To-RO data combinations equate to the reorder review counts and values contained in a CMP report, thereby allowing us to compare NWCF to end-use.

In lieu of the end-use ship's CMP, the NWCF ship uses the Material Financial Control System (MFCS) to calculate and report supply effectiveness metrics. MFCS is a comprehensive financial system that integrates NWCF accounting functions with asset visibility and transaction reporting (Commander, Naval Air Force [CNAF], 2006, § 1003). The MFCS can be accessed both at sea and ashore to allow the ship and TYCOM to interface with WSS.

3. Budget Reports

All afloat supply departments capture and report OPTAR status using two recurring reports: the OPTAR Document Transmittal (TL) Report and Budget OPTAR Report (BOR). The TL provides an itemized listing of obligations, obligation adjustments, and cancellations for a designated reporting period. The frequency of TL submissions can vary based on the fleet commander or the TYCOM but is at minimum a weekly requirement across all commands. The BOR then provides a monthly summary of that period's TLs with year-to-date OPTAR grants and remaining balances. TLs and BORs are submitted to DFAS and the appropriate TYCOM. The weekly CMP inputs capture data from the TLs, and the monthly CMP input captures data from the BOR.

4. Relational Supply

The Navy's hardware and software system used to facilitate inventory and financial transactions onboard ships is called Relational Supply (R-Supply). Unit-Level R-Supply is used for all end-use inventory ships and Force Level R-Supply is used for all NWCF inventory ships. The aforementioned CMP, NWCF, and budget reports are extracted from R-Supply.

5. 3-M Data

All ships use the Navy's Maintenance and Material Management (3-M) system to plan, manage, execute, and track maintenance in an efficient and standardized manner (CNO, 2007). The 3-M system captures all preventive and corrective maintenance. In doing so, 3-M also captures those EMRM requirements necessary to perform maintenance, to include all repair parts and repair-related consumables.

C. DATA COLLECTION

We collected the following data over the course of this project to support our research:

- CMP data for all CGs from January 2008 to December 2012 detailing each ship's gross effectiveness, net effectiveness, reorder review count, reorder review value, and ship's status by month. The final entry for Normandy was August 2008, corresponding with the transition from end-use to NWCF.
- CMP data for all LHDs from January 2008 to December 2012 detailing each ship's status by month.
- CMP data for Normandy from May 2004 to December 2007 detailing Normandy's gross effectiveness, net effectiveness, reorder review count, reorder review value, and ship's status by month.
- COSAL effectiveness metrics for all CNSF–East NWCF ships from October 2008 to December 2012 detailing each ship's gross effectiveness and net effectiveness.
- DEF-To-RO data for all CNSF–East NWCF ships from September 2009 to December 2012 detailing each ship's DEF-To-RO for all BPs and AT codes.
- EMRM requisition listing for all CGs and LHDs from January 2008 to December 2012.
- Monthly EMRM obligation amounts for all CGs and LHDs from January 2008 to December 2012.
- 3-M system data consisting of all maintenance requisitions generated onboard CGs and LHDs from October 2007 to December 2012.

IV. METHODOLOGY

Our methodology was predicated on two comparisons: effectiveness as an indicator of supply readiness and EMRM obligations as an indicator of financial impact.

A. SUPPLY EFFECTIVENESS

1. End-Use CGs vs. *Normandy* After NWCF Conversion

We calculated average gross and net effectiveness during *Normandy's* NWCF pilot project (September 2008 to September 2012) and compared it against all other CGs from January 2008 to December 2012. We also calculated a weighted average gross and net effectiveness based on the number of EMRM requisitions per month. Finally, we compared average gross and net effectiveness using a narrower timeframe to provide a consistent range of months: June 2009 to September 2012.

2. NWCF LHDs vs. *Normandy* After NWCF Conversion

We calculated average gross and net effectiveness during *Normandy's* NWCF pilot project (September 2008 to September 2012) and compared it against all CNSF–East LHDs from October 2008 to December 2012. We also calculated a weighted average gross and net effectiveness based on the number of EMRM requisitions per month. Finally, we compared average gross and net effectiveness using a narrower timeframe to provide a consistent range of months: June 2009 to September 2012.

3. Normandy Before and After NWCF Conversion

We calculated the average gross and net effectiveness during *Normandy's* NWCF pilot project (September 2008 to September 2012) to a comparable time period prior to the conversion (May 2004 to August 2008). Due to gaps in the data, we also compared average gross and net effectiveness using a narrower timeframe consisting of 42 months each: October 2008 to September 2012 for NWCF and January 2005 to August 2008 for end-use.

B. FINANCIAL IMPACT

1. End-Use CGs vs. *Normandy* After NWCF Conversion

We calculated average EMRM obligations per month during *Normandy's* NWCF pilot project (September 2008 to December 2012) and compared it against all other CGs from

January 2008 to December 2012. We also compared average EMRM obligations per month using a narrower timeframe to provide a consistent range of months: September 2008 to December 2012.

2. NWCF LHDs vs. *Normandy* After NWCF Conversion

We calculated average EMRM obligations per month during *Normandy's* NWCF pilot project (September 2008 to December 2012) and compared it against all LHDs from January 2008 to December 2012. We also compared average EMRM obligations per month using a narrower timeframe to provide a consistent range of months: September 2008 to December 2012.

C. HYPOTHESIS TESTS

After narrowing the timeframes, we developed hypotheses to test the differences between population means. Overall, we believed that *Normandy's* supply effectiveness and EMRM obligation amounts would both improve during the NWCF pilot project. First, the onboard inventory would be more robust in that *Normandy's* reorder ability would not be hindered by competing DTO requirements or OPTAR limitations. Second, EMRM OPTAR would be necessary only to issue repair parts out of inventory, while allowance levels would be replenished from the NWCF's revolving BP accounts.

We employed the Data Analysis add-ins available in Microsoft Excel to conduct the following hypothesis tests:

- Hypothesis test 1: supply effectiveness on Normandy versus all other CGs during the NWCF pilot project; our preconceived hypothesis was that Normandy's supply effectiveness would be higher than the end-use CGs.
- Hypothesis test 2: supply effectiveness on Normandy versus all CNSF–East LHDs during the NWCF pilot project; our preconceived hypothesis was that Normandy's supply effectiveness would be comparable with the NWCF LHDs.
- Hypothesis test 3: supply effectiveness on Normandy before and after the NWCF pilot project; our preconceived hypothesis was that Normandy's supply effectiveness would be higher after the NWCF conversion.
- Hypothesis test 4: EMRM obligations on Normandy versus all other CGs during the NWCF pilot project; our preconceived hypothesis was that Normandy's EMRM obligations would be lower than the end-use CGs.

- Hypothesis test 5: EMRM obligations on Normandy versus all LHDs during the NWCF pilot project; our preconceived hypothesis was that Normandy's EMRM obligations would be lower than the NWCF LHDs. While both data populations are NWCF, the CG is the smaller ship in terms of size and displacement, resulting in fewer EMRM requirements.

D. DATA ASSUMPTIONS & AMPLIFICATION

This section provides our assumptions and other such amplifying information as they apply to the methodology and analysis.

1. General

- Higher gross and net effectiveness are direct indicators of higher supply readiness, and thus overall ship's readiness.
- Lower EMRM obligations per month demonstrate a smaller financial impact to the Navy (via the TYCOM) and a more favorable use of resources.
- The weighted average gross and net effectiveness provide a more accurate reflection of supply readiness than the un-weighted monthly averages. The weighted monthly average was calculated as

$$\sum(\text{Effectiveness \%} \times \text{\# EMRM Reqns}) \div \sum(\text{\# EMRM Reqns}) \tag{3}$$

The following scenario demonstrates the weighted average formula:

- Month A: 100% effectiveness with 10 requisitions (i.e., all requisitions satisfied from stock)
- Month B: 50% effectiveness with 40 requisitions (i.e., 20 requisitions satisfied from stock)
- Un-weighted average effectiveness: (100 + 50) ÷ 2 = 75%
- Weighted average effectiveness: (10 + 20) ÷ (10 + 40) = 60%
- The first CMP of the month represents the end-use ships' official pulse point metrics. The supply department can run an unofficial CMP extract at any time but has between the first and fifth of each month to document the results for internal reports to the commanding officer and external reports to the TYCOM.
- CMP offers six options with respect to ship's status for the supply department to choose from when running the extractor. The first three options correspond to the ship's in port maintenance periods: depot-level (D-Level), intermediate-level (I-Level), and organizational-level (O-Level). The operational impact of the maintenance periods ranges from least restrictive at the O-Level to most restrictive at the D-Level, which is often synonymous with the shipyard period. The remaining three ship's status options are local operations, deployed, and Pre/Post-Overseas Movement (POM).

- We assumed the ship's status as selected in CMP by the supply department was correct. For any blank or inconsistent entries however, we made our best judgment, using the months before and after or unofficial CMP submissions within the same month, to determine ship's status.
- Gross and net effectiveness percentages were discarded if ship's maintenance precluded the supply department from issuing parts. During such times of depot-level maintenance, most supply effectiveness percentages were unavailable; however, we discarded the remaining gross and net effectiveness data if they were reported as 0%.

2. *Normandy* Pilot Project

- The NWCF Pilot Project began in August 2008 when the ship's existing inventory was capitalized. The September 2008 reports capture the first month of the NWCF transition.
- *Normandy* entered a shipyard period subsequent to the NWCF transition, from which time no supply effectiveness data are available. The gross and net effectiveness percentages are reported again from June 2009 onward.

V. ANALYSIS

A. SUPPLY EFFECTIVENESS

1. *Normandy* Compared to Other End-Use and NWCF Ships

We compared *Normandy* to other end-use CGs and NWCF LHDs during the same time periods, examining supply effectiveness, reorder review, and EMRM obligations. Table 1 summarizes the comparison of *Normandy* to all other CGs and CNSF–East LHDs with respect to gross effectiveness and net effectiveness. We calculated effectiveness using both an average per month and a weighted average based on the number of EMRM obligations per month. All subsequent effectiveness metrics in this section assume the weighted average, in that it provides a more accurate reflection of supply readiness when comparing across ships. During this time period, *Normandy* was an end-use funded ship from January to August 2008, a small sample size of eight months compared to the 52 months as an NWCF ship.

The highest net effectiveness occurred among CGs, followed by *Normandy* second and the LHDs third. CGs also had the highest gross effectiveness, but *Normandy* was lowest behind the LHDs.

Table 1. Supply Effectiveness: All CGs & CNSF–East LHDs

	Jan 08 - Dec 12		Oct 08 - Dec 12	
	End-Use		NWCF	
	Normandy	All Other CGs	Normandy	CNSL LHDs
Sample Size, Months (n)	8	1172	42	201
Average:				
Gross Effectiveness	54.32%	53.13%	35.27%	42.46%
Net Effectiveness	88.05%	81.12%	76.38%	70.92%
Weighted Average: ∑(Effectiveness % × EMRM Reqns) ÷ ∑(EMRM Reqns)				
Gross Effectiveness	53.41%	54.05%	35.31%	40.01%
Net Effectiveness	86.62%	81.89%	75.12%	69.01%

We also examined the impact of ship's status on supply effectiveness. Table 2 summarizes our findings showing the D, I, and O-level maintenance periods aggregated as a single comprehensive maintenance period. Figures 4 and 5 graph the comparisons as alternate representations.

For end-use funded ships, there is a positive trend towards higher effectiveness as the ship transitions from the maintenance period to POM, local operations, and ultimately deployment where they achieve the highest effectiveness. The trend for NWCF ships is more erratic but again demonstrates higher effectiveness when the ship deploys.

Table 2. Supply Effectiveness & Ship's Status

	All Ships (Excluding Normandy)				Normandy			
	Net Effectiveness		Gross Effectiveness		Net Effectiveness		Gross Effectiveness	
	End-Use	NWCF	End-Use	NWCF	End-Use	NWCF	End-Use	NWCF
Maint Period	74.93%	63.71%	47.06%	39.69%				
POM	77.53%	72.13%	47.99%	37.53%				
Local Ops	79.97%	69.77%	51.60%	38.21%	86.62%	77.11%	53.41%	36.20%
Deployed	86.62%	70.73%	59.63%	45.43%		69.48%		32.77%

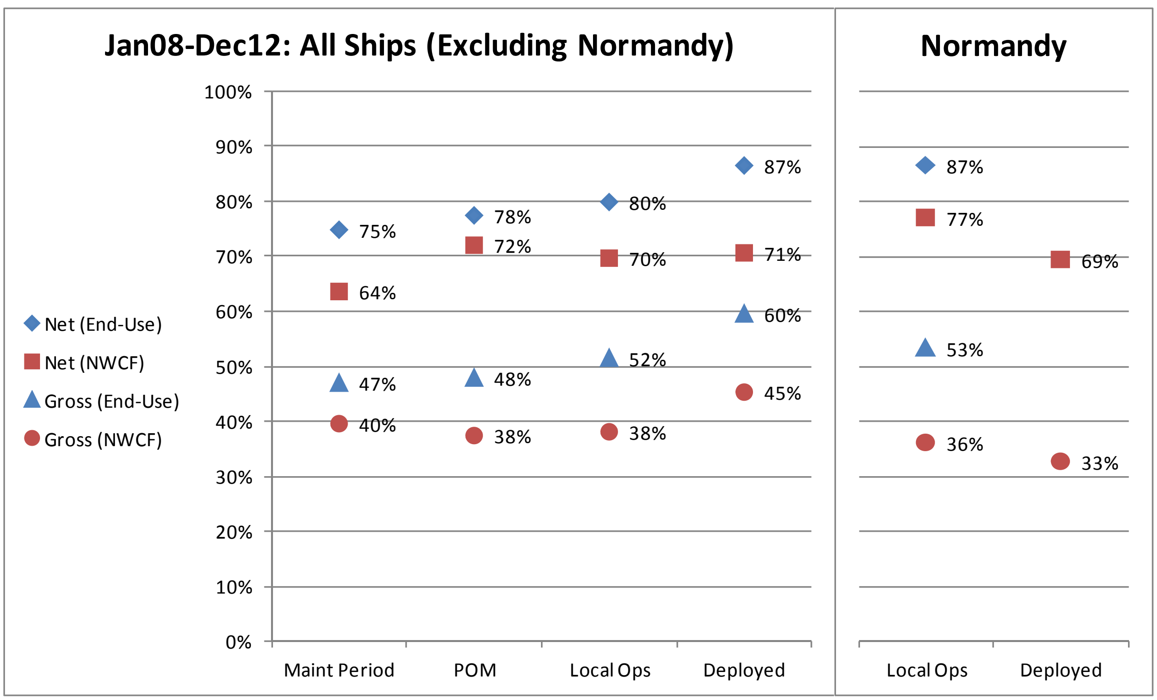

Figure 4. Supply Effectiveness & Ship's Status (A)

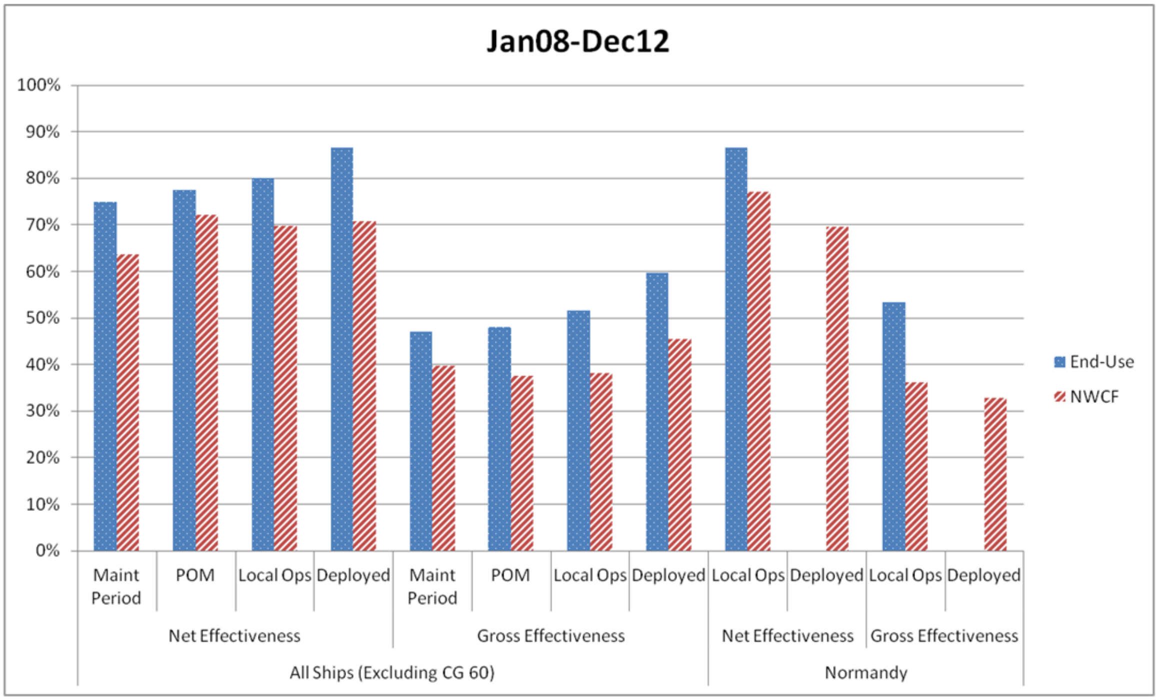

Figure 5. Supply Effectiveness & Ship's Status (B)

We compared *Normandy's* average supply effectiveness to all other CGs before and after the NWCF conversion, specifically, from January to August 2008 (before) and September 2008 to December 2012 (after). The results in Table 3 reveal that *Normandy's* net effectiveness was consistent with the larger population of CGs prior to the pilot project, with a difference of only 0.26%. *Normandy's* gross effectiveness on the other hand was 7.31% lower than all other CGs. After the NWCF conversion, *Normandy's* net effectiveness was 6.07% lower than all other CGs, and gross effectiveness was 17.69% lower. We subtracted the differences in supply effectiveness before and after the conversion to calculate a combined marginal difference. *Normandy's* net effectiveness had a 6.33% marginal decrease, and gross effectiveness had a 10.38% marginal decrease.

Table 3. Supply Effectiveness (All CGs) Before and After NWCF Pilot Project

	Before Conversion	After Conversion
Months of Data	8	52
Avg Net, Normandy	86.62%	75.12%
Avg Net, All Other CGs	86.36%	81.19%
Avg Gross, Normandy	53.41%	35.31%
Avg Gross, All Other CGs	60.72%	53.00%

Finally, we compared the average supply effectiveness by calendar year for all CGs during *Normandy's* NWCF pilot project. Figure 6 demonstrates that the *Normandy's* supply effectiveness improved significantly in 2011, the third full year of the pilot project, while all other CGs declined. In fact, *Normandy's* net effectiveness outperformed all other CGs from 2011 to 2012.

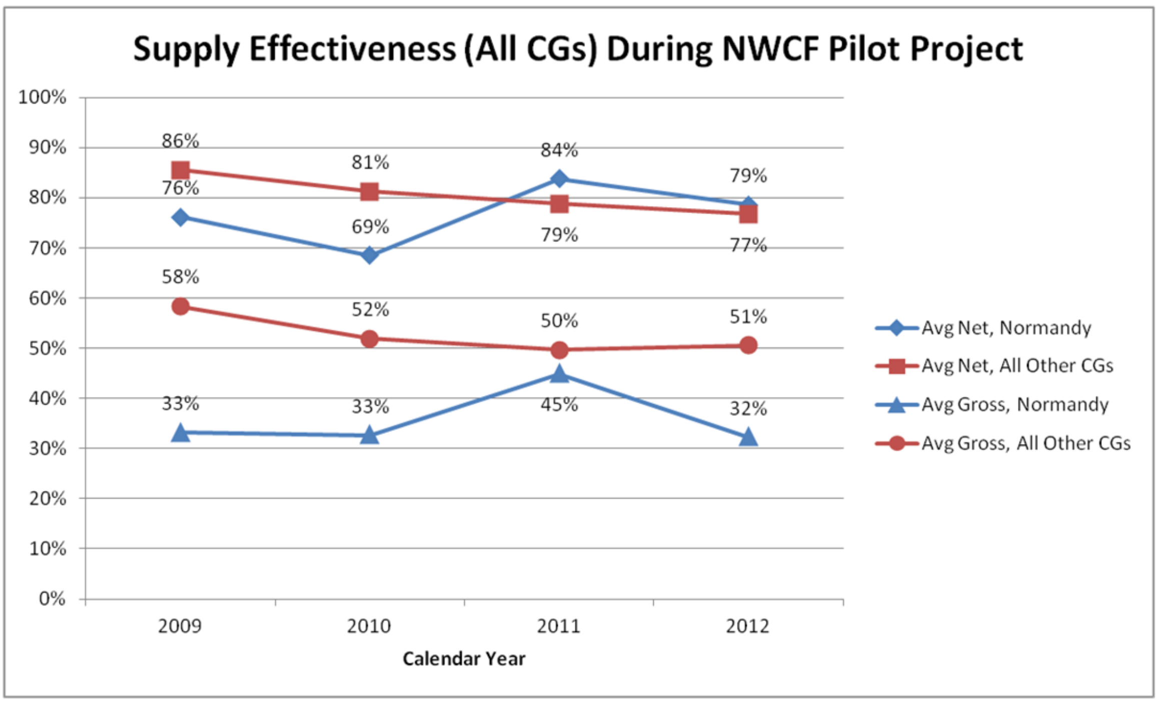

Figure 6. Supply Effectiveness (All CGs) During NWCF Pilot Project

a. Hypothesis Test 1: Normandy *vs. All Other CGs*

The first hypothesis test was between *Normandy* and all other CGs from June 2009 to September 2012. *Normandy* had 40 months of data from this time period, while all other CGs had a cumulative 774 months of data. The hypothesis test results in Figures 13 and

14 (see Appendix A) reveal that *Normandy's* gross effectiveness was different than all other CGs (two-sample *t*-test, *p* two-tail < .05); moreover, *Normandy's* gross effectiveness was actually lower (35.69%) than all other CGs (50.28%) (two-sample *t*-test, *p* one-tail < .05). However, there is not enough evidence to confirm that *Normandy's* net effectiveness (76.94%) was different than all other CGs (78.75%) (two-sample *t*-test, *p* two-tail > .05). Both results are inconsistent with our preconceived hypothesis that *Normandy's* supply effectiveness under NWCF would be higher than the end-use CGs.

b. Hypothesis Test 2: **Normandy** *vs. All CNSF–East LHDs*

The second hypothesis test was between *Normandy* and all CNSF–East LHDs from June 2009 to September 2012. *Normandy* had 40 months of data from this time period, while all CNSF–East LHDs had a cumulative 157 months of data. The hypothesis test results in Figures 15 and 16 (see Appendix A) reveal that *Normandy's* gross effectiveness and net effectiveness were different than all CNSF–East LHDs (two-sample *t*-test, *p* two-tail < .05). Indeed, *Normandy's* net effectiveness was greater (76.94%) than all CNSF–East LHDs (70.92%) (two-sample *t*-test, *p* one-tail < .05), while gross effectiveness was lower (35.69%) than all CNSF–East LHDs (40.62%) (two-sample *t*-test, *p* one-tail < .05). Both results are inconsistent with our preconceived hypothesis that *Normandy's* supply effectiveness under NWCF would be comparable with the NWCF LHDs.

2. *Normandy* Before and After NWCF Conversion

We compared *Normandy* both before and after the NWCF pilot project to evaluate the impact on supply effectiveness. We selected May 2004 as the start date to provide an equal number of months (52) both before and after the NWCF conversion; however, effectiveness percentages were not available for all months. This was particularly true during *Normandy's* shipyard period immediately after the NWCF conversion.

From May 2004 to December 2012, *Normandy's* average supply effectiveness was higher as an end-use ship prior to the NWCF pilot project, as summarized in Figure 7.

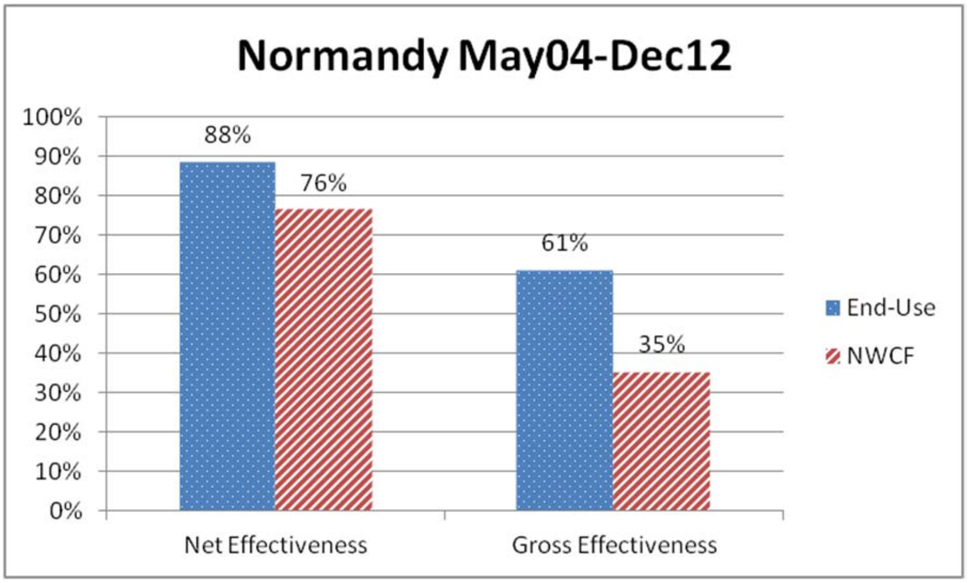

Figure 7. *Normandy* Supply Effectiveness (May 2004 to December 2012)

We also examined the impact of ship's status on *Normandy's* supply effectiveness before and after the NWCF conversion, as summarized in Figure 8. As an end-use ship, *Normandy's* supply effectiveness improved when the ship deployed. During the NWCF pilot project, however, gross effectiveness remained constant during deployment while net effectiveness declined. The weighted averages discussed earlier revealed that gross and net effectiveness both declined during deployment.

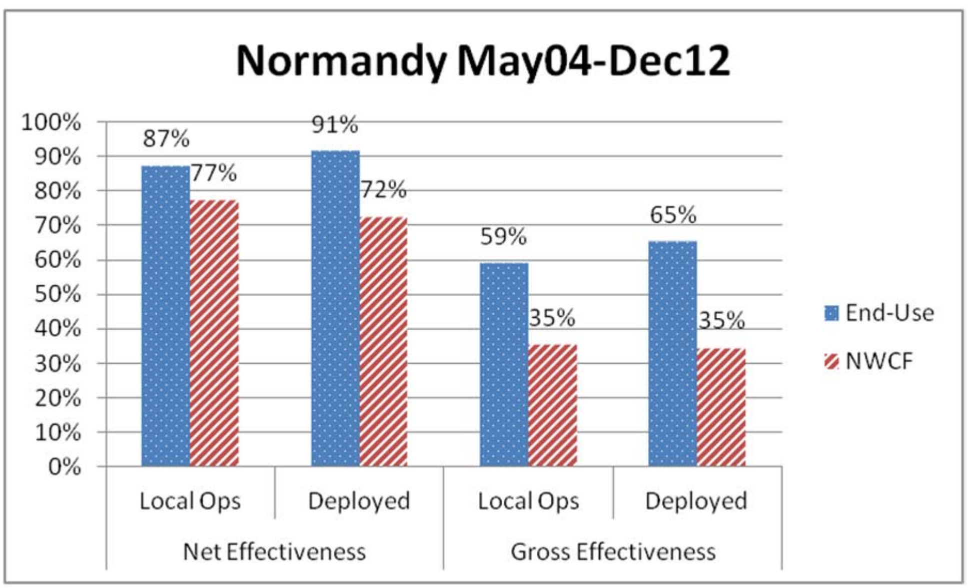

Figure 8. *Normandy* Supply Effectiveness & Ship's Status (May 2004 to December 2012)

Figure 9 provides a month-by-month comparison of supply effectiveness, with August 2008 representing the final month as an end-use ship. *Normandy's* shipyard period after the NWCF conversion is clearly visible as an immediate decline followed by several months of inactivity when no supply effectiveness metrics were available. *Normandy* resumed her supply effectiveness reporting in June 2009.

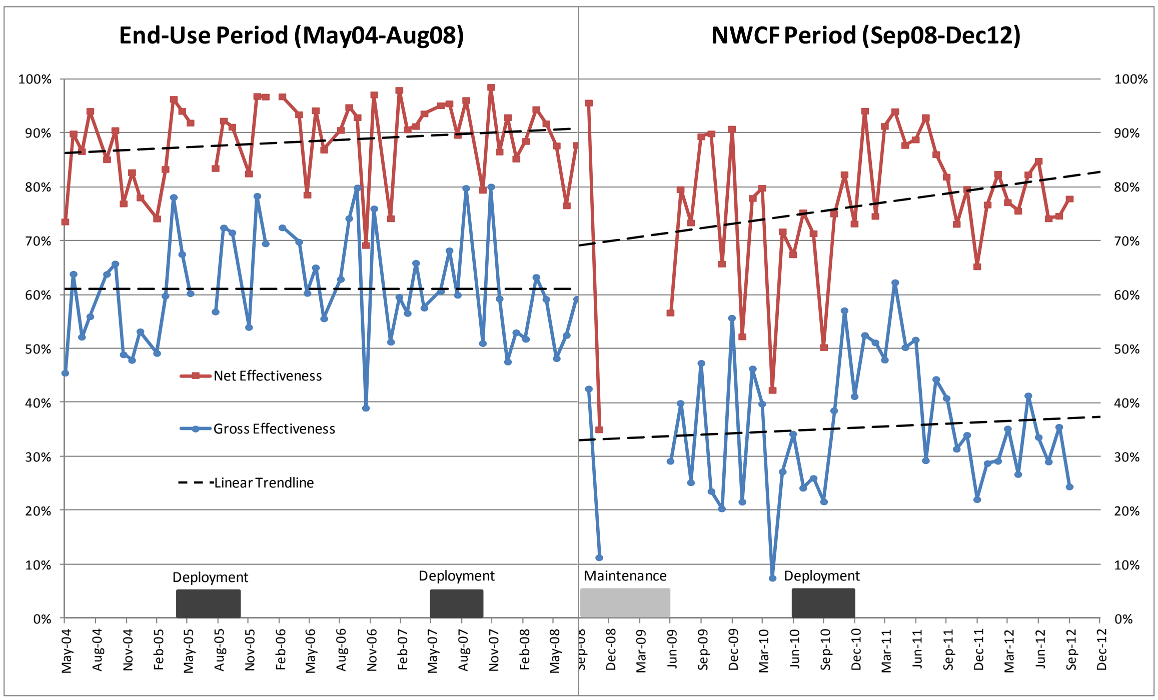

Figure 9. *Normandy* Supply Effectiveness, Month-to-Month (May 2004 to December 2012)

We isolated the data into the two distinct 52-month time periods to evaluate their respective linear trendlines. During *Normandy's* end-use period from May 2004 to August 2008, gross effectiveness was constant while net effectiveness had a positive trend, albeit small. During *Normandy's* NWCF pilot project from September 2008 to December 2012, gross and net effectiveness both had a positive trend after the interstitial period, with net effectiveness improving at the higher rate.

a. Control Charts

The month-to-month supply effectiveness results in Figure 9 revealed a wide range of values–both favorable and unfavorable. We developed control charts to assess and compare the variation before and after the NWCF pilot project. In doing so, we determined when supply effectiveness was in-control and out-of-control by establishing an upper control limit (UCL) and lower control limit (LCL) using the following formula:

$$\text{Upper \& Lower Control Limits} = \bar{\mu} \pm 3\sqrt{\frac{\bar{\mu}(1-\bar{\mu})}{n}} \tag{4}$$

We limited the sample sizes to only those dates with consecutive supply effectiveness data and a consistent range of samples. For the NWCF period, we used the 40 consecutive months from June 2009 to September 2012 after *Normandy* resumed her supply effectiveness reporting. For the end-use period, we used the 40 months prior to the conversion: May 2005 to August 2008. However, two months of the end-use period had no data, resulting in a sample of 38 months. Table 4 summarizes the control chart inputs and results. Note that the UCL of 104.55% for end-use net effectiveness was adjusted to 100%.

Table 4. *Normandy* Control Chart Inputs (May 2005 to August 2008/June 2009 to September 2012)

		mean	samples	Std Error	UCL	LCL
Net Effectiveness	End-Use	89.85%	38	4.90%	104.55%	75.16%
	NWCF	76.94%	40	6.66%	96.92%	56.96%
Gross Effectiveness	End-Use	62.34%	38	7.86%	85.92%	38.76%
	NWCF	35.69%	40	7.57%	58.41%	12.96%

Figures 10 and 11 compare the 40-month net and gross effectiveness results superimposed over each other, with the end-use period's control limits established as baseline. Those data points within the control limits represent common causes of variability, while those outside the control limits represent special causes indicative of an out-of-control process. During the NWCF pilot project, *Normandy's* net effectiveness was out-of-control 40% of time, and gross effectiveness was out-of-control 60% of the time. By comparison, *Normandy* was out-of-control only 5.3% and 0.0% of the time, respectively, in the 40 months as an end-use funded ship prior to the conversion.

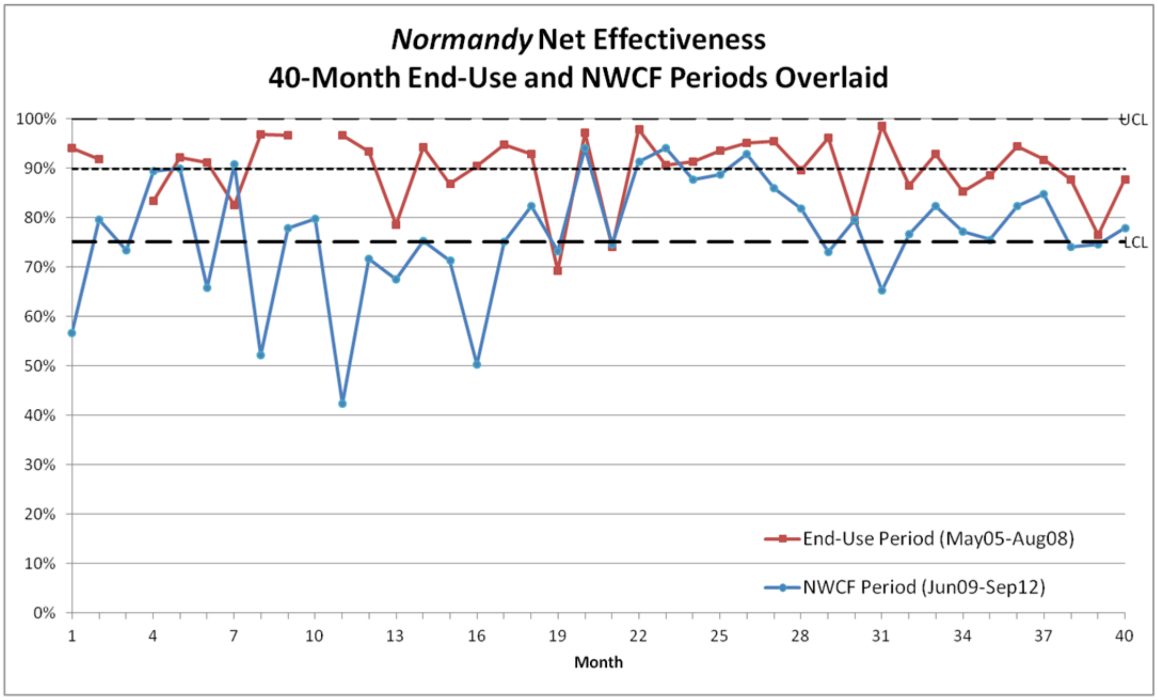

Figure 10. *Normandy* Control Chart: Net Effectiveness

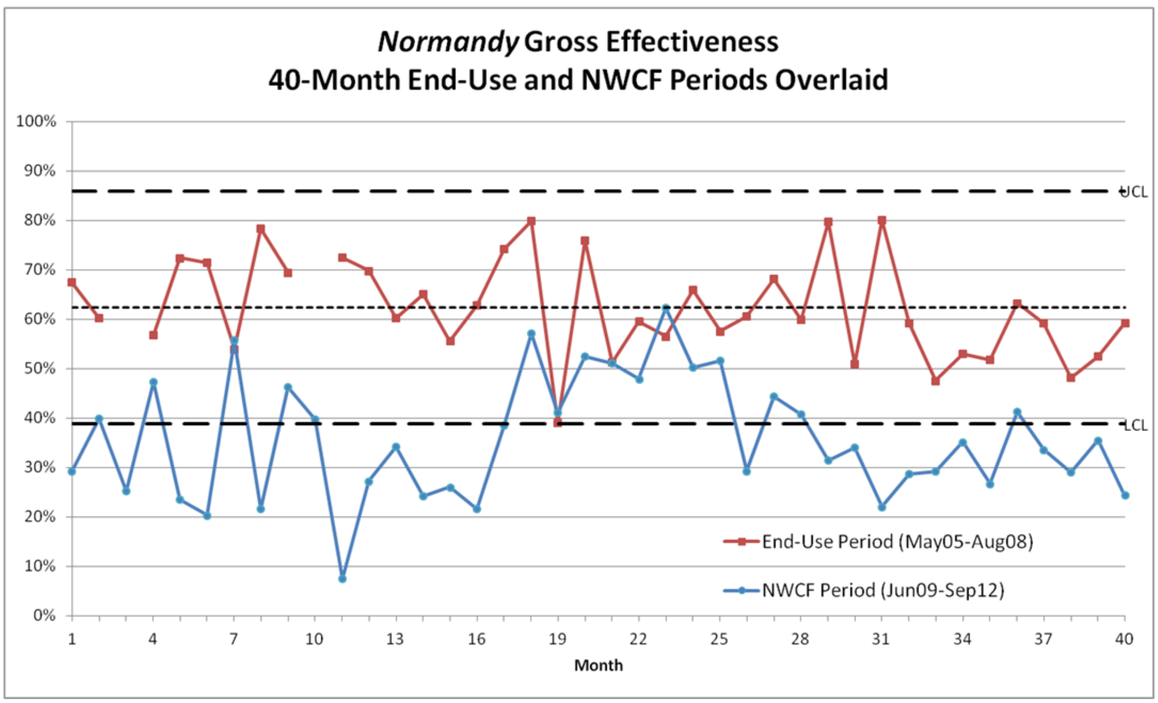

Figure 11. *Normandy* Control Chart: Gross Effectiveness

b. Hypothesis Test 3: Normandy *End-Use vs. NWCF*

We developed a third hypothesis test to analyze *Normandy's* supply effectiveness before and after the NWCF conversion as paired data. As such, we compared the 42 months of supply effectiveness data during the NWCF pilot project to the 42 most recent months of data during *Normandy's* end-use period. The hypothesis test results in Figures 17 and 18 (see Appendix A) reveal that *Normandy's* gross effectiveness and net effectiveness were different after the NWCF conversion (paired two-sample *t*-test, *p* two-tail < .05). However, gross effectiveness was lower as an NWCF ship (35.27%) than as an end-use ship (62.12%; paired two-sample *t*-test, *p* one-tail < .05). Likewise, net effectiveness was lower as an NWCF ship (76.38%) than as an end-use ship (89.19%; paired two-sample *t*-test, *p* one-tail < .05). Both results are inconsistent with our preconceived hypothesis that *Normandy's* supply effectiveness would be higher after the NWCF conversion.

B. FINANCIAL IMPACT

1. EMRM Obligations

We compared *Normandy's* average EMRM obligations per month with all other CGs and all LHDs. The results of this comparison are summarized in Table 5. From January 2008 to December 2012, *Normandy* on average spent less than both end-use funded CGs and NWCF LHDs. Again, we narrowed the data and developed hypotheses to test the differences between population means.

Table 5. EMRM Obligations per Month: All CGs & All LHDs

Jan 08 - Dec 12			
End-Use		NWCF	
Normandy	All Other CGs	Normandy	All LHDs
$363,959	$463,748	$325,173	$387,222

a. *Hypothesis Test 4:* Normandy *vs. All Other CGs*

The fourth hypothesis test was between *Normandy* and all other CGs from September 2008 to December 2012 to correspond with the NWCF pilot project. *Normandy* had 52 months of data from this time period, while all other CGs had a cumulative 1,092 months of data. The hypothesis test results in Figure 19 (see Appendix A) reveal that *Normandy's* average monthly EMRM obligations were lower ($325,173) than all other CGs ($460,746)—a difference of $135,573 or 29.4% (two-sample *t*-test, *p* one-tail < .05). These results are consistent with our preconceived hypothesis that *Normandy's* EMRM obligations would be lower than the end-use CGs.

b. Hypothesis Test 5: Normandy *vs. All LHDs*

The fifth hypothesis test was between *Normandy* and all LHDs from September 2008 to December 2012 to correspond with the NWCF pilot project. *Normandy* had 52 months of data from this time period, while all LHDs had a cumulative 354 months of data. The hypothesis test results in Figure 20 (see Appendix A) reveal that *Normandy's* average monthly EMRM obligations were lower ($325,173) than all LHDs ($390,312)—a difference of $65,139 or 16.7% (two-sample *t*-test, *p* one-tail < .05); however, the difference is minor. The same results reveal that there is not enough evidence to confirm that *Normandy's* average monthly EMRM obligations were different from all LHDs (two-sample *t*-test, *p* two-tail > .05). Nevertheless, these results are consistent with our preconceived hypothesis that *Normandy's* EMRM obligations would be lower than the NWCF LHDs.

2. Reorder Review

We compared *Normandy's* average reorder review (RoR) counts and values per month with all other CGs and all CNSF–East LHDs. The results of this comparison are summarized in Table 6. *Normandy's* unadjusted averages during the NWCF pilot project were considerably higher than the CGs and LHDs (239 allowance deficiencies valued at $892,618). Upon closer review, we discovered that *Normandy's* reorder review accumulated 1,254 allowance deficiencies (over $9 million) during the first six months of reporting after exiting the shipyard period. After removing these first six months of data, the average reorder review values per month decreased to a level more consistent with the CGs and LHDs (136 allowance deficiencies valued at $321,247).

Table 6. Reorder Review (RoR): All CGs & CNSF–East LHDs

	Jan 08 - Dec 12		Sep 09 - Dec 12	
	End-Use		NWCF	
	Normandy	All Other CGs	Normandy	CNSL LHDs
EOM RoR Count:	38	108	239	167
First 6 months of NWCF conversion removed:			136	
EOM RoR Value:	$66,693	$141,971	$892,618	$221,293
First 6 months of NWCF conversion removed:			$321,247	

This comparison revealed a distinction between end-use funded and NWCF ships. The end-use funded supply department is incentivized to keep their reorder reviews as low as possible due to the CMP's pulse point system—using ship's EMRM OPTAR to effect reorders. Meanwhile, the NWCF supply department is subject to the revolving BP accounts and TYCOM involvement as to when and how much to reorder. Among the LHDs, reorder precedence is given to those ships on deployment or preparing to deploy, while nonoperational ships receive lower reorder priority.

VI. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

A. SUMMARY

The goal of this project was to identify whether there was a supply readiness or financial benefit gained by the type of inventory method used on small surface combatants. We began by defining the two methods used to fund spare parts inventories on Navy ships—NWCF and end-use. We provided a historical context for NWCF and highlighted a similar case detailing the costs and benefits of transitioning from NWCF to an end-use funding method.

For our analysis, we obtained readiness metrics and EMRM obligation data from CNSF for all CGs and LHDs for the four-year period from 2008 to 2012. We used that data as a benchmark for *Normandy's* supply effectiveness and OPTAR obligation requirements for the same time period. We also used *Normandy's* data from the four-year period before the pilot project, 2004 to 2008, to provide a before and after snapshot. The significance of analyzing *Normandy* data and LHD data during the pilot program was to provide a comparison of NWCF ships. The significance of analyzing *Normandy* in relation to all other CGs was to provide a side-by-side comparison of two different inventory funding methods used on the same platform.

At the beginning of the project, our original hypothesis was that we would see an improvement in *Normandy's* supply effectiveness metrics under the NWCF inventory method, as well as compared to other CGs. The reason for improvement would be that onboard inventory availability would be more robust under NWCF, since EMRM budget limitations would not be a factor in ordering replacement parts. We also anticipated lower EMRM obligations under the NWCF method since EMRM funding would not be used to replenish inventory but only to issue repair parts for immediate use. We performed five hypothesis tests to identify whether the data provided statistical support for these ideas. Table 7 summarizes our five hypothesis tests and their results.

Table 7. Hypothesis Test Summary

	Hypothesis Test	Preconceived Hypothesis	Outcome
# 1	Supply effectiveness on Normandy vs. all other CGs during the NWCF pilot project	Normandy's supply effectiveness higher than the end-use CGs	Not supported
# 2	Supply effectiveness on Normandy vs. all CNSL LHDs during the NWCF pilot project	Normandy's supply effectiveness comparable with the NWCF LHDs	Not supported
# 3	Supply effectiveness on Normandy before and after the NWCF pilot project	Normandy's supply effectiveness higher after the NWCF conversion	Not supported
# 4	EMRM obligations on Normandy vs. all other CGs during the NWCF pilot project	Normandy's EMRM obligations lower than the end-use CGs	Supported
# 5	EMRM obligations on Normandy vs. all LHDs during the NWCF pilot project	Normandy's EMRM obligations lower than the NWCF LHDs	Supported

As of this research project's completion date, *Normandy* still maintains its capitalized inventory, though the pilot project has officially run its course. CNSF–East is planning to de-capitalize the ship's inventory and revert back to the end-use funding method before the end of its current maintenance availability in Fall 2013. The conversion would alleviate *Normandy's* "lone ranger" status and reconstitute inventory, funding, and technical commonalities among all CNSF–East small combatant supply departments.

B. FINDINGS AND CONCLUSIONS

We begin the discussion of our findings by examining the parallels between our research of inventory funding methods on ships and the existing research on funding methods of Navy shipyards explored in the Literature Review. Though there are differences between the two Working Capital Funds, industrial (shipyards) and stock (inventory) funds, the broad results of the research were comparable. Like the Cain and CBO analyses, we found that there are advantages and disadvantages to both funding methods. More significantly, we identified that the preferred funding method is the one that possesses the most value in the criteria determined by the user. This can be likened to the popular notion that beauty is in the eye of the beholder. The strongest example of this in the naval shipyard research was in the area of financial flexibility. The Navy (end-user) valued funding flexibility over total cost visibility in the shipyard operation. End-use (mission) funding provided that level of flexibility over NWCF and therefore, end-use was determined as the favorable funding method. Though NWCF provided greater cost visibility, the Navy placed a higher value on flexibility.

Likewise, there are advantages and disadvantages in both funding methods for spare parts on Navy ships. We highlight our findings in eight key areas: supply effectiveness, financial impact, inventory levels, stakeholder impact, cultural shifts, training, shore support, and inventory pooling. In this section, we answer our first research question posed in Chapter I: Does a readiness or financial benefit exist when using an NWCF inventory method instead of an end-use inventory method? How does it affect the Navy, TYCOM, and individual unit?

1. Supply Effectiveness

The resulting analysis from the NWCF pilot project did not show an improvement in *Normandy's* supply effectiveness metrics. In fact, *Normandy's* gross and net effectiveness numbers actually declined under the NWCF inventory method. The data also showed that CGs had an overall higher level of effectiveness than LHDs. We determined that this disparity is due in part to the different versions of R-Supply with slightly different effectiveness calculations. When we calculated supply effectiveness from the raw 3-M data and compared it to the CMP metrics, we discovered that CMP is providing higher supply effectiveness numbers. NWCF ships do not use the CMP program in conjunction with R-Supply; instead, they use the MFCS to measure effectiveness. While *Normandy's* effectiveness metrics were lower than all other CGs, they were higher than the LHDs. On average, neither CGs nor LHDs are meeting the 85% net effectiveness or 65% gross effectiveness goals established by the Navy, as demonstrated in Figure 12. The results are even worse for DLRs and FLRs when EMRM consumables are removed from the effectiveness calculations.

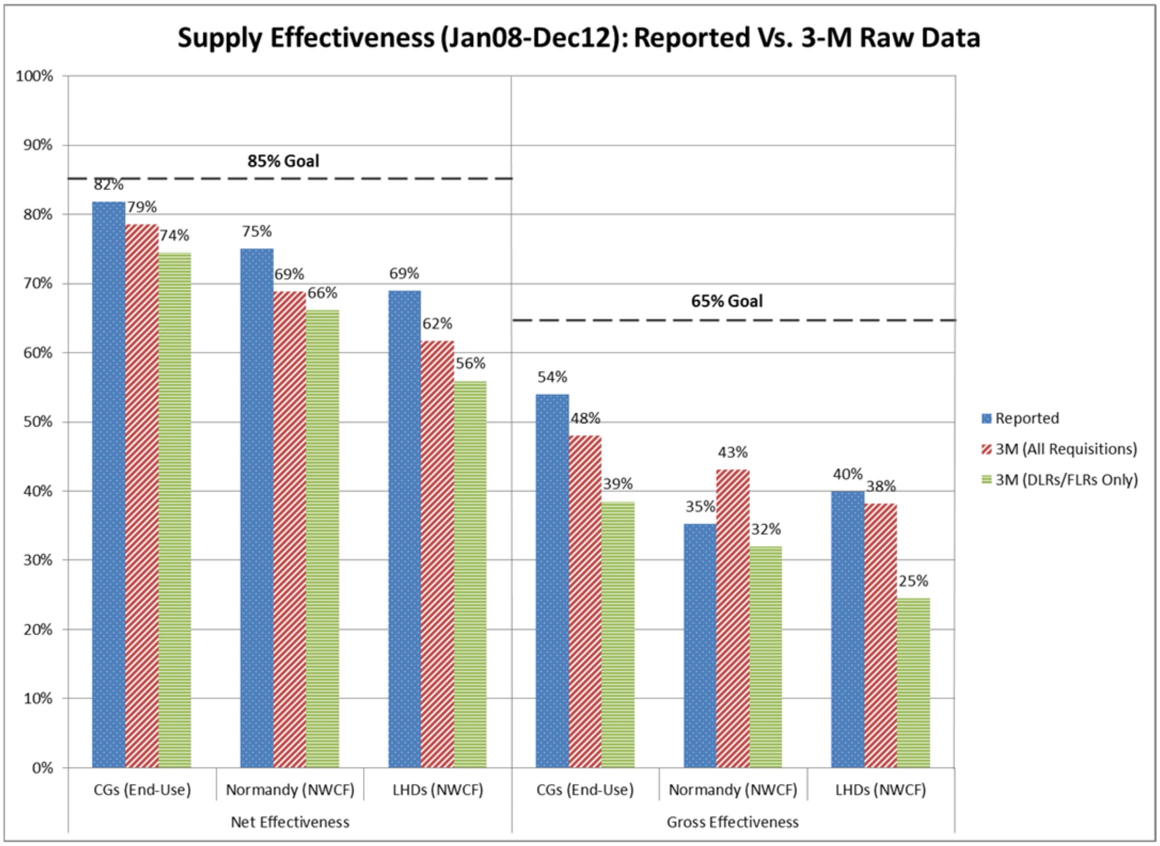

Figure 12. Supply Effectiveness, Reported vs. 3-M Raw Data

2. Financial Impact

During the NWCF pilot project, *Normandy's* EMRM obligations were lower than the average of all other CGs and LHDs. This metric did meet our expectations. The primary differences between NWCF and end-use inventories are (1) the funding source, and (2) timing of the expenditure. End-use ships expend their funding to replenish those assets issued from their inventory or to purchase assets that are not onboard, either because they are not carried or not in stock. NWCF ships use their BP accounts to purchase inventory and use their EMRM funding to buy the part out of inventory. Therefore, they spend EMRM dollars only when a part is necessary for repair; their EMRM funding is not tied up in inventory.

While this provides a savings to the TYCOM, it does not necessarily provide an overall savings to the Navy. The inventory still has to be purchased, albeit from another funding source. A primary advantage of NWCF is that there are no fiscal year limitations, whereas O&MN expires at the end of the fiscal year. Ships would not have to wait for end-of-year money to become available before they replenish their inventory deficiencies; rather, the ships can replenish them as required.

3. Deficiency-to-Requisitioning Objective

End-use ships are incentivized through CMP reporting to keep reorder review quantities and dollar values low when sufficient funding is available. When funding is not available, reorders are prioritized by operational needs. NWCF ships receive more oversight by the TYCOM, as managers of the BP accounts, and are not as heavily scrutinized on DEF-To-RO metrics. The TYCOM prioritizes reorders from the BP funding codes based on the ship's training and deployment cycle, with reorder priority given to operational ships first. Therefore, DEF-To-RO metrics on NWCF ships are viewed more as an indicator of a ship's inventory status rather than deficient inventory management.

4. Impact to Ships, TYCOMs, and the Navy

Table 8 summarizes our interpretation of the perceived impact of each inventory funding method on the stakeholders: the ship, the TYCOM, and the Navy supply system. We assigned the perceived impact as being either favorable or unfavorable. In general, the impact of each category is relevant to just one or two stakeholders.

Table 8. End-Use vs. NWCF: Impact to Ship, TYCOM, and NAVSUP/USN

		Ship	TYCOM	NAVSUP / USN
End-Use	Supply Effectiveness	Favorable	Favorable	-
	Inventory Costs	Unfavorable	Unfavorable	-
	Inventory Risk	Unfavorable	-	Favorable
	Budget Flexibility	-	Unfavorable	-
	Inventory Flexibility	-	Favorable	-
	Asset Visibility	-	-	Unfavorable

		Ship	TYCOM	NAVSUP / USN
NWCF	Supply Effectiveness	Unfavorable	Unfavorable	-
	Inventory Costs	Favorable	Favorable	-
	Inventory Risk	Favorable	-	Unfavorable
	Budget Flexibility	-	Favorable	-
	Inventory Flexibility	-	Unfavorable	-
	Asset Visibility	-	-	Favorable

The end-use ship's higher supply effectiveness benefits the ship and TYCOM alike as positive indicators of performance. Likewise, the NWCF ship's lower OPTAR costs represent a more favorable use of ship and TYCOM resources. Because the end-use ship owns its inventory outright, it carries greater risk in that the ship's COSAL may not reflect appropriate allowance range, depth, and composition. NAVSUP on the other hand is allowed to mitigate this risk by owning less inventory. The two inventory funding methods allow the TYCOMs different degrees of flexibility. NWCF allows the TYCOM to manage its revolving BP accounts and divert funds as necessary to support its more operational units, thus providing greater budget flexibility. However, end-use funding allows the TYCOM to shift its inventory assets between ships with ease, resulting in greater inventory flexibility. Finally, NWCF provides NAVSUP with complete asset visibility; they can see the assets' locations and quantities in real-time.

The raw tally of favorable versus unfavorable results gives a slight advantage to NWCF over end-use funding; however, we acknowledge that in reality the factors have different weights based on the decision-makers' priorities. If greater priority is given to supply effectiveness for example, the balance may tip in favor of end-use funding. Likewise, if priority is given to lower inventory costs and budget flexibility at the customer level, NWCF becomes the preferred method.

5. Cultural Issues

We identified two primary cultural issues that contribute to the complexity of converting to an NWCF inventory method on small combatants. First are the perceptions of shipboard leadership, their understanding of inventory funding methods, and their willingness to accept changes in the business rules. Second are the norms and processes of how materiel is transferred among ships.

a. Leadership

One of the challenges mentioned in *Normandy's* lessons learned was the funding paradigm shift for commanding officers and department heads. If a necessary part was in the onboard inventory but EMRM funding was not available, the CO would not want to hear that the supply department could not issue the part due to lack of funds. Under end-use funding, all onboard spare parts are owned by the ship and can be issued at any time. Under NWCF, the part needs to be purchased from the storeroom before it can be issued. Compounding this challenge is the fact that CG and DDG supply officers are usually an O-3, and the CO is an O-5 or O-6 with the factor of intimidation. This problem is not as prevalent on an LHD where the supply officer is closer in rank as an O-5 and the CO is an O-6.

b. *Transfer of Materiel*

Both end-use and NWCF ships can provide parts to each other through a process called other supply officer (OSO) transfer. Since end-use ships own their inventory, the supply officer can choose to transfer a part being requested by another ship at their discretion, based on their ship's anticipated requirements and their own goodwill. OSO transfers among end-use ships do not require a transfer of OPTAR funds and are considered "free issue." While the part is not literally free, the TYCOM has already purchased the part considering that, over time, ships receive just as much material as they transfer (CNSF, 2008, § 5000). Similarly, transfers among NWCF ships do not require funding, only the proper documentation to account for the stock movement. Transferring material from NWCF inventories may also require permission from the TYCOM or be directed via a cross-deck or referral message (CNAF, 2006, § 808.2).

However, the process changes when an NWCF and an end-use ship transfer parts to each other. When an end-use ship needs a part from an NWCF asset, they must provide a funding document, the same as if they ordered the part through the supply system. There is no "free" issue. When an end-use ship transfers a part to an NWCF ship, they relinquish a paid asset from their inventory, and the NWCF ship will usually order the replacement part to be delivered to the end-use ship. For these reasons, it is much more common for the NWCF ship to provide an asset to an end-use ship, as it is similar to the standard ordering process. The loss of "free issue" OSO transfer capability was cited as a disadvantage in *Normandy's* lessons learned documents after the conversion. Not only did it make it extremely difficult to obtain parts from other CGs with whom they shared common weapons systems, but they also experienced a perceived loss of autonomy for inventory management.

6. R-Supply Training

One of the requirements to support an NWCF inventory is a conversion of the computer operating system used to track the onboard inventory and financial data from Unit-Level R-Supply to Force-Level R-Supply. The Force-Level system allows for greater interface with shore-based systems. While many of the components of these systems are similar, there are some significant differences that require additional training and experience. The quality of data in R-Supply is dependent upon the personnel using the system, which can influence performance metrics. At the time of *Normandy's* conversion, personnel were not trained in Force-Level R-Supply, which created a learning curve for inventory management and reporting.

Transitioning to NWCF provides a training advantage for shipboard logistics specialists (LSs) and supply officers. The fleet would enjoy a single training pipeline and significantly reduce the learning curve when supply personnel report to ships on which they have no experience. This would also provide increased flexibility among the LS community and greater opportunities for technical proficiency among all platforms.

7. Additional Shore-Based Support

NWCF assets have a higher level of oversight from the TYCOM, which is executed mostly by civilian contractors at the time of this report. The primary reason is to manage and distribute the BP dollars that are used to replenish the inventories on current NWCF ships (CVNs and LHDs). In a sense, they also share in the stewardship of NAVSUP's assets, which requires an increased level of involvement in inventory management than would be required for an end-use ship.

Therefore, converting all ship inventories to NWCF assets would require increased oversight and create the need for additional shore-based support at the TYCOM, be it contractors, government civilians, or sailors. This would require additional manpower in an already strained budget environment. At this time, we do not identify an offset where funding can be recaptured to pay for additional shore-based support.

8. Inventory Redistribution and Pooling

If all ship inventories were NWCF, inventory redistribution and pooling for excess materiel and ships entering maintenance periods would be more efficient. Assets could be reallocated as necessary throughout the fleet without the obstacles of working under two unique supply systems. The primary drawback would be a perceived loss of autonomy from end-use ships that "own" their inventories. However, TYCOMs would still be providing the direction, as they are now, with the same goal and intention for each ship to achieve its highest level of supply readiness.

C. RECOMMENDATIONS

This section addresses the two remaining research questions posed in Chapter I. First, should current end-use inventory platforms change to the NWCF inventory method? Second, is the NWCF inventory method a better option to use on future platforms that would traditionally fit the end-use funding method?

In response to the first question, we recommend that CNSF utilize *Normandy's* lessons learned and implement another NWCF pilot project under the following guidelines:

- Utilize three to four ships to implement the pilot. This would allow for a larger sample of data as well as provide additional support for processes such as OSO transfers and redistribution of excess materiel.
- Ensure all stock control personnel are proficient in the use of Force-Level R-Supply. This eliminates the issue of personnel learning curve adjusting to a new system.
- Educate commanding officers and department heads about NWCF and the differences between the two types of funding prior to the conversion to ensure buy-in.
- Develop a weighted means to capture and evaluate all key metrics, including those that are more qualitative than quantitative.
- Capture and compare both EMRM and NWCF inventory costs to identify whether a financial benefit exists and to whom.

Once the second pilot project is complete, if the Navy chooses to convert all small surface combatants to NWCF inventories, we recommend a phased conversion schedule to correspond with the ships' extended maintenance periods. A systematic conversion will preclude the NWCF from capitalizing all shipboard inventories at the same time and allow each ship the required TYCOM support.

In response to the second question, we assert that future platforms, such as the new *Zumwalt*-class of destroyers (DDG 1000), transition to an NWCF inventory. Our recommendation is especially relevant to the DDG 1000 now that the planned number of ships has been reduced to three (O'Rourke, 2013, p. 53) as an afloat test bed for emerging technologies. NWCF inventories allow for greater flexibility in implementing new IT systems such as Navy Enterprise Resource Planning (ERP) and innovations in logistics technology. While manning reduction is not the primary goal for this implementation, NWCF does allow for more distance support and smart ship technologies. As new classes of ships come online, the NWCF inventory method will provide additional flexibility in shaping and implementing ship COSALs.

D. RECOMMENDATIONS FOR FURTHER RESEARCH

There were many avenues we could have explored in this research, but they would expand beyond the scope of our primary research question. Each of these topics builds on the concept of NWCF versus end-use inventories and can continue to build on the data generated by *Normandy's* pilot project.

- Evaluate the NWCF inventory method on Littoral Combat Ships (LCSs). The fleet implemented NWCF on LCS. Due to the minimal manning model of the platform, nearly all functions of a traditional stock control division on a ship are performed by an off-ship Logistics Support Team (LST). This includes all inventory and validity reports, material management, and financial reporting (U.S. Navy Afloat Training Group, 2011). The LST model is better suited to the use of Force-Level R-Supply. We recommend evaluating the LCSs' supply effectiveness metrics, EMRM financials, and BP-XX spending and comparing the results to Normandy's pilot project and other small surface combatants.
- Inventory losses for NWCF vs. end-use inventory methods. One of the critiques for NWCF inventories on small ships is the perception that stock will be used whether or not there is EMRM funding available. We suggest research be conducted to identify whether there is a greater loss of inventory integrity on NWCF ships versus end-use ships across the fleet. Losses can be measured in a variety of ways but would obviously need to be weighted accordingly if the researcher is comparing a CVN to a DDG.
- How effective are the gross and net supply effectiveness measurements? Our data suggest that gross and net supply effectiveness metrics, as they are defined today, may not be the optimal metrics to evaluate the supply system on ships. Determine whether there is a better way to evaluate inventory effectiveness as an indicator of supply readiness. Identify the best measurements to indicate successful inventory management.
- Cost–benefit analysis of conversion from end-use to NWCF inventories for all Navy ships. The approximate inventory value of a CG is $15.5 million. Create a projected schedule and total cost to convert all current end-use inventories to NWCF inventories. Include the cost of capitalizing new ships as they are brought online. Identify total cost savings (if any) to the TYCOMs and the effects on the Navy's O&MN budget.

- Cost–benefit analysis of using a single information technology (IT) system (such as Force-Level R-Supply or Navy ERP) on all Navy ships. Evaluate the costs and benefits of moving to a single IT system on Navy ships and having one training pipeline for LSs. We recommend the researchers also explore the use of ERP as that single IT solution. Does the implementation of ERP necessitate the conversion of all ships to NWCF inventory?

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APPENDIX A: HYPOTHESIS TEST RESULTS

To test our hypotheses, we used the following step-by-step procedure to decide between those *t*-tests and *F*-tests available in the Microsoft Excel Data Analysis add-ins, assuming a level of error of .05:

- Evaluate population data as paired or not paired (i.e., dependent or independent of each other).
    - If population data is paired, use "*t*-Test: Paired Two Sample for Means"
        - P-value < .05: reject null hypothesis
        - P-value > .05: do not reject null hypothesis
    - If population data is not paired, use "*F*-Test Two-Sample for Variances"
        - P-value < .05: use "*t*-Test: Two-Sample Assuming Unequal Variances"
            - P-value < .05: reject null hypothesis
            - P-value > .05: do not reject null hypothesis
        - P-value > .05: use "*t*-Test: Two-Sample Assuming Equal Variances"
            - P-value < .05: reject null hypothesis
            - P-value > .05: do not reject null hypothesis

Hypothesis tests 1–4 compare *Normandy* to other end-use and NWCF ships for the same time period; therefore, the population data is not paired (i.e., independent of each other). On the other hand, hypothesis test 5 compares *Normandy* before and after the NWCF conversion; therefore, the population data is paired.

F-Test Two-Sample for Variances

	Other CGs	*CG 60*
Mean	0.502814146	0.356872387
Variance	0.02607779	0.014809277
Observations	774	40
df	773	39
F	1.760909095	
P(F<=f) one-tail	0.014986042	
F Critical one-tail	1.528761636	

P-Value < .05
Assume the Variances are NOT Equal

t-Test: Two-Sample Assuming Unequal Variances

	Other CGs	*CG 60*
Mean	0.502814146	0.356872387
Variance	0.02607779	0.014809277
Observations	774	40
Hypothesized Mean Diff	0	
df	46	
t Stat	7.261555539	
P(T<=t) one-tail	1.84872E-09	
t Critical one-tail	1.678660414	
P(T<=t) two-tail	3.69743E-09	
t Critical two-tail	2.012895599	

P (one-tail) < .05: Reject Null Hypothesis
P (two-tail) < .05: Reject Null Hypothesis

Figure 13. Hypothesis Test 1: Gross Effectiveness, All CGs (June 2009 to September 2012)

F-Test Two-Sample for Variances

	Other CGs	*CG 60*
Mean	0.787454498	0.769377365
Variance	0.025602504	0.014095226
Observations	774	40
df	773	39
F	1.816395407	
P(F<=f) one-tail	0.011215319	
F Critical one-tail	1.528761636	

P-Value < .05
Assume the Variances are NOT Equal

t-Test: Two-Sample Assuming Unequal Variances

	Other CGs	*CG 60*
Mean	0.787454498	0.769377365
Variance	0.025602504	0.014095226
Observations	774	40
Hypothesized Mean Diff	0	
df	47	
t Stat	0.920747537	
P(T<=t) one-tail	0.180942153	
t Critical one-tail	1.677926722	
P(T<=t) two-tail	0.361884306	
t Critical two-tail	2.011740514	

P (one-tail) > .05: CANNOT Reject Null Hypothesis
P (two-tail) > .05: CANNOT Reject Null Hypothesis

Figure 14. Hypothesis Test 1: Net Effectiveness, All CGs (June 2009 to September 2012)

F-Test Two-Sample for Variances

	CNSL LHDs	*CG 60*
Mean	0.406234822	0.356872387
Variance	0.01755436	0.014809277
Observations	157	40
df	156	39
F	1.185362418	
P(F<=f) one-tail	0.271815773	
F Critical one-tail	1.570102189	

P-Value > .05
Assume the Variances ARE Equal

t-Test: Two-Sample Assuming Equal Variances

	CNSL LHDs	*CG 60*
Mean	0.406234822	0.356872387
Variance	0.01755436	0.014809277
Observations	157	40
Pooled Variance	0.017005343	
Hypothesized Mean Diff	0	
df	195	
t Stat	2.137226651	
P(T<=t) one-tail	0.016912569	
t Critical one-tail	1.65270531	
P(T<=t) two-tail	0.033825138	
t Critical two-tail	1.972204051	

P (one-tail) < .05: Reject Null Hypothesis
P (two-tail) < .05: Reject Null Hypothesis

Figure 15. Hypothesis Test 2: Gross Effectiveness, CNSF–East NWCF (June 2009 to September 2012)

F-Test Two-Sample for Variances

	CNSL LHDs	CG 60
Mean	0.709216858	0.769377365
Variance	0.023844786	0.014095226
Observations	157	40
df	156	39
F	1.691692353	
P(F<=f) one-tail	0.028085857	
F Critical one-tail	1.570102189	

P-Value < .05
Assume the Variances are NOT Equal

t-Test: Two-Sample Assuming Unequal Variances

	CNSL LHDs	CG 60
Mean	0.709216858	0.769377365
Variance	0.023844786	0.014095226
Observations	157	40
Hypothesized Mean Diff	0	
df	76	
t Stat	-2.679075662	
P(T<=t) one-tail	0.004522735	
t Critical one-tail	1.665151353	
P(T<=t) two-tail	0.009045469	
t Critical two-tail	1.99167261	

P (one-tail) < .05: Reject Null Hypothesis
P (two-tail) < .05: Reject Null Hypothesis

Figure 16. Hypothesis Test 2: Net Effectiveness, CNSF–East NWCF (June 2009 to September 2012)

t-Test: Paired Two Sample for Means

	End-Use	*NWCF*
Mean	0.621236299	0.352703364
Variance	0.010375148	0.015636484
Observations	42	42
Pearson Correlation	0.113513223	
Hypothesized Mean Diff	0	
df	41	
t Stat	11.44532941	
P(T<=t) one-tail	1.20742E-14	
t Critical one-tail	1.682878002	
P(T<=t) two-tail	2.41484E-14	
t Critical two-tail	2.01954097	

P (one-tail) < .05: Reject Null Hypothesis
P (two-tail) < .05: Reject Null Hypothesis

Figure 17. Hypothesis Test 3: *Normandy* Gross Effectiveness (January 2005 to September 2012)

t-Test: Paired Two Sample for Means

	End-Use	*NWCF*
Mean	0.891887541	0.763825004
Variance	0.005533844	0.018511188
Observations	42	42
Pearson Correlation	0.253439966	
Hypothesized Mean Diff	0	
df	41	
t Stat	6.034561183	
P(T<=t) one-tail	1.93174E-07	
t Critical one-tail	1.682878002	
P(T<=t) two-tail	3.86348E-07	
t Critical two-tail	2.01954097	

P (one-tail) < .05: Reject Null Hypothesis
P (two-tail) < .05: Reject Null Hypothesis

Figure 18. Hypothesis Test 3: *Normandy* Net Effectiveness (January 2005 to September 2012)

F-Test Two-Sample for Variances

	Other CGs	*CG 60*
Mean	460745.8612	325173.3762
Variance	1.5448E+11	46561605587
Observations	1092	52
df	1091	51
F	3.317756902	
P(F<=f) one-tail	4.1354E-07	
F Critical one-tail	1.441298965	

P-Value < .05
Assume the Variances are NOT Equal

t-Test: Two-Sample Assuming Unequal Variances

	Other CGs	*CG 60*
Mean	460745.8612	325173.3762
Variance	1.5448E+11	46561605587
Observations	1092	52
Hypothesized Mean Diff	0	
df	68	
t Stat	4.210242837	
P(T<=t) one-tail	3.83276E-05	
t Critical one-tail	1.667572281	
P(T<=t) two-tail	7.66552E-05	
t Critical two-tail	1.995468931	

P (one-tail) < .05: Reject Null Hypothesis
P (two-tail) < .05: Reject Null Hypothesis

Figure 19. Hypothesis Test 4: EMRM Obligations, All CGs (September 2008 to December 2012)

F-Test Two-Sample for Variances

	All LHDs	*CG 60*
Mean	390311.5514	325173.3762
Variance	87041888291	46561605587
Observations	354	52
df	353	51
F	1.869391899	
P(F<=f) one-tail	0.003748575	
F Critical one-tail	1.458970639	

P-Value < .05
Assume the Variances are NOT Equal

t-Test: Two-Sample Assuming Unequal Variances

	All LHDs	*CG 60*
Mean	390311.5514	325173.3762
Variance	87041888291	46561605587
Observations	354	52
Hypothesized Mean Diff	0	
df	82	
t Stat	1.928130121	
P(T<=t) one-tail	0.028650096	
t Critical one-tail	1.663649184	
P(T<=t) two-tail	0.057300193	
t Critical two-tail	1.989318557	

P (one-tail) < .05: Reject Null Hypothesis
P (two-tail) > .05: CANNOT Reject Null Hypothesis

Figure 20. Hypothesis Test 5: EMRM Obligations, CNSF–East NWCF (September 2008 to December 2012)

APPENDIX B: PUBLICATION DESCRIPTIONS

NAVAL SUPPLY PUBLICATIONS

The Naval Publication 485 (P-485; NAVSUP, 1997) is recognized as the afloat supply manual. The manual is every supply officer and LS's "bible" to conducting business onboard ships. Volume I of the P-485 is an extremely detailed guide that delineates funding, requisitioning, and inventory procedures for the fleet, to name only a few. Users of the P-485 may be stationed on end-use funded or NWCF ships. The following section, taken from the P-485, discusses the policy on procuring inventory items. It clearly provides that there is a line to be drawn with regards to funding sources for shipboard inventories and that there is a way that those parts must be handled. For example, a user would find the following guidance:

> 1. PROCUREMENT FROM END-USE AFLOAT ACTIVITIES. Emergency requisitions for Navy Working Capital Fund (NWCF) material submitted by SAC activities to end-use ships require special handling to ensure proper financial reporting and credit to the transferring ship's Type Commander. The DD Form 1348 6-Part submitted to the issuing ship will contain a statement such as: This issue to be processed as a turn-in to a stores account and should not be included in your A or B summary. Credit for material transferred will be provided to your TYCOM. (NAVSUP, 1997, § 3821)

This illustrates that while end-use ships and NWCF ships can transfer materiel to and from each other, the process requires a great deal of additional oversight to ensure that each type of ship retains equity in the transfer.

The P-485 (NAVSUP, 1997) shows the additional knowledge, layers of administration, and follow-up that are required when working with both types of funding.

NAVAL SURFACE FORCE GUIDANCE

Small surface combatants and amphibious ships home-ported in the continental U.S. (CONUS) are under administrative control of Commander, Naval Surface Force (CNSF). Geographically, Surface Force maintains two offices, one on the West Coast (CNSF–West) and one on the East Coast (CNSF–East). Although the instructions and guidance for both coasts are the same, the two entities are funded separately. CNSF–West funds those ships home-ported in California, Washington, Hawaii, and Japan; CNSF–East funds ships in Virginia, Florida, and the remainder of the East Coast.

In this document, we refer to Commander, Naval Surface Force, as the TYCOM. Supply officers and personnel aboard these ships use CNSF Instruction 4400.1 (CNSF, 2008), commonly referred to as the SURFSUP. Accordingly, "the SURFSUP contains the information and guidance for personnel engaged in supply operations under Commander Naval Surface Forces (CNSF) cognizant [*sic*]. This publication amplifies and supplements procedures for financial management and inventory control" (CNSF, 2008). It clarifies areas where TYCOM sets policy and is used to supplement the P-485 (NAVSUP, 1997) and other publications. Most importantly, this document details reporting procedures for inventory, the ship's budget, and overall performance goals for the supply department in the areas of inventory and financial management.

NAVAL AIR FORCE GUIDANCE

CVNs are governed by Commander, Naval Air Force (CNAF), and also contain East and West components that divide the funding. However, aircraft carriers are only a part of CNAF's scope; CNAF is also responsible for all Navy aircraft in the fleet. The Supply Instruction for CVN supply personnel is the Commander, Naval Air Force Instruction 4440.2 (CNAF, 2006), commonly referred to as the Supply Operations Manual (SOM). The SOM also delineates reporting procedures for inventory, the ship's budget, and performance goals. The majority of storeroom inventory on a CVN is owned by the NWCF; like the SURFSUP, the SOM details the procedures for transferring inventory to end-use funded ships. The SOM is used to reference elements of the NWCF and how it is used in the fleet.

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[1] Access to this electronic document requires a valid government common access card.

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