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APPLYING COMMERCIAL PROCEDURES AND TECHNOLOGY TO NAVY AUDIT READINESS

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APPLYING COMMERCIAL PROCEDURES AND TECHNOLOGY TO NAVY AUDIT READINESS

December 2021

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ABSTRACT

The Department of the Navy (DON) does not have sufficient record keeping, processes, or controls in place for the management of physical assets, and this has a negative impact on our readiness. There are multiple technologies available, which have demonstrated inventory accuracy improvement. We address current practices, current regulations, and possible alternatives that could be implemented to improve compliance with applicable directives and inventory accuracy. We conduct a cost benefit analysis to determine which of these methods are feasible and provide recommendations on implementing the technologies.

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TABLE OF CONTENTS

LIST OF FIGURES

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LIST OF TABLES

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LIST OF ACRONYMS AND ABBREVIATIONS

3M	Maintenance and Material Management
3MC	3M Chief
3MO	3M Officer
BLS	Bureau of Labor Statistics
CAC	Common Access Card
CBA	Cost Benefit Analysis
CG	Guided Missile Cruiser
CMP	Continuous Monitoring Program
CNSL	Commander Naval Surface Forces Atlantic
COA	Course of Action
CONOPS	Concept of Operations
COR	Contracting Officer's Representative
CVN	Nuclear Aircraft Carrier
CVW	Carrier Air Wing
DAU	Defense Acquisition University
DDG	Guided Missile Destroyer
DFARS	Defense Federal Acquisition Regulation System
DLA	Defense Logistics Agency
DLR	Depot Level Repairable
DOD	Department of Defense
DON	Department of the Navy
DPAS	Defense Property Accounting System
FAR	Federal Acquisition Regulation
FIAR	Financial Improvement and Audit Readiness
FY	Fiscal Year
FYTD	Fiscal Year to Date
GAO	Government Accountability Office, formerly the Government Accounting Office
HERO	Hazards of Electromagnetic Radiation to Ordnance
IBS	Integrated Barcode Systems

ILO	Integrated Logistics Overhaul
ISIC	Immediate Superior in Charge
IUID	Item Unique Identification
LCS	Littoral Combat Ship
LHA	Landing Helicopter Assault Ship
LHD	Landing Helicopter Dock Ship
LPD	Amphibious Transport Dock Ship
LS	Logistics Specialist
LSD	Dock Landing Ship
MCM	Mine Countermeasure Ship
MM	Machinist Mate
MR	Machinery Repairman
NALCOMIS	Naval Aviation Logistics Command/Management Information System
NAVSEA	Naval Sea Systems Command
NAVSUP	Naval Supply Systems Command
NPS	Naval Postgraduate School
NSN	National Stock Number
OMMS-NG	Organizational Maintenance Management System – Next Generation
OPM	Office of Personnel Management
PBUSE	Property Book Unit Supply Enhanced
R-SUPPLY	Relational Supply
RFID	Radio Frequency Identification
RMC	Regional Maintenance Center
SECDEF	Secretary of Defense
SECNAV	Secretary of the Navy
SKU	Stock Keeping Unit
SOP	Standard Operating Procedure
SSBN	Ballistic Missile Submarine
SSGN	Guided Missile Submarine
SSN	Fast Attack Submarine

WSS	Weapons Systems Support
UII	Unique Item Identifier
USD AT&L	Under Secretary of Defense Acquisition Technology & Logistics
ZIDL	Zone Inspection Discrepancy Listing

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I. INTRODUCTION

The Department of the Navy (DON) does not have sufficient record keeping processes or controls in place for the management of physical assets and inventory generating a negative impact on our readiness, economic efficiency, and compliance with applicable directives. There are several readily available technologies and processes that have been proven to vastly improve inventory accuracy in warehousing, managing supply chains, and reducing manhours required for compliance tasks. To support decision making with identifying feasible alternative technology and inventory practices, there is a need to evaluate applicable Department of Defense (DOD) directives, Item Unique Identification (IUID) and Radio Frequency Identification (RFID) technologies in terms of their processes and technological tools available to enable Real Time Audit and roadmap to implementation in the Navy. In this study, we focus on identifying commercially available inventory technologies and processes and conduct a cost benefit analysis (CBA) to determine their suitability for use in the DOD and/or DON to improve inventory accuracy.

> Historically, military logisticians supported the warfighter with limited information on assets, particularly in theater. This obstacle led to ineffective inventory management, introducing waste, inefficiency, and delay across the supply chain. Ultimately, these shortfalls impacted the warfighter's overall materiel readiness, the ability to close the force, and the operational availability of weapon systems. The lack of synthesized end-to-end, real-time theater information on assets (including both at-rest and in transit items) across all components, undercuts the ability of the Combatant Commander (COCOM) to exercise directive authority for logistics. (Estevez, 2005, p. 23)

Recent conflicts in which the U.S. military has participated have demonstrated that logistical support can and should be improved to increase operational readiness. Limited information regarding inventories leads to waste, inefficiency, and delayed support for operational units (Estevez, 2005). Historically, Navy inventory information systems are not updated in real-time, leading to inaccurate inventory records. In 2002, Burch sampled FLC San Diego and 11 of their partnership inventory sites. His analysis indicates inventory accuracy rates between 67.31% and 100% among those sites. This was against goals of either 90% or 95% depending on the category of material. In 2004, the Under Secretary of

Defense for acquisition, technology and logistics (USD AT&L) created a policy ordering the implementation of commercially available technology to be used in military inventory processes (Estevez, 2005). The IUID methods and systems are used for creating globally unique identifiers for critical components (MIL-PAC Technology, n.d.). Individual components would have a unique, scannable code that enables the scanner to identify specific components from cradle to grave.

Following a Government Accountability Office (GAO) study in 2014, the DON implemented the Financial Improvement and Audit Readiness (FIAR) audit system, meant to discover and remedy discrepancies within inventory and financial statements. Following the release, additional studies and reports from the GAO and external auditors have confirmed the continued occurrence of discrepancies within the Navy supply system.

Unlike large commercial warehousing companies, such as Federal Express, Amazon, and Target, the Navy deploys units and ships on dynamic missions that face different challenges by tracking inventory. Simple shipping and tracking procedures are compromised by limited connectivity, frequent delays in delivery, and human error due to ineffective training and high turnover rates.

The aim of this study is to assess two different technologies: IUID and RFID for potential implementation within the Navy. We conduct a cost estimate and identify the benefits the Navy can expect regarding inventory accuracy, reduced inventory costs, and Financial Improvement and Audit Readiness. The DOD's vision of RFID technology's end state is "for the DOD supply chain is to be a fully integrated adaptive entity that leverages state-of-the-art enabling technologies and advanced management information systems to automate routine functions and achieve accurate and timely in-transit, in-storage, and in-repair asset visibility with the least human intervention" (Estevez, 2005, p. 24).

A. RESEARCH QUESTIONS AND METHODOLOGY

This research study attempts to address the following research question:

What are the benefits and costs associated with use of IUID and RFID for potential implementation within the Navy?

Through answering this question, the research uses the following approach:

- Examine current technologies and guidance utilized within the DON.
- Identify common discrepancies of DON asset performance.
- Provide recommendations for implementation of processes, technologies, managerial styles, and organizational cultures the DON can adopt.
- Determine cost of implementation of the recommended Course of Action (COA).

To address the research question, this study uses a review of prior studies, fleet experience and data from Navy entities. The literature review encompasses ongoing challenges within DON inventory accuracy, commercially available technologies, and possible means of implementation to improve the DON's processes. Additionally, this study addresses business practices, managerial methods, and recommendations for implementation of current guidance to improve Navy inventory processes.

B. BENEFITS AND LIMITATIONS

This research study aims to provide a decision support model that can be adjusted and support a recommendation on technologies and processes that can improve the overall inventory accuracy of the U.S. naval fleet. The focus is to analyze available processes and technologies that have demonstrated inventory accuracy improvement through their implementation. This is then compared to U.S. naval practices and technologies to determine areas for improvement. The goal is to significantly mitigate the current risks of inventory discrepancies and improve factors such as time management, reduce required man hours due to dated processes, further rework, and improve traceability on items from cradle to grave.

The recommendations of this study aim to increase the efficiency of current processes in the DON, and bring the Navy into greater compliance with current guidance. This study examines types of technology that the Navy could potentially adopt. It gives the benefits and limitations on those technologies. Finally, we conduct a cost benefit analysis to support our recommended Course of Action (COA). The study's analysis and conclusions are based on data collected from Naval Supply Systems Command (NAVSUP) headquarters in Mechanicsburg, PA. It gives several scenarios for cost avoidance that may be realized following implementation. Follow on research may be needed to confirm and build upon findings.

C. ORGANIZATION OF STUDY

This research is organized in six chapters, including this introduction chapter. Chapter II provides background information on current DON inventory standards and required procedures. Chapter III discusses technologies the DON has tried to implement and literature review. Chapter IV analyzes data from Naval Supply Systems Command, Weapons Systems Support, detailing their current inventory accuracy rates and conducts a cost benefit analysis to determine the most appropriate and effective technology and processes measures for implementation. Chapter V states a summary of the data. Chapter VI lists the recommendations and conclusions of the study.

II. BACKGROUND AND CURRENT GUIDANCE

This chapter details DON regulatory inventory standards and procedures. "The impact of inventory accuracy ranges from audit readiness to DOD budget credibility. There is a negative impact on readiness when material on an accountable record cannot be found" (NAVSUP P-485, 2020, p 6–4). From Financial Improvement and Audit Readiness (FIAR) to DOD and NAVSUP regulation, DON has implemented policies and processes meant to improve and monitor inventory accuracy, ultimately to increase readiness.

A. FINANCIAL IMPROVEMENT AND AUDIT READINESS

The goal of FIAR is to "improve the Department's financial management operations, helping provide America's Service men and women with the resources they need to carry out their mission and improving our stewardship of the resources entrusted to us by the taxpayers" (Department of Defense, n.d., under "FIAR Goal"). It is the military's responsibility to ensure they are utilizing the most efficient and accurate technologies and processes to conduct and report inventories. Since 2005, DOD FIAR reports have clearly stated that "effective financial management depends on information that is accurate, reliable, and timely" (FIAR, 2005, p. 1). Timeliness, accuracy, and reliability are only achieved when the teams are equipped with the most effective means possible. Current practices of manually reading NSNs and comparing them to spreadsheets can lead to multiple errors and additional costs due to hours of rework. Lost inventory due to bad tracking technology increases the wasting of funds.

B. FEDERAL ACQUISITION REGULATION

All contracting actions are required to adhere to the Federal Acquisition Regulation (FAR). The FAR is "established for the codification and publication of uniform policies and procedures for acquisition by all executive agencies" (FAR 1.101, 2021). As all DOD inventory items are at some point initially contracted for, then FAR regulations regarding the purchase of and requirements for contractors to follow must have been stated. Currently, there are two specific regulations from the Defense Federal Acquisition Regulation System (DFARS), a supplement to the FAR, that clearly state that items of a specific value or nature are required to be marked with either IUID (DFARS 252.211-7003) or RFID (DFARS 252.211-7006) technology. Though it is up to the contractor to ensure that the markings are applied to the equipment, the Contracting Officer must ensure the applicable clause is included in the solicitation and subsequent contract and that the contractor complies with the requirement. However, once in the fleet, Supply Officers need to know there is a requirement they should be inspecting for and have the capability to ensure any missing or damaged markings are applied or reapplied as applicable.

C. NAVAL SUPPLY SYSTEMS COMMAND STANDARDS

The Naval Supply Systems Command Publication 485 (P-485) *Operational Forces Supply Procedures Manual* is the principal directive from DON regarding inventory policy. It has clear guidance on inventory types, procedures, accuracy rates, and the required timelines to be conducted. It is provided as instruction for the operation and management of all operational units, afloat and ashore. The instructions are the "minimum essential acceptable supply management procedures and are mandatory unless specifically stated as being optional" (NAVSUP, 2020, under "Introduction to Volume I - Operational Forces Supply - Purpose"). It requires random partial and full, monthly, quarterly, and annual inventories to be conducted, where findings must then be reported to higher echelons for review of compliance and maintained standards via the Continuous Monitoring Program.

NAVSUP P-485 VOLUME I – SIXTH REVISION

OPERATIONAL FORCES SUPPLY PROCEDURES

Category	Sub-Population	Goal	Tolerance
A	Unit price > $1,000 and all DLRs	99%	99%
B	All other material	95%	95%
C	Controlled inventory items (see paragraph 6062)	100%	100%
95 PERCENT CONFIDENCE LEVEL +4 PERCENT BOUND APPLICABLE TO EACH CATEGORY			

Figure 1. Operational Required Inventory Accuracy Rates. Source: NAVSUP (2020).

NAVSUP P-485 VOLUME I – SIXTH REVISION

OPERATIONAL FORCES SUPPLY PROCEDURES

INVENTORY SCHEDULE

USS __________ LAST ILO/ILR:______________

FISCAL YEAR: ______ NEXT ILO/ILR:______________

TYPE OF INVENTORY	PERIODICITY	DATE SCHEDULED	DATE COMPLETED	TOTAL ITEMS	TOTAL # DISCREPANCIES	ACCURACY RATE %
PRECIOUS METALS	QUARTERLY					
SIM/DBI	SEMI-ANNUAL					
BULKHEAD MOUNTED SPARES	SEMI-ANNUAL					
RADIOACTIVE MATERIAL	SEMI-ANNUAL					
ORGANIZATIONAL CLOTHING	SEMI-ANNUAL					
PRECIOUS METALS	QUARTERLY					
CLASSIFIED, PILFERABLE AND SENSITIVE ITEMS (CIIC: A-M,O,S,T,V-Z, 1-6, 8 AND 9)	ANNUAL					
DLR	ANNUAL					
HAZMAT VIA HICSWIN	ANNUAL					
LAP ALL LOCATIONS	ANNUAL					
ASBESTOS (SMCC: N)	ANNUAL					
PRECIOUS METALS	QUARTERLY					
SIM/DBI	SEMI-ANNUAL					
BULKHEAD MOUNTED SPARES	SEMI-ANNUAL					
RADIOACTIVE MATERIAL	SEMI-ANNUAL					
ORGANIZATIONAL CLOTHING	SEMI-ANNUAL					
PRECIOUS METALS	QUARTERLY					
MAINTENANCE ASSISTANCE MODULES (MAM)	refer to TYCOM INST.					
CONTROLLED EQUIPAGE (CE)	refer to TYCOM INST.					

LEADING LS:______________________/______________________/________

PRINT SIGNATURE DATE:________

SUPPLY OFFICER:______________________/______________________/________

PRINT SIGNATURE DATE:________

RETENTION: 10 years for inventories and reconciliations.

Figure 2. Operational Required Inventory Schedule. Source: NAVSUP (2020).

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III. TECHNOLOGIES AVAILABLE AND REVIEW OF PREVIOUS ASSESSMENT STUDIES

This chapter details current technologies utilized by the DON and the challenges the DON faces regarding inventory technologies used. Radio Frequency Identification (RFID) and IUID technologies are currently required per DFARS regulation, subject to specific requirements. Their implementation, however, has been inconsistent. This chapter describes what the separate technologies are, their benefits, limitations, and the policies that require their usage.

A. RADIO FREQUENCY IDENTIFICATION (RFID)

1. WHAT IS RFID?

RFID technology has been around for decades. Charles Walton is credited with officially developing and patenting RFID technology in 1983. (Pargon ID, 2021) The basic idea is that an organization is identifying trackable items with tags. The tag contains a transponder that emits a signal, readable by specialized readers. They typically contain an identification number, (National Stock Number [NSN] or Stock Keeping Unit [SKU]) which corresponds to a central database from information received by the scanners. The tags themselves can be writable, enabling additional data to be utilized, such as location, and shipping tracking. There are two kinds of RFID tags, active and passive. Active tags require their own power source requiring a much larger tag, have significant costs associated, and are not cost effective with the return on investment for the DOD, therefore, for this study, they will not be further discussed. Passive tags cost as low as $0.05 per tag, compared to $5.00-$10.00 for an active tag. Though the total quantity of information able to be held by passive tags is less, it is still substantial enough to hold relevant inventory information for the DON. Additionally, passive tags can be much smaller than active tags as they lack their own power source. Tags can be encased in plastics such as ID cards or adhered to materials, such as metal based items. The type of tag depends on the environment, specifically what material the signal must traverse to be read. The key to successful reading is the scanner itself. Scanners can continuously receive data or be on a demand basis. Data is received through the frequency waves emitted by the tags. This can be low or high frequency, again dependent on the environment in which the items are stored (Ferrer et al., 2010)

.

Figure 3. Sample RFID Tag. Source: Idencia (2018).

2. RFID POLICY AND USE IN SOLICITATIONS

RFID implementation has been a key focus area of the DOD's Joint Vision JV 2020 long range plan since 1999. The goal is to improve Total Asset Visibility, providing logisticians the ability to locate and identify assets automatically. Use of RFID technology would provide insight of the movement and usage of items within their life cycle. "Defense Logistics Agency (DLA), is responsible for integrating tracking capabilities within the DOD's massive inventory" (Davis & Jones, n.d., under "Introduction").

The "US DOD requires suppliers to use RFID on lowest possible piece part/case/pallet packaging once the supplier's contract contains language regarding the requirement" (Weinstein, 2005, p. 29). Per DFARS 252.211-7006, "Passive RFID technology is required for cases and palletized unit loads packaging levels and any additional consolidation level(s) deemed necessary." Some items included in this are: packaged operational rations, clothing, organizational tools, hand tools, packaged petroleum products and lubricants, medical materials (excluding pharmaceuticals); however, bulk items and those shipped to locations other than Defense Distribution Depots when utilizing Fast Payment methods.

3. BENEFITS OF RFID

There are multiple specific benefits to the utilization of RFID tags. As they do not require line of sight access to read the tag, they can be continuously monitored within a warehouse or shipboard storage location. The read range is larger than a standard bar code meaning less man hours are required to complete inventories (Doerr et al., 2006). Additionally, scanners are able to scan multiple RFID tags simultaneously. As shipments are delivered, the entire load can be scanned as it enters or exits a storage location without needing to scan individual items. Lastly, RFID tags are able to both hold more data and have read/write capabilities, enabling them to update location and tracking data.

4. LIMITATIONS OF RFID

While RFID presents many benefits, it also has multiple concerns the DOD needs to work through to fully accept the technology. A common concern with RFID is privacy. Any time a signal is required, there is the threat that the signal could be compromised. The signal must be weak enough to not be accessed by foreign threats but must be strong enough to be read within the walls of the storage location.

Additionally, RFID onboard ships face obstacles for implementation. For example, it is not currently known how metal bulkheads will affect readability and range of RFID scanners. There are also concerns about how RFID scanners and tags will fit into Navy Hazards of Electromagnetic Radiation to Ordinance (HERO) instructions. These concerns would need to be tested in a limited trial to determine further suitability of RFID technology onboard Navy ships.

B. ITEM UNIQUE IDENTIFICATION (IUID)

1. WHAT IS IUID?

IUID is "a system of marking items by establishing unique item identifiers (UII) within the DOD by assigning a machine-readable character string or number to a discrete item, which serves to distinguish it from other like and unlike items." (Adair & Scalf, 2017, p. 1) It should be noted each unique identifier will and can occur only once within its defined scope (Adair & Scalf, 2017). Careful use of terminology is required when discussing IUID and UII. IUID is the system or method of marking required items and UII is the data that is contained in the markings. These terms are sometimes used interchangeably, but they represent two distinct concepts in this particular inventory system (Bradford, 2012). To be effective, UII markings should be clear, unambiguous, and unique. There are four steps to complete the marking process as follows:

1. Create the two-dimensional data matrix.
2. Verify the information contained in the matrix is within standards.
3. Validate the data constructed is accurate for future tracking.
4. Affix the data matrix to the item (Jennings et al., 2008).

MIL-STD-130N is the DOD-wide guidance for how to properly mark items and contains instructions for how to properly mark each item.

Figure 4. Sample Two-Dimensional Data Matrix. Source: Item Unique Identification: The Basics (2010).

2. BENEFITS OF IUID

IUID allows for an item to be individually marked and tracked throughout its life-cycle by a unique data field that is created in the IUID registry once, and only once. This allows an individual item to be tracked specifically to its assigned location and provides other information such as procurement cost. The IUID registry allows an item to be transferred from unit to unit and its location and ownership can be tracked as applicable.

Additionally, use of IUID has been mandated by the SECDEF and SECNAV through various instructions at their respective levels. Those are detailed below.

3. IUID POLICY AND USE IN SOLICITATIONS

The DOD requires certain items to be uniquely tracked throughout their lifetime. Some of these items are as follows: small arms, nuclear weapons-related materiel, special tooling, depot-level repairables (DLRs), items that require tracking of miles, rounds fired, hours of usage, life-limited, time-controlled, critical items, and any item with an acquisition price of over $5,000 etc. The Department of Defense Instruction (DoDI) 8320.04, dated 27 Aug 2019, proscribes IUID as the central repository for government owned items that require Unique Item Identification (UII). The DOD has mandated this to help it track applicable items throughout their life-cycle as well as to keep accurate records of the valuation of these assets for accuracy in the DOD's financial statements in support of audit readiness. Additional benefits include mitigating the risks from counterfeit goods, reduced ownership costs, improved life cycle management, and improved asset visibility (Adair & Scalf, 2017) & (DoDI 8320.04).

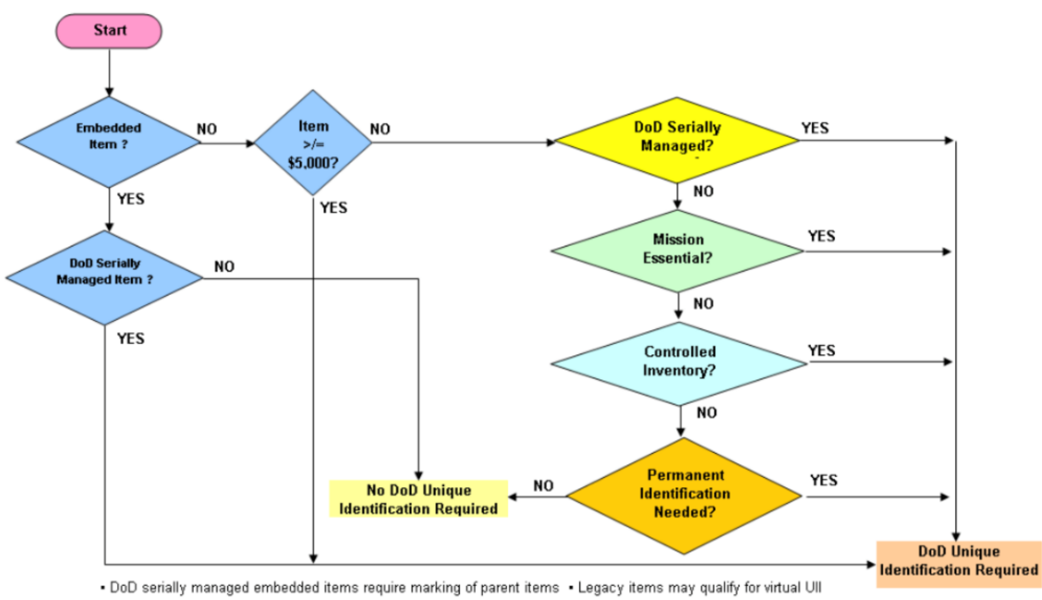

Figure 5. IUID Marking Decision Tree. Source: Item Unique Identification: The Basics (2010).

To this end, DoDI 8320.04 requires that the military services designate a focal point for their implementation of this instruction and to develop and promulgate guidance related to IUID markings. Additionally, each service is responsible for ensuring that required materiel under its purview is marked and recorded in the DOD IUID registry. There are other requirements for the military departments related to IUID that are not germane to this study.

An additional benefit that results from IUID technology and UII tracking was identified in DoDI 4151.19, dated 09 Jan 2014, namely that it allows for optimum materiel availability at the best ownership cost. This results from enhanced and more efficient sustainment operations, reducing. At this point, the DOD was referring to this type of material tracking as serialized item management for life-cycle management of materiel. This eventually was rolled into the IUID program.

Another instruction, the DoDI 5000.64, dated 10 Jun 2019, requires all material that is in the Defense Property Accountability System to be marked using IUID. If an IUID data matrix has not yet been established for a given item, it must be tracked by serial number or other unique asset identification. Additionally, the use of automatic information technology (AIT) is required through the use of barcode printers, scanners, Common Access Card (CAC) readers, or other technology unless deemed impractical through a cost-benefit analysis. Such determinations must be documented in a memorandum for the record and must be reevaluated every two years. This requirement takes effect on the receipt, delivery, or acceptance of material.

Currently, the Navy is not in compliance with these instructions or the Congressional intent to mark necessary items in a consistent manner. The Navy is not alone in this regard. Indeed, research from Adair and Scalf in 2017 has laid out many of the same issues for the U.S. Army. Their NPS thesis strictly focused on the Army, while our research focuses exclusively on the Navy. It should be noted that while all services have been delayed in coming into 100% compliance with the applicable DOD instructions, Bradford notes in her thesis that the Navy did take the early lead in implementing IUID systems. In the 4th quarter of 2006, the number of Navy IUID implementation plans grew at 150%

(Bradford, 2012). However, as we will discuss later the Navy has still not reached complete compliance with these instructions.

As an experiment, we tested a random sample of 50 U.S. Navy solicitations between August and September of 2021 using the SAM.gov website found that 16 out of 50 solicitations did not include any references to IUID markings for applicable equipment. Defense Federal Acquisition Regulation Supplement (DFARS) 252.211-7003 specifically deals with these required markings, as applicable for equipment covered by the above instructions. This clause was missing for 32% of examined solicitations. GAO reported that all services were having issues determining the rate of compliance with the DFARS including this clause in 2012 and it appears to still be an issue (Merritt, 2012).

Metadata analysis for the entire SAM database of Navy solicitations reveal that just 17% of solicitations referred to IUID markings. While not all solicitations will be for items that require unique item identification, there seems to be an issue with contracting officers not including required clauses in their solicitations.

Additionally, when the DFARS 252.211-7003 clause is included in solicitations it usually mentions that if an item is too small to be marked with an IUID marking, that the item should be marked in some other manner that would allow the Navy to keep specific track of that individual item. This is in accordance with DOD instructions but does complicate the method of marking individual items that would otherwise be subject to IUID markings.

From interviews with several officers around the fleet it appears that calibrated gauges seem to be a particular area of concern in that they do not arrive from manufacturers correctly marked according to DOD instructions and MIL-STD-130. These gauges are initially provided as part of the new ship construction process and are received, inventoried, and installed by the constructing shipyard. Therefore, Navy personnel often do not see these particular items before they are already installed on a ship and before they can be properly marked should they be sent from the manufacturer without required markings. At this point in the process, it is too late to be marked by either civilian or military Navy personnel. It is critical that contracting officers include applicable clauses in contracts for ships and that contracting officer representatives (CORs) be well trained to inspect IUID parts before acceptance.

4. LIMITATIONS OF IUID

While use of UII markings under the IUID system are required according to DOD instructions for applicable equipment, there are limitations to this technology. The primary limitation for full compliance with IUID mandates is the fact that not all commands have the scanners required to be able to scan and read UII markings. This prevents personnel from scanning items and having them read automatically in whatever inventory system the command uses, typically R-Supply or NALCOMIS. The scanners that are required for reading UII markings are different than one dimensional scanners and thus the few commands that Integrated Barcode System (IBS) barcodes and scanners would need to switch equipment to equipment that would be compatible with IUID or at least add another inventory management system to manage their inventories.

Another drawback regarding IUID is that it requires either engraving or a printer that is capable of printing metal labels. Most commands do have equipment capable of making these types of labels but this equipment still requires that personnel to be trained to use that equipment and how to properly affix labels.

The data labels themselves can potentially become another drawback for IUID, the UII markings become damaged. Should this occur, a new label would have to be made and the damaged label would then need to be removed and replaced by the new label. This would increase processing time and costs (Harris et al., 2008). The type of item being marked would greatly influence the probability of a label being damaged. Items that are handled more frequently face a higher chance of being damaged than a fixed item that is not handled at all.

Contracting officers also can also be a drawback for IUID if they do not include required applicable clauses from the DFARS in their contract solicitations. If contracting officers don’t require contractors to mark items before delivery to the Navy, then contractors won’t mark required items. If contractors do mark items before delivery, CORs could then inspect material for applicable markings before acceptance. This would reduce the need for marking material after it arrives and would help increase compliance with DoDI 5000.64 and DoDI 8320.04.

As with any other inventory management system and method of maintaining inventory, IUID is highly dependent on proper implementation of each step in the marking process and data registration. If errors occur at any steps they have the potential to negatively impact the effectiveness of an IUID system. Therefore, to maximize the benefits of IUID, care must be maintained when registering data in the registry, accurately marking items, and maintaining the readability of markings (Goodman et al., 2010).

C. PREVIOUS ASSESSMENT RESEARCH

As previously noted, Bradford (2012) pointed out in her thesis that the Navy initially made progress with developing and implementing IUID marking plans, while the other services lagged behind. However, in the period since her thesis was published in 2006, the other services, particularly the Army and Marine Corps have made up ground. There have been several theses to come out of the Naval Postgraduate School alone from Army and Marine officers that contained sound guidance for how those services can improve their IUID program compliance.

In 2017, Adair and Scalf wrote a Concept of Operations (CONOPS) and Standard Operating Procedure (SOP) for Army program managers to use regarding adopting IUID into the various Army inventory management systems. One of their more interesting recommendations was for the Army to reduce the number of inventory management systems, e.g., PBUSE, DPAS, etc., into a single system or to develop a single integrator that can ensure data flows seamlessly between the systems to give an enterprise-wide view of IUID information (Adair & Scalf, 2017). While the number of databases that the Navy uses to manage inventory is beyond the scope of this paper, the Navy has realized that there are myriad systems that complete, fundamentally, the same task. That is why in 2018, the RAND Corporation published a study commissioned by the Navy to provide recommendations on how to update the Navy's inventory management system (Wilson et al., 2018).

Adair and Scalf's work outlined the steps required to show how to register a UII mark in the IUID database and how to accurately inventory and transfer the item between commands. Their work could be used to tailor a generalized process to the Navy's specific inventory management systems such as R-Supply or NALCOMIS. Of course, the Navy and Army use separate and distinct inventory management systems and track some different data fields, but this work could be examined by Navy inventory management personnel and detailed IUID implementation plans could be developed from modified work already conducted by the Army. It could even be used to "fall-in" on other service gear in-theater and maintain accurate inventory records while these items are in the custody of Navy personnel.

We can look to the 2008 research of Blakiston, Jennings, and Punzel regarding the markings of legacy materiel. The Navy, like other branches of the military, has a large quantity of legacy materiel that requires marking, that is not currently marked. Marking these legacy items will require significant effort and will be dependent on work orders being submitted for completion during yard periods, especially for items that will require disassembly or other manipulation. Their research also indicates that the estimated cost of creating each label is approximately $4.47 in 2021 dollars. The Defense Acquisition University has produced research that certain commands have been able to get their cost per label as low as $1.77 in 2021 dollars (Rash-Gehres et al., 2013). So there exists variations in costs, but the individual labels are relatively cheap. Blakiston, Jennings, and Punzel looked at a very specific group of items to mark, namely required components on the Marine Corps' M1A1 Abrams tanks, they were then able to calculate how long it would take to complete marking that set of legacy items. Our paper is not focused on one specific set of items for the Navy and therefore we cannot provide a timeline for the completion of marking legacy items. We can expect it to be a multi-year period as ships only enter shipyard availabilities every few years, which provides a good opportunity for marking of items that are not being used and can be disassembled if necessary.

Regarding the potential for UII markings to become damaged over time, Harris, Wright, & Locklar found in their study that between 45%–71% of items surveyed had damaged UIIs. However, their study focused on small arms in the Marine Corps. To be sure, the Navy has items that are required to be UII marked that are handled frequently. However, the Navy also has a significant percentage of items that are required to be marked that are fixed or semi-fixed in place e.g., calibrated gauges, displays, etc. For these items the expected likelihood of the labels becoming damaged is low. Harris et al. (2008) found that 50% of damaged labels came from normal wear and tear. Therefore, if an item is fixed and not being handled, the risk of label damage is mitigated.

Their study also found that the armories they surveyed did not have scanners capable of reading the UII labels. Based on this paper's authors' recent fleet experience, this is typical of ships in the fleet. Therefore, to make the most out of IUID technology the Navy would need to invest in scanners for the fleet. Bradford reported in 2012 that the Navy's Fleet Forces Command had funded Navy ships to purchase IUID scanners and software to begin marking their legacy items (Bradford, 2012). This was anticipated to be completed no later than 2015, but this is, as of yet, to be completed in the fleet.

Previous research has indicated that for a majority of the Navy's UII marking needs, label making methods utilizing adhesive tape or adhesive ink-jet labels would be sufficient. This would help reduce costs, even if commands still had to buy machines capable of engraving aluminum plates, adhesive labels are still cheaper to produce than engraved plates. Adhesive labels can also be used to more easily mark irregularly shaped items. Metal plates do have the advantage of being more durable than adhesive labels however and would therefore last longer (Goodman et al., 2010).

The DAU also recommends when commands implement IUID they take the time to re-examine their business processes to try to find new efficiencies (Rash-Gehres et al., 2013). Given the current method of manually inventorying items on Navy ships via printing paper reports and then comparing the physical inventory to the reports, IUID and RFID represent a new way of conducting business for Naval logisticians. Therefore, new methods will be required to complete inventorying procedures. Similar to the CONOPS developed by the Army for IUID implementation, the Navy could produce guidance for the fleet. As lessons are learned, those lessons can be fed to NAVSUP which then issue revised guidance.

The Government Accountability Office (GAO) estimates that the DOD could save between \$3B and \$5B per year by fully implementing IUID. Our data will help provide some Navy specific figures for expected cost savings with implementation of IUID (Merritt, 2012).

IV. METHODOLOGY

The Boardman et al. article describes a Cost Benefit Analysis (CBA) as "is a policy assessment method that quantifies in monetary terms the value of all consequences of a policy to all members of society" (Boardman et al., 2018, p. 2). The cost benefit analysis framework follows the main steps as described in Boardman et al. (2018) and in the OMB *Circular A-94* which provides general guidance on the use cost benefit analysis of government programs or projects (Office of Management and Budget, 1992).

The steps, according to Boardman et al., included are listed in the following figure.

1. Explain the purpose of the CBA
2. Specify the set of alternative projects
3. Decide whose benefits and costs count (specify standing)
4. Identify the impact categories, catalogue them, and select metrics
5. Predict the impacts quantitatively over the life of the project
6. Monetize (attach dollar values to) all impacts
7. Discount benefits and costs to obtain present values
8. Compute the net present value of each alternative
9. Perform sensitivity analysis
10. Make a recommendation

Figure 6. Steps of a Cost Benefit Analysis. Source: Boardman et al. (2018).

The 1992 A-94 circular from the Office of Management and Budget describes a Benefit-cost analysis "as the technique to use in a formal economic analysis of government programs or projects" (OMB, 1992, p. 4). It describes the elements of a CBA as the policy rationale or justification for the analysis, provides a listing explicit assumptions utilized to arrive as stated estimates, provides an evaluation of alternatives, and verification that the potential benefits are valuable.

For this study analyze the cost effectiveness (estimated cost to avoid inventory loses) from potential use of IUID and RFID within the Navy. We gathered data from

Commander, Naval Surface Forces Atlantic (CNSL) regarding the inventory accuracy rates for the ships under their purview. This list of ships included 30 destroyers, nine cruisers, seven amphibious ships, two expeditionary mobile base ships, four mine countermeasure ships, and four shore based units. The data received included inventory accuracy rates, inventory completion rate, line items inventoried, count of losses and gains by inventory, sum of losses and gains by inventory. This data was listed for A, B, and C categories of inventory. This data is presented as FY 21, 4^{th} quarter data but included all results FYTD.

For the purposes of this study, we do not examine gains by inventory. We were able to extrapolate total fiscal year end losses by taking the proportion of the inventory completed and carrying it through to a 100% inventory completion rate. We then modify the data to simulate inventory losses for all ships of the same classes listed above. We also exclude category B findings as these items are high usage items under $1,000 per item. Our findings will be artificially low as we do not have data for aircraft carriers, submarines, or all shore activities as they do not fall under the CNSL umbrella.

We obtained price information for IUID systems to allow commands the ability to make their own IUID labels and the software to register these labels. We then compare the costs at several levels of implementation. For example, should the Navy purchase them for all NAVSUP depots, all regional maintenance centers (RMCs), and all ships, or should the Navy focus solely on all NAVSUP depots and all RMCs, while excluding ships. As mentioned in the previous chapter given the current unknowns about shipboard effectiveness of RFID systems, this study does not perform a cost benefit analysis of that particular technology.

The information regarding price information for IUID systems was provided by Camcode, which is a company that specializes in helping companies and government agencies implement UII markings for required assets. It was then compared against previous research conducted by Goodman, et. al.(2010) to verify that the prices were still relatively similar. Goodman, et. al (2010) analysis of IUID implementation costs were adjusted for inflation from 2010 and were found to be in-line with information provided by Camcode (J. Keserich, managing director of Camcode Global, November 17, 2021).

For completing the cost benefit analysis, we examine payback periods at different levels of implementation effectiveness. For example, what would the payback periods be if inventory losses were reduced by 10%, 25%, and 40% for surface ships. Again, the payback periods would most likely be high as our data does not include losses by inventory on carriers or large deck amphibious ships.

Due to space concerns onboard MCM, SSN, SSBN, and SSGN classes we expect that labels can be created at either the TYCOM or RMC level. This has the benefit of saving on costs of outfitting these units as well as reducing variable labor costs. These units can also better allocate the space that would be required for the equipment necessary to make UID labels.

Based on previous studies (Goodman et al. 2020) we calculated variable costs based on the time it takes to create tags and pay schedules for civilian workers. For Sailors onboard ships, labor is a sunk costs and will not be factored into variable costs in those situations. There have been previous studies that provide the per tag costs for materials, but whenever possible we have used actual price data obtained from industry.

Specific analysis and results will be covered in the next chapter. This data allows for the decision makers to make informed choices about how to best implement an effective IUID system. As DOD and SECNAV instructions already mandate use of an IUID system, this is another benefit. Improving inventory tracking will lead to cost avoidance through reduction of losses.

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V. ANALYSIS AND FINDINGS

Based on our methodology we estimate that for destroyers, cruisers, mine countermeasure ships, amphibious ships (excluding LHA and LHD classes), and select shore units, the Navy can expect to lose, on average, $1,424,000 per fiscal year in category A inventory. Category C material is a much smaller concern, with an expected loss of $4,720 per year. Again, these numbers did not account for carriers, LHA and LHD class amphibious ships, submarines, or all shore units. Additionally, the data shows where some unit classes at the CNSL level of reporting, reported no losses by inventory, which was surprising.

CATEGORY A - INVENTORY WITH A UNIT PRICE >= $1,000 AND ALL DLRS. ANNUAL (FY) 100% W2W INVENTORY WITH AN INVENTORY ACCURACY >= 99%			
CNSL CAT A:	Gains	$79,801.16	9
	Losses	($533,962.75)	110
	Total Discrepancies	$613,763.91	119
		Total Inventoried	24741
		Percent Inv Acc	99.50%
		FYTD Comp Rate	89.60%
		FYTD % Inv Acc	99.50%
CATEGORY C - CONTROLLED EQUIPAGE AND CLASSIFIED PARTS. ANNUAL (FY) 100% W2W INVENTORY WITH AN INVENTORY ACCURACY OF 100%			
CNSL CAT C:	Gains	$0.00	0
	Losses	($2,281.18)	19
	Total Discrepancies	$2,281.18	19
		Total Inventoried	693
		Percent Inv Acc	97.30%
		FYTD Comp Rate	88.60%
		FYTD % Inv Acc	98.60%

Table 1. CNSL Total Inventory Discrepancies Q4 FY21. Category A & C Rates of Completion and Accuracy.

CNSL DIRECT DATA Q4 FY2021									
Ship Class	# Ships in CNSL by Class	Cat A Inv Loss Total	Cat A Inv Loss Avg	Cat A losses Total	Cat A Losses Avg	Cat C Inv Loss Total	Cat C Inv Loss Avg	Cat C Losses Total	Cat C Losses Avg
DDG	30	($489,170.00)	($16,310.00)	30	3.000	($2,250.00)	($70.00)	30	0.566
CG	9	($4,570.00)	($510.00)	3	0.333	$0.00	$0.00	0	0.000
Amphib	7	($37,820.00)	($5,400.00)	15	2.142	($30.00)	$0.00	2	0.286
ESB	2	$0.00	$0.00	0	0.000	$0.00	$0.00	0	0.000
Shore Units	4	$0.00	$0.00	0	0.000	$0.00	$0.00	0	0.000
MCM	4	($2,400.00)	($600.00)	2	0.500	$0.00	$0.00	0	0.000
TOTALS	56	($533,960.00)	($22,820.00)	50.000	5.975	($2,280.00)	($80.00)	32.000	0.852

Table 2. CNSL Data Q4 FY21 Inventory Losses. Total and Average across all Units in Class.

CATEGORY A - CNSL TO FLEET PROJECTION AT CURRENT 89.6% COMPLETE RATE									
Ship Class	# Ships in Class in Fleet	Cat A Inv Loss Total - Projected Yearly	Total Fleet Unit Estimate			Cat A Quantity Loss Total - Projected Yearly	Cat A Losses Total Fleet Estimate	Cat A Losses Avg - Projected Yearly	Cat A Losses Total Fleet per Unit Estimate
DDG	70	($489,170.00)	($1,273,880.00)	($16,310.00)	($42,460.00)	30	78.125	3	7.813
CG	22	($4,570.00)	($12,470.00)	($510.00)	($1,390.00)	3	8.185	0	0.909
Amphib	22	($37,820.00)	($132,670.00)	($5,400.00)	($18,950.00)	15	52.615	2	7.513
ESB	3	$0.00	$0.00	$0.00	$0.00	0	0.000	0	0.000
Shore Units	4	$0.00	$0.00	$0.00	$0.00	0	0.000	0	0.000
MCM	8	($2,400.00)	($5,350.00)	($600.00)	($1,340.00)	2	4.464	1	1.116
TOTALS	129	($533,960.00)	($1,424,380.00)	($22,820.00)	($64,140.00)	50.000	143.389	6	17.351

Table 3. CNSL to U.S. Fleet Category A Inventory Losses per Platform. Yearly Projection and U.S. Fleet Yearly Projection.

CATEGORY C - CNSL TO FLEET PROJECTION AT CURRENT 88.6% COMPLETE RATE									
Ship Class	# Ships in Class in Fleet					Cat C Losses Total - Projected Yearly	Cat C Losses Total Fleet Unit Estimate	Cat C Losses Avg - Projected Yearly	Cat C Losses Total Fleet per Unit Estimate
DDG	70	($2,250.00)	($4,650.00)	($70.00)	($150.00)	30	62.020	2	3.510
CG	22	$0.00	$0.00	$0.00	$0.00	0	0.000	0	0.000
Amphib	22	($30.00)	($90.00)	$0.00	($10.00)	2	5.569	1	2.387
ESB	3	$0.00	$0.00	$0.00	$0.00	0	0.000	0	0.000
Shore Units	4	$0.00	$0.00	$0.00	$0.00	0	0.000	0	0.000
MCM	8	$0.00	$0.00	$0.00	$0.00	0	0.000	0	0.000
TOTALS	129	($2,280.00)	($4,740.00)	($80.00)	($170.00)	32.000	67.589	3	5.897

Table 4. CNSL to U.S. Fleet Category C Inventory Losses per Platform. Yearly Projection and U.S. Fleet Yearly Projection.

Variable costs per tag onboard ships large enough to make their own will be $4.47 per tag. This is composed solely of the purchase price per tag as labor rates for Sailors is a sunk cost. For tags made for submarines, MCMs, and LCSs (which are anticipated to be made at either TYCOM or the local RMC) must account for civilian labor costs. These costs are shown in Appendix A.

Based on the thesis conducted by Goodman, Rodriguez & Infante in 2010, it is estimated that the time required to create an individual UII mark is approximately 7.6 minutes (Goodman et al., 2010). This is coupled with the labor cost for one GS-7 individual (which is used as a representative in this analysis) at a local RMC or TYCOM to make UII tags for the above types of units. The Office of Personnel Management (OPM) lists the basic hourly wage of a GS-7 step 5 employee at $20.46 per hour. At this price, and at 7.6 minutes to complete a UII marking process, the labor costs is $2.59 per tag. This labor cost plus the material cost of $4.47 gives a total variable cost of $7.06 per tag for a civilian employee to create a tag.

IUID process	**Time to conduct each operation (min)**
1) Identify assets / parts for IUID marking	0.6
2) Generate construct data for mark	0.6
1b) Generate IUID mark	5.4
4) Verify IUID construct data is correct	0.2
3) Place IUID mark on part	0.4
5) Link construct data with IUID mark	0.4
Total Time	**7.6**

Figure 7. Time Required to Make 1 IUID from Identification through Completion. Source: Goodman et al. (2010).

Previous research by Goodman et al. (2010) indicates that fixed price for one IUID system should cost approximately $73,352, this takes inflation into account of 26.896% from 2010 to 2021. Additionally, this was confirmed by conversations with Mr. Jon Keserich from Camcode International. Our research indicates that a system can be expected to have costs according to the following breakdown:

Items in IUID System	Amount Needed	Price/Item ($)	Total Retail Costs ($)
Scanner	2	1,487	2,974
Printer	1	3,050	3,050
Verifier	1	4,495	4,495
Scanner/Computer	2	3,338.5	6,677
Software	1	647	647
Laser Engraver	1	39,885	39,885
Total Price			**57,728**

Figure 8. Equipment investment needed for each IUID Marking System. Source: Goodman et al. (2010).

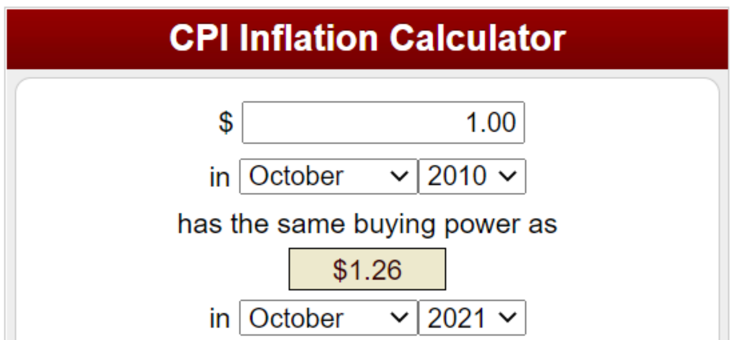

Figure 9. Consumer Price Index Inflation Calculator. Source: CPI Inflation Calculator (2021).

Items in IUID System	Amount Needed	Price/Item ($)	Total Retail Costs ($)
Scanner	2	1886.94	3773.88
Printer	1	3870.33	3870.33
Verifier	1	5703.98	5703.98
Scanner/Computer	2	4236.43	8472.86
Software	1	821.02	821.02
Laser Engraver	1	50612.49	50612.49
Total Price			**73254.56**

Figure 10. Equipment investment needed for each IUID Marking System updated for inflation of 26.986% increase from 2010 to 2021 Dollars. Adapted from Goodman et. al (2010).

According to this cost structure, implementation at six Navy RMC locations (Naval Sea Systems Command, n.d.), 26 NAVSUP locations, and 117 ships (22 Cruisers, 70 Destroyers, 22 LPDs/LSDs and 3 ESBs), totaling 149 complete systems, would cost approximately $10,914,929.44 ($73,254.56 for 1 Marking System * 149 Ships). The locations that were selected are listed in appendix B and can be tailored by applicable Navy decision makers either to add to, subtract from, or swap locations.

In anticipation of loss reduction due to better inventory tracking, we examined three scenarios regarding levels of loss reduction. We considered scenarios of loss reduction of 10%, 25%, and 40%. This allows payback period analysis of each loss reduction benchmark compared to the overall cost of IUID implementation. This will allow decision makers the ability to determine how fast to get to compliance with instructions and will allow them to allocate funding to meet their goals. Payback period tables are below. Each table lists the data driving the calculations underneath.

These tables provide an example of estimated fixed costs payback periods. Variable costs will vary depending on the rate at which commands identify and mark their assets. Navy decision makers will have to determine the right mix of UII marking systems to maximize best value for the Navy.

Price per System	$ 73,254.56	$ 73,254.56	$ 73,254.56	$ 73,254.56
# Units	149	34	26	6
Total Cost	$ 10,914,929.44	$ 2,490,655.04	$ 1,904,618.56	$ 439,527.36

Table 5. Cost of Proposed Unit Quantities.

	Estimated Yearly Loss	**10% Reduction**	**25% Reduction**	**40% Reduction**
Average Loss Expected Cat A	$1,424,380.00	$142,438.00	$356,095.00	$569,752.00
Average Loss Expected Cat C	$4,740.00	$474.00	$1,185.00	$1,896.00
Total Average Expected Reduction in Loss	$1,429,120.00	$142,912.00	$357,280.00	$571,648.00

Table 6. Benefit of Loss Reduction.

# Units	10% Reduction	25% Reduction	40% Reduction
149	76.630	30.550	19.094
34	17.428	6.971	4.357
26	13.327	5.331	3.332
6	3.076	1.230	0.769

Table 7. Cost to Benefit Analysis (in Years).

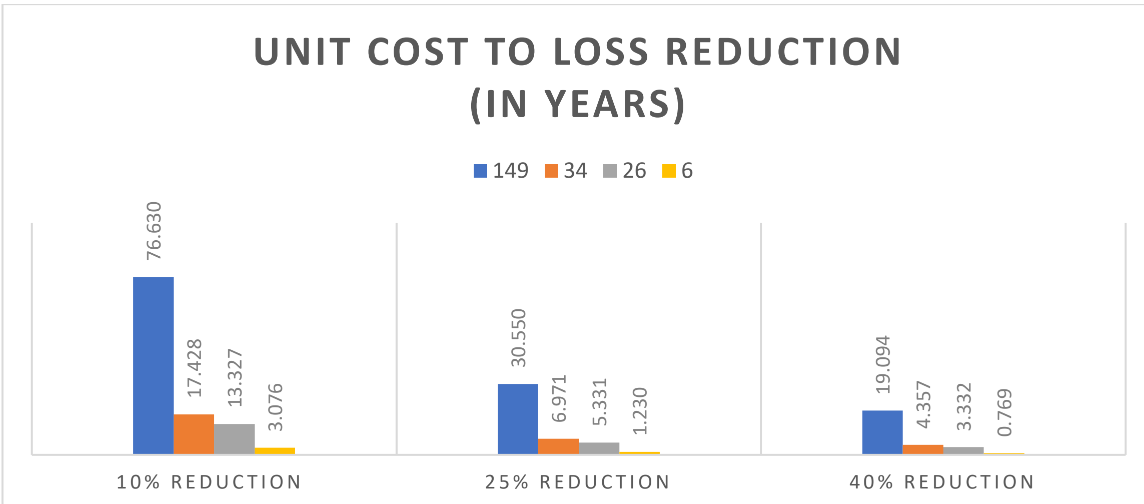

Table 8. Unit Cost ot Loss Reduction Benefit (in Years).

Broadman et al. (2018) states that “analysts always face some uncertainty about the magnitude of the predicted impacts and the assigned values” (Boardman et al. 2018, p. 279). Given the data provided by CNSL, we extrapolated general assumptions regarding the larger U.S. Fleet. Without exact inventory data, our findings will only demonstrate a predicted level of loss to the benefit of implementing the IUID system. However, we do view these inventory rates as representative. As industry improves, the costs have the potential to decrease, thus decreasing the overall price. Lastly, with open competition, contracting and industry are potentially capable of achieving a lower price for purchase and implementation. Our numbers were based off a single provider at a standard rate.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

Over the course of this research, we discussed Navy inventory practices, available inventory management technologies, current Navy inventory accuracy rates for certain surface ship classes, IUID policy, and current status of IUID implementation within the Navy. The Navy has not effectively implemented its IUID plans to be in compliance with applicable DOD and SECNAV instructions. This is partially due to the fact that not all required contract solicitations have necessary DFARS clauses in the solicitations and contracts, but it is mainly because Navy commands do not acquire the hardware and software, and performed the training to construct their own asset UII marking tags.

Additionally, the software required to implement IUID is another system that the Navy would be required to purchase, training personnel on, and does not currently integrate with R-Supply, NALCOMIS, or the other inventory management systems the Navy uses. While software and computers are available that can allow Navy personnel to input items into the IUID registry, they are standalone machines and are not networked with other computers.

The Navy also has the potential to save scarce funding through inventory loss mitigation via improved inventory tracking. This would free up these funds to better serve the needs of the Navy. While also eliminating wasteful use of funds, IUID has the potential to help better posture the Navy to complete mandated requirements under FIAR.

The initial outlay of funds for necessary IUID hardware and software, should the Navy decide to pursue implementation, could potentially be significant. This would be determined by how quickly the Navy decides to mark its required assets. The quicker the Navy wants to have its assets marked, the more systems it would have to purchase and put into use. However, with an increase in initial outlay, should come a corresponding increase in speed reaching compliance and realizing cost avoidance.

While the payback periods presented in some of the scenarios presented represent relatively long time frames, and others are unrealistically long, the Navy now has information that will be helpful in determining whether the cost of compliance is worth these lengthy payback periods. The Navy also has information that will allow it to tailor any solution it deems worth pursuing. Cost information has been provided that will allow the Navy to determine how many systems it should purchase as well as where it should deploy these systems.

B. RECOMMENDATIONS

The authors' recommendations include purchasing an initial batch of 26 IUID marking systems to place at each of the six RMC sites, as well as for each aircraft carrier and large deck amphibious ship. Given the large amount of inventory on CVNs and LHA/LHDs this would give them the ability to mark required equipment right at the command where the inventory is located. They additionally would likely have personnel that could be easily trained to use the required hardware and software. The RMCs would have the ability to mark equipment when ships go through their maintenance availabilities and items are sent to them. Given the type of material the RMCs perform maintenance on, they would see a substantial amount of material that is required to be marked per DOD instructions.

Should this initial feasibility test prove to work well, the NAVSEA and NAVSUP can determine whether the program should be expanded to other classes of ships. One potential exception to this concept is for submarines, LCSs, and MCMs. Given space limitations on these classes of ships, and the large number of submarines and LCSs, their ISICs or TYCOMs can be the centralized activity for completing and distributing UII tags, in consultation with the particular ship crews.

In furtherance of helping the Navy find and ensure that legacy material is marked, training on IUID requirements should be implemented at 3MO/3MC school. This will allow these key positions onboard ships to help implement verifying IUID markings on required equipment in their ships' zone inspection program. Required items found to be lacking UII markings can then be noted on the Zone Inspection Discrepancy Lists (ZIDL). These are key documents that command leadership use to verify that discrepancies are being corrected. This program can also be used to enter work candidates in OMMS-NG or other maintenance tracking systems to have labels created either by ship's force or by the local maintenance facility.

For the actual physical creating of UII markings, training on applicable hardware and software can be implemented at Logistics Specialist (LS), Machinist Mate (MM), Machinery Repairman (MR) "C" schools.

One relatively straight forward process improvement that has the ability to improve IUID compliance at the margins is increased training for Navy contracting officials to reiterate that contract solicitations and follow on contracts contain required DFARS clauses. Contracting officials enforcing compliance from contractors to the DFARS can help reduce shipment of material to the Navy that is out of compliance. This would require CORs and receiving personnel to also be trained on what is required to be marked with a UII marking and to report non-compliance to the contracting officials.

C. AREAS FOR FURTHER RESEARCH

While the data in this study was for various classes of ships and provided a good sample of expected inventory losses for those classes of ship per type of inventory, this study did not cover inventory losses for aircraft carriers and large deck amphibious ships. Given the significantly larger inventory per ship any reduction in loss of inventory would help reduce the payback period if IUID systems were only implemented at RMCs. Additionally, this study does not cover inventory loss rates for Carrier Air Wing (CVW) units. Therefore, no cost benefit analysis has been performed to determine payback periods for IUID implementation at CVW units.

While the recommendations made above presented training various types of Navy personnel to help better manage required assets, these recommendations were presented in broad strokes. Specific implementation, should the Navy decide to pursue IUID implementation more rapidly, would need to be developed and implemented at the specific schools and training pipelines for those roles within the Navy.

One area that may provide promise for future research is the feasibility of RFID technology onboard Navy ships. This will have to take into account the effect that metal bulkheads would have on transmission of RFID tags as well as how these transmissions may affect other Navy equipment that emits and receives electromagnetic signals. Only after this technology is determined to be feasible would a cost benefit analysis provide any value to Navy decision makers.

APPENDIX A. SALARY TABLE

SALARY TABLE 2021-GS

INCORPORATING THE 1% GENERAL SCHEDULE INCREASE

EFFECTIVE JANUARY 2021

Hourly Basic (B) Rates by Grade and Step
Hourly Title 5 Overtime (O) Rates for FLSA-Exempt Employees by Grade and Step

Grade	B/O	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9	Step 10
1	B	$ 9.46	$ 9.77	$ 10.09	$ 10.40	$ 10.72	$ 10.90	$ 11.21	$ 11.52	$ 11.54	$ 11.83
	O	*14.19*	*14.66*	*15.14*	*15.60*	*16.08*	*16.35*	*16.82*	*17.28*	*17.31*	*17.75*
2	B	10.63	10.89	11.24	11.54	11.67	12.01	12.35	12.70	13.04	13.38
	O	*15.95*	*16.34*	*16.86*	*17.31*	*17.51*	*18.02*	*18.53*	*19.05*	*19.56*	*20.07*
3	B	11.60	11.99	12.38	12.76	13.15	13.54	13.92	14.31	14.70	15.08
	O	*17.40*	*17.99*	*18.57*	*19.14*	*19.73*	*20.31*	*20.88*	*21.47*	*22.05*	*22.62*
4	B	13.03	13.46	13.89	14.33	14.76	15.20	15.63	16.06	16.50	16.93
	O	*19.55*	*20.19*	*20.84*	*21.50*	*22.14*	*22.80*	*23.45*	*24.09*	*24.75*	*25.40*
5	B	14.57	15.06	15.54	16.03	16.52	17.00	17.49	17.97	18.46	18.95
	O	*21.86*	*22.59*	*23.31*	*24.05*	*24.78*	*25.50*	*26.24*	*26.96*	*27.69*	*28.43*
6	B	16.24	16.79	17.33	17.87	18.41	18.95	19.49	20.03	20.58	21.12
	O	*24.36*	*25.19*	*26.00*	*26.81*	*27.62*	*28.43*	*29.24*	*30.05*	*30.87*	*31.68*
7	B	18.05	18.65	19.26	19.86	20.46	21.06	21.66	22.26	22.87	23.47
	O	*27.08*	*27.98*	*28.89*	*29.79*	*30.69*	*31.59*	*32.49*	*33.39*	*34.31*	*35.21*
8	B	19.99	20.66	21.32	21.99	22.66	23.32	23.99	24.66	25.32	25.99
	O	*29.99*	*30.99*	*31.98*	*32.99*	*33.99*	*34.98*	*35.99*	*36.48*	*36.48*	*36.48*
9	B	22.08	22.82	23.55	24.29	25.02	25.76	26.50	27.23	27.97	28.70
	O	*33.12*	*34.23*	*35.33*	*36.44*	*36.48*	*36.48*	*36.48*	*36.48*	*36.48*	*36.48*
10	B	24.32	25.13	25.94	26.75	27.56	28.37	29.18	29.99	30.80	31.61
	O	*36.48*	*36.48*	*36.48*	*36.48*	*36.48*	*36.48*	*36.48*	*36.48*	*36.48*	*36.48*
11	B	26.72	27.61	28.50	29.39	30.28	31.17	32.06	32.95	33.84	34.73
	O	*36.48*	*36.48*	*36.48*	*36.48*	*36.48*	*36.48*	*36.48*	*36.48*	*36.48*	*36.48*
12	B	32.02	33.09	34.16	35.22	36.29	37.36	38.43	39.49	40.56	41.63
	O	*36.48*	*36.48*	*36.48*	*36.48*	*36.48*	*37.36*	*38.43*	*39.49*	*40.56*	*41.63*
13	B	38.08	39.35	40.62	41.89	43.15	44.42	45.69	46.96	48.23	49.50
	O	*38.08*	*39.35*	*40.62*	*41.89*	*43.15*	*44.42*	*45.69*	*46.96*	*48.23*	*49.50*
14	B	45.00	46.50	48.00	49.50	51.00	52.49	53.99	55.49	56.99	58.49
	O	*45.00*	*46.50*	*48.00*	*49.50*	*51.00*	*52.49*	*53.99*	*55.49*	*56.99*	*58.49*
15	B	52.93	54.69	56.46	58.22	59.98	61.75	63.51	65.28	67.04	68.81
	O	*52.93*	*54.69*	*56.46*	*58.22*	*59.98*	*61.75*	*63.51*	*65.28*	*67.04*	*68.81*

Table 9. The 2021 Salary Table for GS Employees

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APPENDIX B. SELECTED LOCATIONS FOR NAVSUP AND CNRMC IUID IMPLEMENTATION

Selected NAVSUP locations considered for implementation of IUID systems.

FLC Jacksonville
- NCBC Gulfport
- NS Mayport
- SUBASE Kings Bay
- NAS Meridian
- NSA Panama City
- NAS Pensacola

FLC Norfolk
- Norfolk Naval Shipyard
- SUPSHIP Bath
- FLCN Oceana
- FLCN Groton
- FLCN Crane
- NAS Pax River

FLC Pearl Harbor

FLC Puget Sound
- FLC Everett
- NAS Whidbey Island

FLC San Diego
- NAB Coronado
- NAS North Island
- NAS Lemoore
- NAS Fallon

FLC Sigonella

FLC Yokosuka
- FLC Guam

Commander, Navy Regional Maintenance Center locations considered for implementation of IUID systems.

Mid-Atlantic Regional Maintenance Center (MARMC) – Norfolk, VA

South-East Regional Maintenance Center (SERMC) – Mayport, FL

South-West Regional Maintenance Center (SWRMC) – San Diego, CA

Forward Deployed Regional Maintenance Center (FDRMC), Det Rota – Rota, Spain

Regional Maintenance Center Northwest – Puget Sound, WA

Hawaii Regional Maintenance Center – Pearl Harbor, HI

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