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IMPLEMENTATION OF RFID TO IMPROVE ACCOUNTABILITY IN DISTRIBUTED MARITIME OPERATIONS AND EABO

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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

IMPLEMENTATION OF RFID TO IMPROVE ACCOUNTABILITY IN DISTRIBUTED MARITIME OPERATIONS AND EABO

by

Briana N. Barca and John D. Elliott II

June 2023

Thesis Advisor: Thomas J. Housel
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This study examines the possibility of implementing radio frequency identification (RFID) technology to improve inventory control within the Marine Corps' Expeditionary Advanced Base Operations (EABO) construct. The lack of inventory control in austere environments and isolated operations reduces the Marine Corps' ability to train, man, and equip the operating forces. The study focuses on the technology's applicability to maritime operations, resource management, and implementation within EABO. The costs and benefits of using RFID in amphibious operations and the littorals will be analyzed with special attention given to accountability and electromagnetic (EM) signature. By-hand accountability is labor- and time-intensive. Implementing RFID technology can reduce man-hours spent tracking equipment and save hundreds of hours on asset visibility. The study shows that implementing RFID technology in the Marine Corps' EABO construct can improve resource management, reduce manpower hours, and save costs due to the ease of understanding and implementation of this technology. This study demonstrates that projected improvements from RFID technology in the DOD may be overly conservative and that decision-makers should consider the actual outcomes from previous case studies when assessing the potential benefits of implementing RFID technology.

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IMPLEMENTATION OF RFID TO IMPROVE ACCOUNTABILITY IN DISTRIBUTED MARITIME OPERATIONS AND EABO

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ABSTRACT

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LIST OF ACRONYMS AND ABBREVIATIONS

AIT	Automatic Inventory Tracker
AWS	Amazon Web Services
BOG	Beach Operation Group
CMR	Consolidated Memorandum Report
DOD	Department of Defense
EAB	expeditionary advanced base
EABO	expeditionary advanced base operations
HCL	Hindustan Computers Limited
iATM	Intelligent Asset Tracking and Management
IOT	Internet of Things
LoRaWAN	Long Range Wide Area Network
MAGTF	Marine Air Ground Task Force
MEU	Marine Expeditionary Unit
MND	Ministry of National Defense
NAVLOG	Navy Logistics
POG	Port Operation Group
RFID	radio frequency identification
ROI	return on investment
ROK	return on knowledge
UID	Unique Identifier
USMC	United States Marine Corps

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EXECUTIVE SUMMARY

This study showcases the potential benefits of radio frequency identification (RFID) technology for logistical inventory processes in the Marine Corps' Expeditionary Advanced Base Operations (EABO) construct. The lack of inventory control in austere environments can result in reduced training and equipping of operating forces, but RFID technology can provide real-time visibility of inventory levels and locations, prevent stockouts and overstocking, and reduce manpower hours required for conducting logistics operations.

The study evaluates the feasibility of conducting end-to-end inventory from deployment on land to ship, small vessel, remote island, and back, with special attention given to accountability and electromagnetic (EM) signature. The study models the use of RFID technology with an Incremental To-Be Model and a Radical To-Be Model to estimate the value of the technology in streamlining logistical processes. The preliminary results indicated that there would be a potential increase in productivity as evidenced by the ROK and the ROI (productivity ratios) estimates of 359% and 259% for the Incremental To-Be Model and, a 1363% and a 1263% for the Radical To-Be Model.

The one-year cost savings for the incremental and radical model data are represented in Table 12 of this thesis, and the data was then extrapolated over a 10-year period using a straight-line multiplier with the estimated cost savings reported in Figure 21. The radical model was used to project a 10-year and 20-year projection based on 231 total process executions per year, resulting in a projected cost savings in excess of $80,000,000, with a ROK and a ROI of 2110% and 2010%.

This study recommends immediate implementation of the Radical To-Be Model utilizing RFID technology. The ease of learning and implementing this mature technology also makes it a low-risk, practical solution for the Marine Corps. Future research and recommendations include conducting the experiment on a large or small scale, testing and evaluating RFID technology for real-world scenarios, and exploring the use of RFID implementation on a MEU for exercises in the Pacific for units on Okinawa, Guam, Japan, and Hawaii for whenever they leave an island and/or conduct training.

In conclusion, the implementation of RFID technology can enhance the inventory control system within the Marine Corps' EABO construct, providing better accountability of resources, and act as a forcing function for push-based logistics to better manage resources. The Radical To-Be Model utilizing RFID technology shows the most significant cost savings and is recommended for immediate implementation. It is possible that projected improvements from the use of RFID technology in the DOD logistical processes may be overly conservative and that decision-makers should consider the actual outcomes from using the technology for inventory processes in previous case studies when assessing the potential benefits of implementing RFID technology. Finally, the implementation of RFID technology is a low risk, practical solution that can save significant costs, boost ROI, and provide better visibility and accountability of resources for the Marine Corps.

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I. INTRODUCTION

A. PROBLEM STATEMENT

The problem that motivated this research is the lack of inventory control within the Marine Corp's expeditionary advanced base operations (EABO) construct. This new construct currently requires resources to be more dispersed in austere environments with minimal means to account for said gear. This is a problem because these isolated operations reduce the Marines Corps ability to train, man, and equip the operating forces.

B. PURPOSE STATEMENT

The purpose of this research is to model the potential value added of RFID within EABO and to determine its potential functionality, limitations, use cases for the Marine Corps. This is important because it will enable commanders to make critical decisions with relevant and timely inventory information. RFID implementation will foster better accountability of resources and act as a forcing function for push logistics to better manage resources.

C. METHODOLOGY

The current inventory control and management process used by the Marine Corps for loading and unloading Marine Expeditionary Units (MEUs) is a personnel-heavy process that requires multiple counts, heavy supervision, and redundant processes for quality assurance. Before loading is executed, a detailed planning process is conducted to ensure that all the necessary equipment and supplies are loaded within given parameters. The "As-Is," baseline process involves various sub-processes such as inventory preparation, sending manifests for approval, counting, marking and moving equipment and supplies, loading equipment and supplies, assigning equipment to tenders, moving equipment from tenders to the forward operating base (FOB), monitoring inventory, and sending reports for resupply requests. The technology tools used for the To-Be model would be interoperable with most new systems that would be put in place as well as, current systems used to inventory, track, and assign equipment throughout the various stages of loading including Personal Deployment Kit (PDK) and current tracking tools. A MEU is comprised of multiple ships, and there are three ways to load equipment on a MEU, which include through the well deck, the hanger bay, or the flight deck.

The current As-Is model for accountability is examined using the knowledge value added (KVA) methodology. The KVA methodology, developed by Dr. Thomas Housel and Dr. Valery Kanevsky, is a framework for managing and maximizing a return on knowledge assets (i.e., using the ROK productivity ratio). KVA describes all process outputs in common units. This permits a productivity (i.e., output/input) estimation resulting in comparable Return on Investment (ROI) ratio and Return on Knowledge estimates (ROI and ROK are 100% correlated) for all processes . The KVA methodology was used to assess the current As-Is process for MEU onload and offloads and a to create To-Be models that assumed the implementation of RFID technology.

Measuring return on knowledge (ROK) is a crucial aspect of the KVA methodology. Completing a KVA analysis will produce an ROK ratio that allows a user to estimate the value added by a given knowledge asset (i.e., human or technology), regardless of its location in the process. The KVA theory assumes that organizationschange process inputs, using the knowledge embedded in humans and technology, into process outputs, and the amount of knowledge required to produce an output can be reliably estimated in common learning time units. This description of outputs in common units makes all process outputs comparable.

The KVA methodology can be broken down into nine steps, and there are three approaches to measuring the value of knowledge within a process: learning time, process process instructions, and binary query (bits) method. The learning time approach was used in this research to generate all the productivity (i.e., ROI, ROK) estimates. .

The KVA methodology has been applied to countless companies over the last 30 years, allowing organizational leaders to reexamine how their companies execute their business strategies in the context of comparable estimates of core process productivity. The KVA analysis in this project will compare the current As-Is process for MEU on-load and off-load with the proposed two versions of the To-Be processes that incorporate the addition of RFID technology. The analysis showed the affect of this technological addition on efficiency, that includes the affect of decreased time per task and better inventory control.

Recent studies were also reviewed to see how common inventory process applications utilized or studied how RFID improved inventory logicial processes The most recent study by Medeiros and Zukowski (2021), evaluated the potential utilization of passive RFID technology to improve asset accountability in the Marine Corps. The study found that the RFID-enhanced process model can save up to $31,568.09 per implementation and $402,777.60 annually across all twelve communication line Marine companies, indicating that passive RFID technology also can bring significant benefits to the Marine Corps inventory process. The second study by Obellos et al. (2007) examined the inadequate asset visibility in military logistics and how it affects combat readiness. The study proposed implementing RFID and Unique Item Identification (UID) technology in the Navy Supply material operational processes at Naval Surface Warfare Center, Crane, to improve asset visibility and enhance customer service. The analysis showed that the implementation of RFID/UID technology promised to significantly increase inventory process ROI, resulting in a total estimated improvement of 212%. Both studies highlight the advantages of implementing RFID technology in military inventory processes to improve productivity, reduce time, cost, and improve asset visibility.Lastly, the Korean Ministry of National Defense plans to implement RFID technology in its logistics operations to improve productivity and reduce costs as proven by a study done by Jung et al. (2009). These authors used the KVA theory to accurately determine the ROI of the RFID implementation. The two case studies showed an expected improvement range of 272% to 394%, which can help decision-makers estimate the ROI for current and potential IT investments. The study suggests that RFID has the potential to improve logistics processes, and the KVA methodology is recommended as a promising way to evaluate the value added benefits of RFID implementation. We believe that the projected improvement from RFID technology in the DOD may be too conservative.

D. THESIS ORGANIZATION

This thesis is comprised of six chapters. Chapter I will be an introduction to the research topic and focus of the study. Chapter II will be comprised of the literature review, discussing the background of EABO and RFID technology. Chapter III will discuss the methodology that was used to model potential affects of the technology on given logistical processes that were the focus of this thesis study. Chapter IV the estimated results of the technology on productivity using the KVA methodology. As well as the two optimization modeling results, explaining the findings of the incremental and radical To-Be models. Lastly, Chapter V will be the conclusion that wraps up the study and provides future research reccomenations and paths to explore on this topic.

II. LITERATURE REVIEW

A. RADIO FREQUENCY IDENTIFICATION OVERVIEW

The problem that motivated this research is the lack of inventory control within the Marine Corps' EABO construct. This construct requires resources to be dispersed in austere environments with minimal means to account for said gear. The lack of inventory control limits the Marine Corps' ability to train, man, and equip the operating forces. One potential solution is the implementation of RFID technology.

RFID technology functions by using a broad frequency range within the electromagnetic (EM) spectrum to wirelessly identify and track objects or people (Bolic et al., 2010). RFID tags are attached to objects and serve as their unique identifier, while RFID interrogators communicate remotely with the RFID tags to identify the object in question (Bolic et al. 2010).

Three types of RFID technology are available today: active, passive, and semi-passive (Bolic et al., 2010). The active RFID operates using battery-powered tags that communicate with interrogators, while passive RFID technology uses interrogators to communicate with tags. Semi-passive tags function as a network of nodes that can carry out tasks collectively and locally once they are established (Bolic et al., 2010). All of these tag options have a limited range and a low EM signature. The best implementation for successful use in EABO would be a combination of these technologies, outlined later in this chapter.

RFID technology utilizes radio waves to automatically identify (Auto-ID) and track objects or people, making it a type of Automatic Identification Technology (AIT) (Dobkin, 2007). Its radio wave technology allows it to identify and retrieve information remotely, such as a military member's identification card (Dobkin, 2007). Other types of AIT systems include "bar code, biometric, voice identification, and optical character recognition" (Lahiri, 2005, p. 96). Auto-ID systems are designed to identify objects without human intervention and can be integrated with Automatic Identification Data Capture (AIDC) to input information into computer databases without manual data entry (Medeiros et al., 2021). The main objectives of Auto-ID systems are to increase efficiency, reduce errors caused by manual data entry, and allow personnel to focus on more critical tasks, such as surveillance and security (Medeiros et al., 2021)

1. Spectrum

The use of RFID technology can significantly improve inventory control in austere environments, which is critical to the Marine Corps' EABO construct. Therefore, understanding the different RFID frequency bands and their applications can help us determine the most suitable technology for this purpose. Different RFID systems operate at various frequencies. The most common RFID frequency bands are 125/134 kHz, 13.56 MHz, 860–960 MHz, and 2.4-2.45 GHz (Dobkin, 2007) as seen in Table 1.

Table 1. Spectrum Analysis. Source: Medeiros et al. (2021).

Band	Frequency Range	Operating Environment	Antenna size	Read rate	Read distance
LF	**125-134kHz**	**Metals, liquids, dirt, snow, mud**	**Largest**	**Lowest**	**Less than 1 foot**
HF	**13.56MHz**	**Fair on metals & liquids**	**Large**	**Low**	**About 3 feet**
UHF	**315-433Mhz**	**Poor on metals & liquids**	**Small**	**High**	**About 30 to 300 feet**
MW	**2.45 or 5.8GHz**	**Very poor on metals & liquids**	**Smallest**	**Very high**	**About 100 feet**

RFID technology operates at different frequencies, and the wavelength of low-frequency RFID systems (125/134 kHz) is significantly longer than high-frequency and ultra-high-frequency bands. Due to the longer wavelength, low-frequency RFID is best suited for short-range and limited data transmission applications, like access control with your Common Access Card (CAC) (Dobkin, 2007). Conversely, high-frequency tags have a shorter read range but can transmit data at a higher rate due to a larger bandwidth. They are often used in encrypted access control systems, passports, and near-field communication equipment (Dobkin, 2007). The advantages of ultra-high frequency RFID include its long-range capability, high data rates, and affordability and can be used to scan large items moving onto a MEU through a bay door, or Marines entering a small amphibious vessel (Medeiros et al., 2021).

2. System

RFID tags play a crucial role in inventory control, as they serve as the unique identifier for each object. Therefore, understanding the different types of RFID tags and their components is essential for determining the most effective way to track and manage resources in the EABO construct.

a. Tags

Understanding the different types of RFID tags is critical to determining the most suitable technology for inventory control in EABO. Each type of tag has its unique features, and understanding these features can help us determine which type of tag is best suited for the Marine Corps' specific needs. The three types of RFID tags are passive, semi-passive, and active, which use different means to communicate with the interrogator (Bolic et al., 2010). Passive RFID tags rely on backscattered signals to communicate with the interrogator, as they lack a local power source (Dobkin, 2007). Instead, they draw energy from the radio waves transmitted by the interrogator, before transmitting data back to the interrogator. Semi-passive RFID tags, on the other hand, have a local battery to power their onboard circuitry, but rely on backscattered signals to communicate with the interrogator (Dobkin, 2007). Active RFID tags have their own power source, which allows them to transmit data directly to the interrogator (Medeiros et al., 2021).

RFID transponders typically have three main components: an antenna, a microchip, and a protective casing (Lahiri, 2005). The antenna is designed to receive the reader's signal, and it can have a three-dimensional shape for a more efficient signal absorption rate. The microchip unit is responsible for storing the data, and its storage capacity varies depending on the type of tag (Lahiri, 2005). The unit will be "read-only" or "read-write." A "read-only" microchip is typically used for initial identification, and it ensures that the tag contains the same information throughout its lifetime. For instance, when manufacturing tags are attached to vehicles, they contain information that does not change throughout the vehicle's life, such as the vehicle identification number (VIN) (Lahiri, 2005).

b. Passive RFID Tag

A passive RFID tag is not self-powered and instead receives its energy from the reader to transmit data. This type of tag would prove beneificial in an austere environment where low EM signature is critical, and where battery replacement is not likely to occur. The radio frequency transmitted by the reader provides energy to the tag's antenna, which in turn activates the microchip circuitry to send the encoded signal back to the reader, as shown in Figure 1 (Dobkin, 2007). Passive tags are advantageous as they have a longer lifespan (about 20 years), lower unit cost, and smaller size due to not needing a battery (Dobkin, 2007). Passive tags are the most affordable and smallest type, making them suitable for many different applications. However, passive tags also have some disadvantages, such as a limited read distance between the reader and tag, limitations in electrical power usage, and an extended lifespan. These disadvantages can lead to incorrect information in the database (Dobkin, 2007). Since passive tags rely on backscattered signals to communicate with the interrogator, their read range is limited. Therefore, understanding the limitations of passive RFID tags is essential to determine whether they are suitable for monitoring items at a distance, or simply used to account for items as they pass through an interrogator aboard a ship.

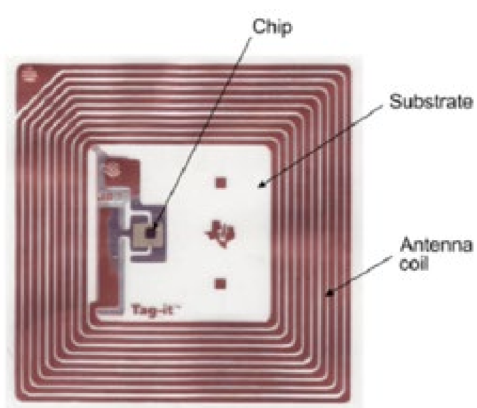

Figure 1. RF Tags. Source: Dobkin (2007).

c. Active RFID Tag

The tags that are powered by a battery are known as active RFID tags. These tags have a built-in power source and their transmitter sends a continuous signal to a reader (Kumar Pal et al., 2017). Active tags have the advantage of being able to record external temperatures through various sensors which can be used to monitor essential equipment functionality (Kumar Pal et al., 2017). However, active tags have certain disadvantages, such as battery dependence, which can limit their lifetime expectancy, and their larger size and higher cost, which may reduce their applicability. Replacing the battery can also be expensive in the long term.

d. Semi-passive RFID Tag

Semi-passive RFID tags are composed of transponders, which act as both transmitters and receivers, and have their power supply that is battery-powered. These tags become active when they receive a specific coded signal from the reader, and they only use battery power when transmitting the signal back. This enables them to save battery power and extend their lifespan. They have advantages such as longer read distance rates than passive tags, extended service life, and the ability to conduct two-way communication. Active and semi-passive tags have the advantage of extended range capabilities that can be used over 30 meters. On the other hand, passive tags are less expensive and can be used for low and high-cost items with reading ranges of less than seven meters. Semi-Passive tags may be the most beneficial for EABO when weighing the capabilities and limitations among the three types of tags. Figure 2 provides details on the capabilities of various RFID tags (Hoon 2017).

Tag type	Frequency type	Advantages	Limitation	Capabilities
Passive	All frequencies, mainly LF & HF	Best in cost, and life-span.	Identification only, less read range	Anti-theft, supply chain management, inventory control, access control, animal tagging
Semi-Passive	All frequencies, mainly LF & HF	Better in cost, life-span, less sensors	Limited memory, battery dependent	Pallet-level of supply chain management, inventory control, environmental control
Active	All frequencies, mainly UHF & MW	High memory, reading range, more sensors	High cost, battery dependent	Inventory management and control, electronic toll collection, real time location management

Figure 2. RFID Tag Capabilities. Source: Hoon (2017).

3. Reader

An RFID reader, or interrogator, is a system component that communicates with RFID tags, transmitting and receiving data. One of its main functions is to energize a passive tag by converting the reader's radio frequency into an electrical field, as seen in Figure 3. A reader can either be handheld or fixed, depending on its purpose and operation. A handheld device is typically used for inventory management, while a fixed device is used to read mobile tags in the operational area, such as shipping or receiving bay doors. A reader antenna facilitates communication between the the tag and the reader. It must be appropriately positioned for maximum reading accuracy (Kumar Pal et al., 2017). Antennas are typically square boxes or rectangles and have a three-dimensional, ellipsoid-shaped footprint that determines the read zone or window. The read accuracy and rates are optimized within this footprint (Kumar Pal et al., 2017; Hoon, 2017).

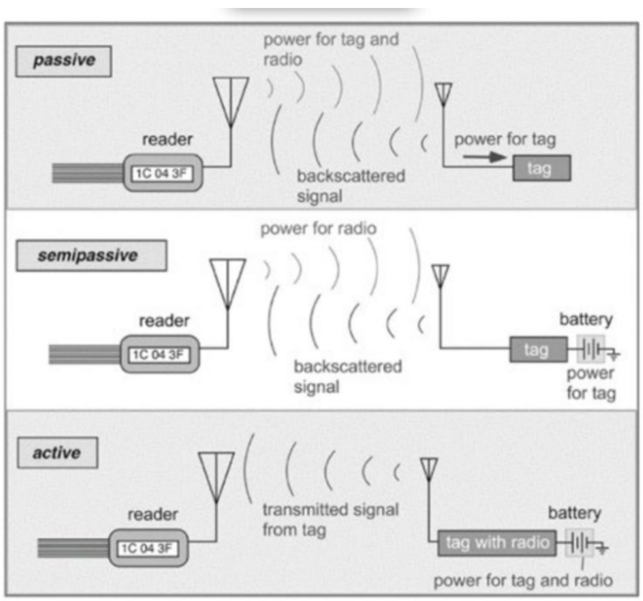

Figure 3. RFID Tag Configuration. Source: Dobkin (2007).

A reader antenna is essential for reader-tag communcation. It functions by sending an RF signal from the reader transmitter within the operational environment and then receiving the signal back from to the tag (Hoon, 2017). To ensure that reading accuracy is optimized, the antennas must be correctly positioned. The antennas come in different shapes, such as square boxes or rectangles, and the read zone, window, or pattern is determined by the antenna's footprint, which is three-dimensional and ellipsoid in shape (Hoon, 2017). Read rates and accuracy are optimized within this footprint.

Different types of antennas are used for specific applications, depending on the operating frequency, tag size, and the reading distance required (Kumar Pal et al., 2017). Two common types of antennas used in RFID systems are the linearly polarized and circularly polarized antennas. Linearly polarized antennas are commonly used in applications where the tag's orientation is known, whereas circularly polarized antennas can read tags from any orientation, making them suitable for general applications (Hoon, 2017).

RFID systems can also incorporate additional features, such as real-time location systems (RTLS) and sensors, to provide more functionality. RTLS uses a network of RFID readers and antennas to track and locate tagged objects within a defined area (Kumar Pal et al., 2017). Sensors can also be integrated into RFID systems to monitor environmental conditions, such as temperature and humidity, during the product's transportation and storage. This integration provides real-time monitoring, enabling the system to raise an alert if conditions fall outside the specified range.

4. Infrastructure

The communication infrastructure is a vital part of the RFID system that links all system components and supports system security and management. The connection between different components can be either wired or wireless. Bluetooth wireless products can operate in various types of networks, such as personal area networks (PANs), local area networks (LANs), and wide area networks (WANs) (Hoon, 2017).

5. LoRaWAN

LoRaWAN is a wireless network protocol that can be instrumental for connectivity in the littorals. This technology leverages sensor terminals to transmit data to gateways, which then send data packets to a server, typically via a cellular connection such as 4G/5G (Figure 4). LoRaWAN can be used in diminished and downgraded environments to leverage communications for a read distance of five to 10 kilometers (3.1 to 6.2 miles), with packets containing 292 bits to 50 kilobits of data (Handley, 2022). Thus, Internet of Things (IoT) Ventures seeks out opportunities that cannot be easily solved using other technologies. With low-Earth orbit (LEO) satellites that employ LoRaWAN transmission, data can be forwarded to a server every time a satellite is within range (Handley, 2022).

a. Implementation

Managers must carefully examine and analyze the issues of selection and justification before investing in RFID technology. In the case study that follows, we focus on the operational requirements of RFID technology and the benefits it offers in terms of quality, speed, flexibility, and cost of the four main operational process capabilities (Jones, 2022).

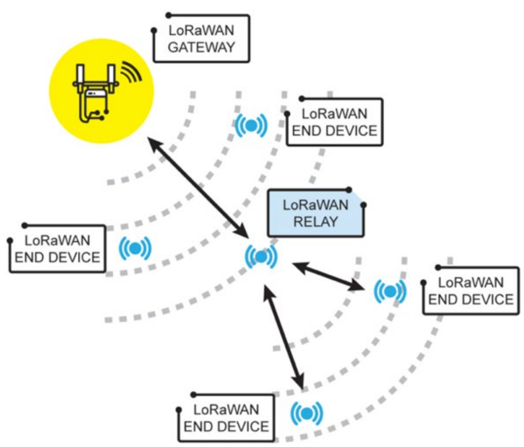

Figure 4. LoRaWAN Relay. Source: Jones (2022).

b. Cook Island Case Study Take Aways

- IoT Ventures' LoRaWAN-based sensors, with satellite or cellular connectivity, can bring visibility into the fill levels of water tanks in the most remote Cook Islands, or at other sites, as well as warn citizens and officials about water problems during droughts (Jones, 2022).
- In the long term, the technology will help both federal and local officials better strategize water usage by predicting consumption based on the collected data (Jones, 2022).

The LoRa Alliance's innovative technology will allow for expanded coverage in low-connectivity zones. "The relay feature allows for the implementation of battery operated, easy-to-deploy network coverage extensions in lieu of additional gateways. This allows LoRaWAN to achieve coverage in use cases requiring deep indoor or underground coverage, or to relay data on satellite connected LoRaWAN devices within proximity" (Jones, 2022, p. 1).

B. USMC MEU LOGISTICS

1. MEU

To better understand the challenges facing the Marine Corps in inventory control, it is important to first understand the role of the MEU and its various capabilities. As stated by the United States Marine Corps (2000), the MEU is designed to provide quick deployable forces with the ability to self-sustain for up to 15 days. This self-sustainability is provided by the Combat Service Support Element (CSSE), which "contains all the essential capabilities, functions, activities, and tasks necessary to sustain all elements of operating forces in theater at all levels of war" (USMC, 2018, p. 1-1). However, with the new EABO construct, resources are now more dispersed in austere environments with minimal means to account for said gear. This is a problem because these isolated operations reduce the Marines Corps ability to train, man, and equip the operating forces, especially for the core MEU missions of amphibious operations, direct action, and military operation other than war (MOOTW) (USMC, 1998).

2. Tactical Logistics

Tactical logistics plays a fundamental role in the success of MAGTF expeditionary operations. According to USMC (2000), logistics encompasses various functions such as "supply, maintenance, transportation, general engineering, health services, and other services" (Figure 5). Specifically, the supply function involves managing the request, distribution, storage, care, salvage, and determining the type and quantity of supplies. Transportation, on the other hand, entails the movement of supplies from one location to another using different modes such as highways, waterways, oceans, railways, pipeline, and airways (USMC, 2000). In the context of EABO, the lack of inventory control makes it difficult to effectively manage and account for these crucial resources. Furthermore, contested logistics within the littorals will further stress the tactical logistics trains. RFID will enable key personnel to focus outward on security and decision making, while technology can reduce the manpower needed to count inventory.

Supply	**Maintenance**	**Transportation**
Determination of requirements	Inspection and classification	Embarkation
Procurement	Service, adjustment, and tuning	Landing support
Storage	Testing and calibration	Port and terminal operations
Distribution	Repair	Motor transport
Salvage	Modification	Air delivery
Disposal	Rebuilding and overhaul	Freight/passenger transportation
	Reclamation	Materials handling equipment
	Recovery and evacuation	
General Engineering	**Health Services**	**Services**
Engineer reconnaissance	Health maintenance	Command services:
Horizontal/vertical construction	Casualty collection	• Personnel administration
Facilities maintenance	Casualty treatment	• Religious ministries support
Demolition and obstacle removal	Temporary casualty holding	• Financial management
Explosive ordnance disposal	Casualty evacuation	• Communications
Bridging		• Billeting
		• Messing
		• Band
		• Morale, welfare, and recreation
		CSS services:
		• Disbursing
		• Postal services
		• Exchange services
		• Security support
		• Legal services support
		• Civil affairs support
		• Graves registration

Figure 5. Functions and Subfunctions of Tactical Logistics. Source: USMC (2010, p. 1-3).

3. Expeditionary Operations

Navy (2009), defines an expedition as “a military operation conducted by an armed force to accomplish a specific objective in a foreign country.” These operations can range from humanitarian assistance, protecting U.S. citizens, establishing, and keeping peace, or armed conflict with an enemy government (USMC, 1999. p. 34). The terminology expeditionary, usually infers that the mission or operation will be temporary in nature and implies that there will be an intended withdrawal from the area in which forces are operating in. Expeditionary operations will typically be conducted in five phases: redeployment, deployment, entry, enabling and decisive actions, and lastly redeployment, as seen in Figure 6. An expeditionary airfield is a prefabricated airfield during these types of operations that can be used in many different capacities.

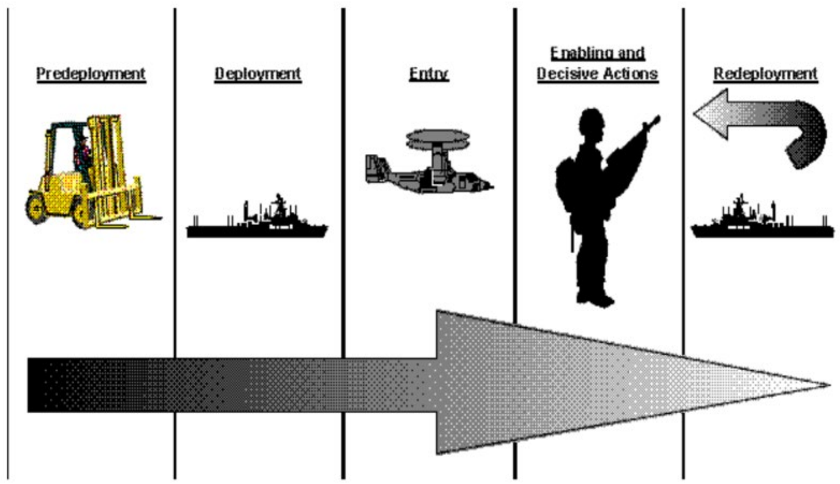

Figure 6. Logistics in Expeditionary Operations. Source: USMC (1999, p. 2-17).

C. USMC/NAVY RFID POLICY

While there is no clear document on RFID for the Marine Corps and the Navy, there have been visions and directives that outline a general idea of which direction the force will head. The most recent Marine Corps Order (MCO) in 2013 describes the mission and execution for using AIT. "AIT is defined as a suite of technologies to include, but not limited to linear barcodes, two-dimensional (2D) barcodes, magnetic strips, Integrated Circuit Chips (ICC), Optical Memory Cards (OMC), RFID (active and passive), and Contact Memory Buttons (CMBs). These enable the automatic capture of source data, thereby enhancing the ability to identify, track, and document material moving through the distribution chain as well as deploying and redeploying personnel, equipment, and materiel" (USMC, 2013, p. 3). The vision the Marine Corps has used in past projects for passive RFID is as follows:

> The Marine Air Ground Task Force (MAGTF) Deployment Support System II (MDSS II) is the Commander's unit level deployment database capable of planning and supporting rapid military deployment anywhere in the

> world. MDSS II enables BICmd to build and maintain a database that contains the prepositioned Maritime Prepositioning Equipment / Supplies (MPE/S) data, reflecting how the MAGTF is configured for deployment. It is vitally important that the data contained in MDSS II is complete, correct, and timely. The processes to enter the data into MDSS II are manual and subject to human error. (USMC, 2009)

The Marine Corps identifies a massive opportunity for AIT in the future fight, recognizing that this innovative technology will decrease individual responsibilities and increase the force's combat effectiveness. A portion of the to-be commander's intent reads, "AIT is a force multiplier with the potential capability to link adjacent and higher logistical organizations" (USMC, 2013, p. 2).

D. EXPEDITIONARY ADVANCE BASE OPERATIONS

The section contains definitions of Expeditionary Advanced Based Operations (EABO) and the Navy and Marine Corps leadership's take on how EABO will be implemented throughout the forces. It will further discuss background information on EABO, the possible mission type, and the definition of an expeditionary advanced base.

1. Background and EABO Defined

The Department of the Navy and Commandment of the Marine Corps created a plan for executing EABO in the *Tentative Manual for EABO* published in February 2021. This document defined the scope and mission of EABO at the unclassified level. EABO is defined as "a form of expeditionary warfare that involves the employment of mobile, low signature, persistent, and relatively easy to maintain and sustain naval expeditionary forces from a series of austere, temporary locations ashore or inshore within a contested or potentially contested maritime area in order to conduct sea denial, support sea control, or enable fleet sustainment" (USMC, 2021, p. 1). The EABO concept will create a resilient force in a forward operating environment, explicitly designed to be conducted by low signature joint forces in dispersed forward-basing infrastructure.

2. Mission Types and Bases

According to USMC (2021), the following are possible missions for EABO:

- Support Sea control operations.
- Conduct Sea denial operations within the littorals.
- Contribute to maritime domain awareness.
- Provide forward command, control, communications, computers, combat systems, intelligence, surveillance, reconnaissance, targeting (C5ISRT), and counter-C5ISRT capability.
- Provide forward sustainment. (USMC, 2021)

Multiple bases must exist as part of EABO to support a naval campaign/MEU operation. While joint doctrine defines a 'base' as an area well-defended with a solid infrastructure, EABO bases might not fall in line. An Expeditionary Advanced Base (EAB) is "a locality within a potential adversary's weapons engagement zone (WEZ) that provides sufficient maneuver room to accomplish assigned missions at sea while sustaining and defending friendly forces" (USMC, 2021, p. 29). These EABs can support and sustain regionally aligned naval forces along with the platforms they possess, as well as warfighters with their weapons and other systems. EABs are not to be confused with stagnant bases; they can be mobile locations such as barges or ferries, which can still allow for mission support. The idea of EABs is to provide the same support as a traditional base, but they allow for less vulnerability and prioritize resiliency over efficiency.

3. The Role of Marines in EABO

The concept of EABO and EABs is not new to the Department of the Navy and the Marine Corps. "The formal mission to establish EABs arises from the enduring operational requirement to support and sustain forward-deployed naval forces." The Marine Corps title 10 responsibilities will now reflect its naval missions formally:

> The Marine Corps shall be organized, trained, and equipped to provide fleet marine forces of combined arms, together with supporting air components, for service with the fleet in the seizure or defense of advanced naval bases and for the conduct of such land operations as may be essential to the prosecution of a naval campaign. (Marine Corps Warfighting Lab, Concepts & Plans Division [MCWL, C&P], 2018)

Marines will be essential to the fight at sea, making austere environments key products of success.

4. Force Design 2030

The Tentative Manual for EABO breaks down the new structure of the MEU for future operations to come by 2030. As pictured in Figure 7, the 2030 MEU will bolster capabilities abroad. It will have many capabilities, including:

- Enabling sea denial and conducting amphibious operations.
- Crisis-response operation.
- Designated special operations to support the requirements of multiple combatant commanders. (USMC, 2018)

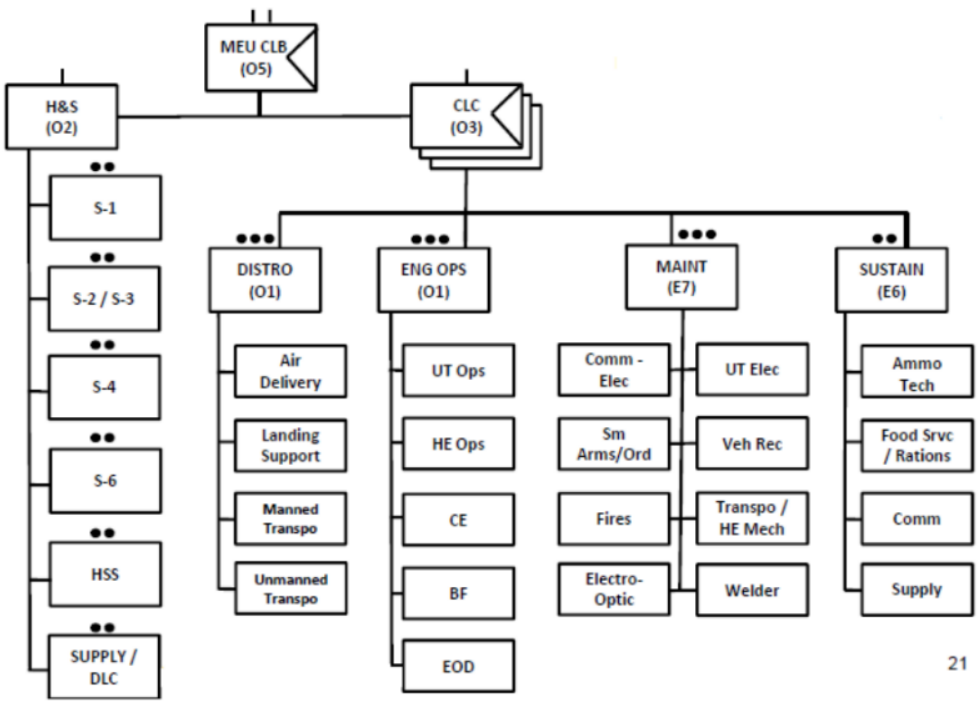

Figure 7. MEU Force Structure. Source: USMC (2021).

For Force Design 2030 to work efficiently, the commanders cannot only restructure the GCE and ACE but the Logistics Combat Element (LCE) as well. "If we do not actively incorporate logistics into our planning for as intricate an operation as EABO, we can expect preventable casualties as a result" (Panicacci, 2021, p. 67). The primary fight for EABO will be in austere environments on multiple island chains, such as those in the south pacific.

E. CASE STUDY

1. Falkland Island

An example of using EABO throughout history is during the Falkland Islands conflict in the 1980s. This historical example supports the need for logistics to adapt for a future fight in EABO to stay relevant and lethal. When Argentina invaded the Falkland Islands, they did not expect much pushback from the British Ministry, who owned those lands, to defend them. The distance from the Falklands to the United Kingdom was a logistical nightmare to launch a campaign; the idea of sustaining a force with that great of distance was something that did not seem possible, reference Figure 8.

Figure 8. Falkland Islands. Source: Panicacci (2021).

Eventually, the British found the answer was EABO, when planners could identify Ascension Island as a piece of crucial terrain for their navy. This island was essentially the halfway point for the United Kingdom to the Falkland Islands, which served as an EAB to support their deployed forces. Ascension Island facilitated the logistics sustainment of their task force so much that they could build tempo in a way that eventually denied the Argentinians time to mount a force strong enough to fight back (Panicacci, 2021). The British's rapid logistic tempo and sustainment led to the Argentine surrender just two months after the initial invasion. A key takeaway from this case study is that the Marine Corps today has similar capabilities that the British did 40 years ago during the Falkland Island Campaign; the capabilities need to be better aligned with its current adversaries to achieve success.

2. Haiti

In 2010, the DOD utilized RFID technology to track shipping containers during a humanitarian aid mission in Haiti following an earthquake (O'Connor, 2010). The RFID tags were read and monitored using the DOD's In-Transit Visibility (ITV) network, which is utilized to track shipments worldwide. Although there have been no significant changes to the RFID technology used by the U.S. military since the mid-1990s, the deployment of a reader infrastructure in Haiti was made easier due to the introduction of portable deployment kits (PDKs) developed by Savi Technology in 2005 (O'Connor, 2010). These PDKs, which include, "an RFID reader, a mobile antenna, and an Iridium 9601 Short Burst Data satellite modem," enabled the military personnel to connect to the Web-based ITV server via the Iridium modem and made ground-based connections and tracking much faster (O'Connor, 2010, p. 2). The PDKs were a significant improvement over the previous method of locating phone lines to establish an Internet connection, as was required during a previous disaster in 1994 (O'Connor, 2010).

F. ASSET VISIBILITY WITH INDUSTRY LEADERS

1. Walmart Cost Analysis for RFID

RFID technology is utilized by the world's largest retailers, including Walmart, to improve inventory management and logistics. By implementing RFID technology, these companies have been able to improve efficiency, reduce costs, and enhance the overall customer experience (Lui, 2023). Walmart was one of the early adopters of RFID and began using it to track inventory in its stores and warehouses in 2003 (Vitasek, 2022). Since then, the company has expanded its use of RFID to other areas of its operations, such as tracking items in its supply chain and managing its food safety program.

While their RFID investment information is not public domain, estimating the cost of implementing and maintaining RFID for Walmart is a complex task that requires a detailed analysis of Walmart's specific needs and requirements. However, we can provide a general overview of the potential costs involved. Firstly, the cost of implementing RFID technology would depend on the scope of the project. Walmart operates over 11,000 stores worldwide and implementing RFID across all stores would require a significant investment (Vitasek, 2022). The cost of the RFID hardware, software, and associated infrastructure would depend on the number of stores, the size of each store, and the specific RFID technology used. According to industry estimates, the cost of implementing RFID technology for a retail store can range from a few thousand dollars to several hundred thousand dollars per store, depending on the number of RFID readers and tags required, the integration with existing systems, and the level of customization required (Lui, 2023).

Assuming a conservative estimate of $50,000 per store, implementing RFID across Walmart's 11,000 stores worldwide would cost approximately $550 million. In addition to the initial implementation costs, there are also ongoing maintenance and operational costs associated with RFID technology. These costs include the cost of replacing and upgrading hardware and software, the cost of maintaining and managing the RFID system, and the cost of training personnel. Again, the exact cost of ongoing maintenance and operational costs would depend on Walmart's specific needs and requirements. However, industry estimates suggest that ongoing maintenance costs could range from 5% to 15% of the initial implementation cost per year (Lui, 2023). Assuming a conservative estimate of 10%, the annual maintenance cost for implementing RFID across Walmart's 11,000 stores would be approximately $55 million per year.

2. Target

While specific cost estimates for implementing and maintaining RFID technology for Target are not publicly available, we can make some educated guesses based on industry standards and trends. First, the cost of RFID tags themselves has been declining steadily over the past decade, with current estimates ranging from a few cents to 50 cents per tag, depending on the type and quantity ordered. However, the cost of implementing the necessary infrastructure, such as readers and antennas, can be significant, especially for a company the size of Target. According to Jones (2015), a single RFID reader can cost anywhere from $500 to $2,000, while a high-performance reader can run as much as $10,000 or more. Antennas can cost between $100 and $500 each (McKevitt, 2016).

In addition to hardware costs, there are also software and labor costs to consider. Target would need to invest in software to manage and analyze the data collected by RFID, as well as potentially hire additional staff to maintain the system. According to some estimates, the cost of implementing an RFID system for a large retailer like Target can range from several hundred thousand dollars to several million dollars, depending on the size and complexity of the operation (Jones 2015). This cost includes the purchase of RFID tags, readers, software, and related infrastructure, as well as the cost of integration and installation. In terms of maintenance costs, Target would need to factor in the ongoing costs of replacing damaged or lost RFID tags, upgrading the RFID infrastructure, and maintaining the software systems (Jones, 2015). The maintenance cost can be a significant ongoing expense, but it is difficult to estimate accurately without knowing the specifics of Target's RFID system.

3. Airbus

According to a case study published by AIM, an industry association focused on automatic identification and mobility technologies, Airbus implemented an RFID-based solution for tracking aircraft parts and tools in its Hamburg plant (Nizam, 2020). The solution involved installing RFID readers and antennas at various locations, as well as tagging parts and tools with RFID labels. The system was integrated with Airbus' existing IT systems to provide real-time visibility into the location and status of parts and tools.

The cost of the Airbus deployment was not disclosed in the case study, but industry estimates suggest that a typical RFID deployment for a large enterprise can cost anywhere from several hundred thousand dollars to several million dollars, depending on the scope and complexity of the deployment. For example, a report by Frost & Sullivan estimated that the average cost of an RFID deployment for a large enterprise is around $2 million to $5 million (Frost & Sullivan, 2016). In addition to the initial implementation costs, there are also ongoing maintenance and support costs associated with RFID. These can include hardware maintenance, software upgrades, and tag replacement costs. Industry estimates suggest that these ongoing costs can range from 10% to 20% of the initial deployment cost per year.

4. Amazon

Similarly, Amazon uses RFID technology in its operations, including in its warehouses and distribution centers to track inventory and improve efficiency. The company has also experimented with using RFID-enabled dash buttons for customers to reorder products with a single press. Additionally, Amazon has acquired several companies in the past that specialize in RFID technology, such as Canvas Technology and Ring (Mathur, 2021).

Amazon is a large multinational company that has implemented RFID technology in various aspects of its operations. However, due to the limited information available in the public domain, it is difficult to estimate the exact cost of implementing and maintaining RFID for Amazon. Amazon has implemented RFID technology in its warehouses to improve inventory accuracy, reduce misplaced items, and streamline order fulfillment. According to a 2019 article by Supply Chain Dive, Amazon has implemented RFID in over 25 of its fulfillment centers, with plans to expand to additional locations (Cosgrove, 2019). The article also notes that the implementation of RFID has resulted in increased efficiency and cost savings for the company. Amazon has also implemented RFID technology in its Amazon Go stores, which are cashier-less convenience stores that use RFID and other sensors to track purchases and charge customers automatically (Figure 9). However, it is unclear how much the implementation of RFID has contributed to the overall cost of the stores (Mathur, 2021).

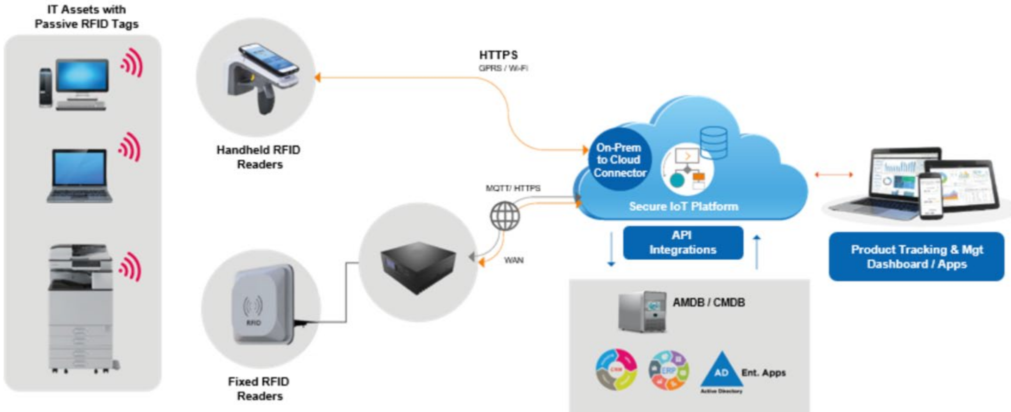

Figure 9. Asset tracking from Handheld Terminal or through a Gateway.
Source: Mathur (2021).

Amazon recently partnered with HCL Technologies and Amazon Web Services (AWS) IoT to create a smart digitization solution for the asset value chain. As seen in Figure 10, the solution uses HCL's Intelligent Asset Tracking and Management (iATM) platform, which leverages AWS IoT to capture and analyze real-time data from assets, and provides actionable insights to improve efficiency, reduce costs, and enhance customer experience (Mathur, 2021). The system uses sensors and IoT devices to collect data, the use of AWS IoT services for data management and analysis, and the integration with other enterprise systems. The solution is applicable to various industries, such as manufacturing, logistics, and healthcare, and can help businesses transform their asset value chain by improving visibility, control, and decision-making.

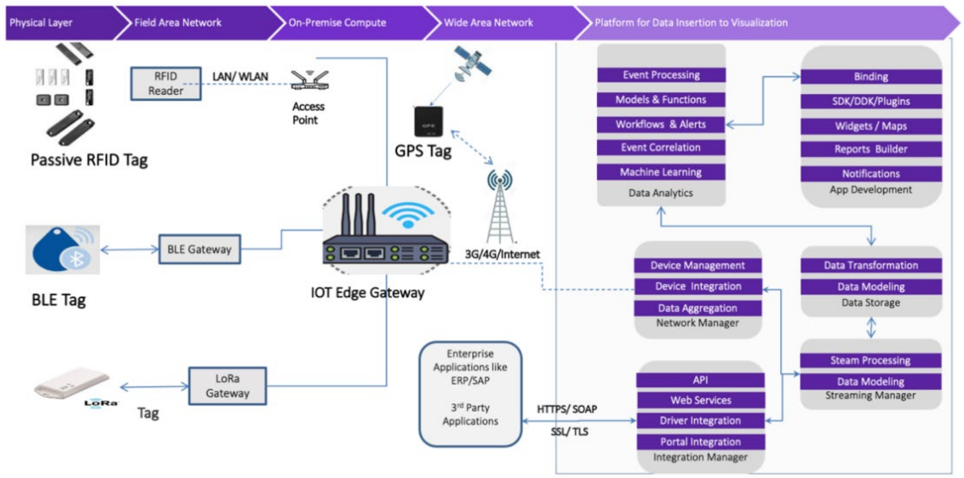

Figure 10. Overview of Data and Control from Physical to Visualization Layers in the IATM Solution. Source: Mathur (2021).

The system does this through a few critical steps as stated by Mathur (2021), seen in Figure 11:

Define your asset tracking requirements: Identify the assets you want to track, the data you want to capture, and the key performance indicators (KPIs) you want to monitor.

Install sensors and IoT devices: Install sensors and IoT devices on your assets to capture data such as location, temperature, humidity, and vibration. These devices should be configured to send data to any platform.

Configure AWS IoT Core: Configure the AWS IoT Core platform to receive and manage data from the sensors and devices. You can use the AWS IoT Core rules engine to transform, filter, and route data to other AWS services or external systems.

Create a digital twin of your assets: Create a digital twin of your assets in the HCL iATM platform. This twin should include relevant information about the asset, such as its physical attributes, maintenance history, and performance metrics.

Integrate AWS IoT and HCL iATM: Integrate the AWS IoT platform and the HCL iATM platform to enable data flow between the two systems. This can be achieved through API calls or by using AWS IoT integration services such as AWS IoT Greengrass.

Analyze asset data: Use the HCL iATM platform to analyze the data collected from the sensors and devices. You can use the platform's analytics engine to identify patterns, anomalies, and trends in the data, and to generate insights that can improve asset performance and efficiency.

Monitor KPIs: Monitor the KPIs defined in step 1 using the HCL iATM platform. You can set up alerts and notifications to proactively identify issues and prevent downtime.

Optimize asset performance: Use the insights and data generated by the HCL iATM platform to optimize asset performance and reduce operational costs. This may involve adjusting maintenance schedules, improving asset utilization, or implementing predictive maintenance strategies.

Continuously improve: Continuously monitor and improve the asset tracking and monitoring process to ensure that you are maximizing the value of your assets. This may involve incorporating new sensors or devices, refining data collection and analysis methods, or adopting innovative technologies as they become available.

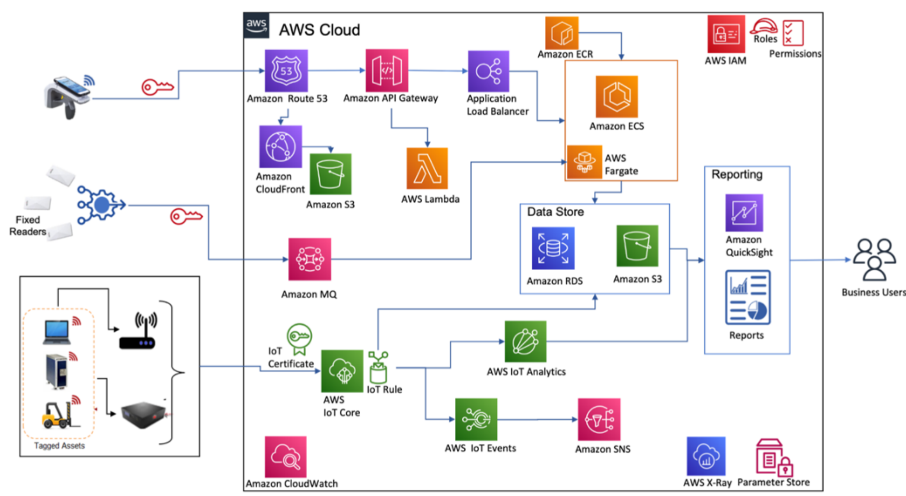

Figure 11. IATM Implementation. Source: Mathur (2021).

This innovative technology would heavily benefit the Department of Defense and could be used to leverage assets and improve asset visibility. The costs would be substantial; however, the integration could be packaged as SaaS and PaaS to introduce a secure way to implement the tracking equipment. Given the limited information available, it is difficult to estimate the cost of implementing and maintaining RFID for Amazon. However, it is likely that the costs would be substantial, given the size and scale of the company's operations. The costs would likely include the purchase and installation of RFID readers, tags, and software, as well as ongoing maintenance and support costs. Additionally, the costs would vary depending on the specific use cases and applications of RFID technology within Amazon's operations.

5. Conclusions

Based on the analyses of Airbus, Amazon, Walmart, and Target, it is difficult to provide a precise estimate for the cost of outfitting a large organization with RFID technology, as the costs can vary depending on the size and complexity of the organization's operations. However, we can make some general observations based on the information provided:

The cost of implementing RFID technology can vary widely depending on the scope of the project. For example, Airbus spent approximately €2.1 million to implement RFID technology in one of its factories (Frost & Sullivan, 2016), while Walmart spent $3 billion to implement RFID technology throughout its supply chain (Kay, 2022).

The ongoing costs of maintaining RFID technology can also vary depending on the size and complexity of the organization. For example, Walmart estimates that it spends approximately $600 million per year to maintain its RFID technology (11,000+ stores) (Kay, 2022), while Target spends an estimated $2-3 million per year (<2000 stores) (Target Corp, 2022).

The benefits of RFID technology can outweigh the costs for many organizations. For example, Walmart estimates that its RFID technology has saved the company approximately $2 billion in costs related to out-of-stock items and inventory inaccuracies (Kay, 2022).

Overall, it is likely that outfitting a large organization with RFID technology would require a significant investment, but the potential benefits in terms of increased efficiency and cost savings could be substantial.

III. METHODOLOGY

A. AS-IS MODEL

1. The As-Is Model for Inventory Control and Management

Currently, the Marine Corps processes for loading and unloading MEUs are personnel-heavy processes. The As-Is process is outlined in Table 2.

Table 2. As-Is Process.

Sub – Process Name	Sub-Process Description
BLT Tasked with Mission	
Inventory Preparation	Inventory is prepared at the home station and counted/cataloged for movement to the MEU port of embarkation
Send Manifest to Craft Master/Navy Logistic (NAVLOG)	Once inventory is complete, manifests are sent to NAVLOG for approval
Count, Mark, & Move to BOG/POG	Conduct Counts, Mark Equipment, Move Equipment & Supplies to BOG/POG
Assemble and Load	Assemble Cargo, Load Equipment & Supplies
Assign Equipment to Tenders	Mission essential equipment is loaded on tenders in the most tactically efficient manner
Load and Account	Tenders are expeditiously loaded, and equipment is account for by personnel aboard.
Movement to Port/Beach	Tenders move to the Port or Beach of debarkation/assault
Unload/Move to FOB	Equipment is moved from tenders to the FOB for use
Monitor Inventory	Inventory is monitored by hand to ensure its timely replenishment
Send Reports to ARGMEU (cyclical)	Reports are routinely sent back to the ship for resupply requests and the process repeats

Many of these processes require multiple counts, heavy supervision, and redundant processes for quality assurance. Before any loading is executed, a detailed planning process occurs to ensure that everything that is needed for mission success is loaded appropriately within the given parameters. This planning process includes consideration of the following:

> **Square Footage:** The total square feet of vehicles and equipment to be embarked that require square foot stowage consideration (e.g., wheeled vehicles, tracked vehicles, skid-mounted equipment, MILVANs, ISO containers, some of which maybe stackable), not including mobile-loaded and/or preloaded items in the landing craft.
>
> **Cube:** The total cubic feet of stackable cargo (e.g., standard cargo [2-man lift], unitized cargo [pallets], less mobile-loaded items). These items must be further broken down by types for hazardous cargo (e.g., ammunition, packaged POL etc.).
>
> **Aircraft Deck Spots:** The quantity needed to support the planned number of aircraft to be embarked. Several factors can influence the quantity of spots, such as operational tempo, ability for day and night operations, and mixture of aircraft among the ships.
>
> **Landing Craft Spots:** The quantity necessary for the landing craft required to support the landing plan.
>
> **Bulk Liquids:** This includes the total gallons by type of bulk POL. It also includes the total gallons of potable and non-potable water stored in shipboard tanks. (USMC, 2022)

Many of the tools used for the As-Is model would be interoperable with most new systems put in place. Below are the current systems used to inventory, track, and assign equipment throughout the various stages of loading pictured in Figures 12 and 13.

Figure 12. Current Tracking Tools. Source: USMC (2022).

Figure 13. Personal Deployment Kit (PDK). Source: USMC (2022).

A MEU is made up of multiple ships. Figure 14 is breakdown of a MEU. There are three ways to load equipment on a MEU. The first is loading through the well deck. The well deck is pictured in Figure 15. This is loaded at the Port and is typically loaded first. It houses amphibious vehicles and other waterborne vehicles. Most of the equipment in the well deck is pre-boated, as seen in Figure 16, on waterborne vehicles so it can be quickly unloaded. For example, a Landing Craft Air Cushion (LCAC) will be loaded at a beach node with vehicles, equipment & supplies. The Beach Operation Group (BOG) will ensure that all equipment is properly loaded and manifested. Once the LCAC is full, it will load the well deck in reverse to ensure it can be employed expeditiously and in the proper order (Navy, 2009). This load method is often referred to as roll on/roll off.

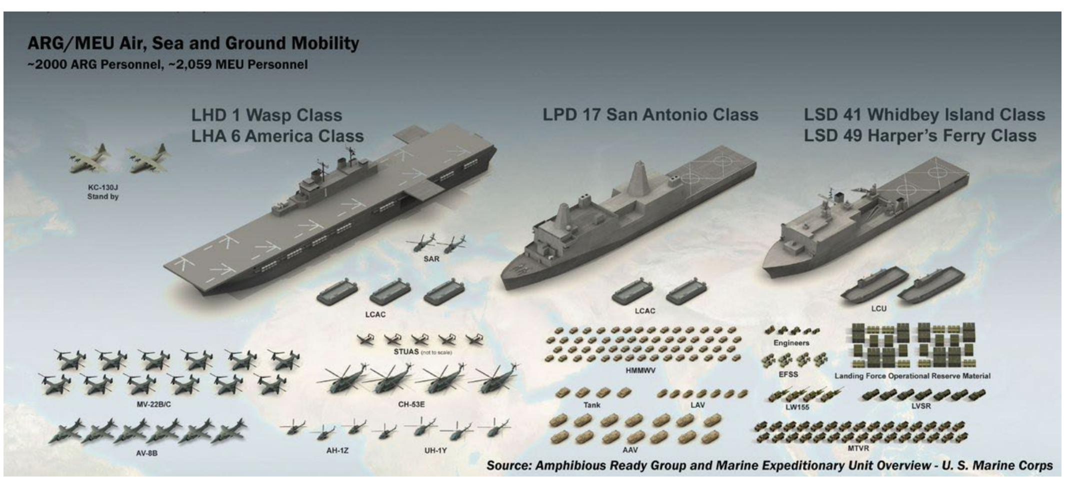

Figure 14. MEU Construct. Source: Navy (2009).

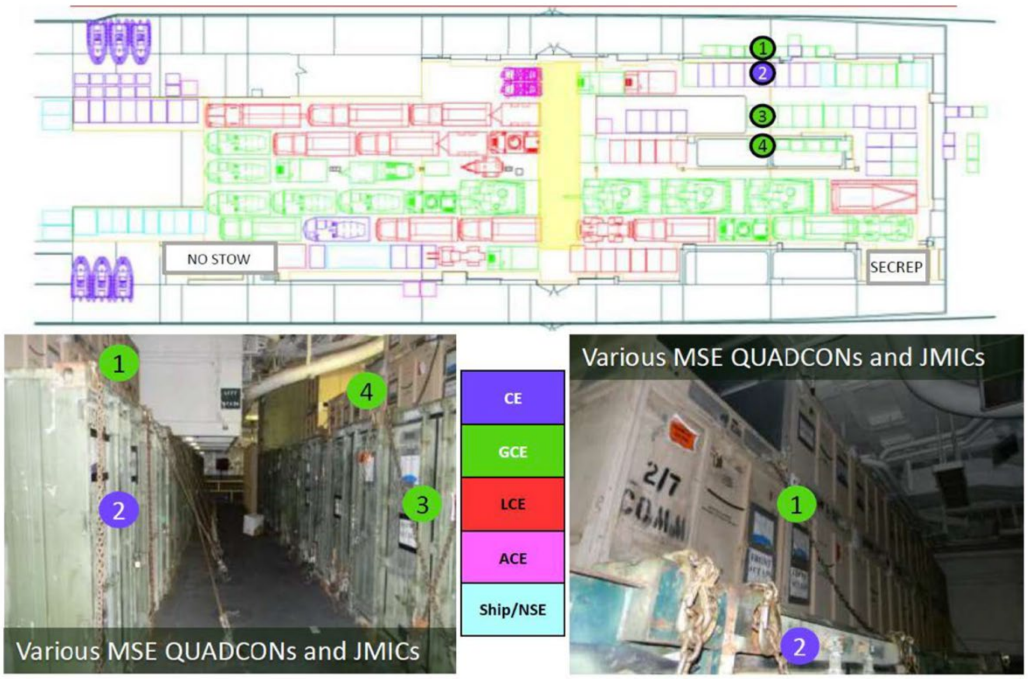

Figure 15. Well Deck Embarkation Plan USS Essex. Source: Navy (2009).

Another way to load the MEU is through the hanger bay. The hanger bay consists of one or two large openings in the side of the ship that is typically loaded at the Port. These large bay doors are loaded with gear that cannot be loaded through the well deck or gear that will not be loaded on amphibious crafts; i.e., food items, medical supplies, and other necessary items. The Hanger Bay Doors are typically used for rapid resupply when visiting foreign ports (Navy, 2009).

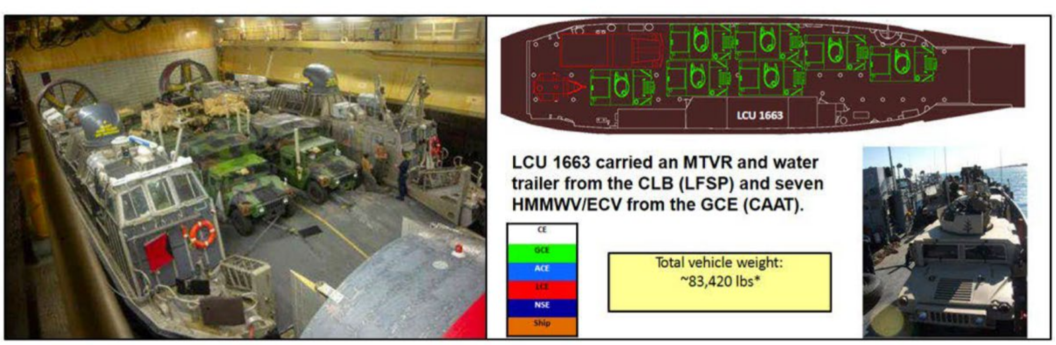

Figure 16. Pre-Boated Landing Craft Unit (LCU). Source: Navy (2009).

The last way to load the MEU is through the flight deck. The flight deck has an elevator, as seen in Figure 17 and 18, that can be used to load and unload cargo, personnel, and supplies. In many cases, the Airwing (ACE) will load their equipment and personnel exclusively through the flight deck, and they will fly from their point of origin directly onto the ship with whatever they intend to take for the duration of the MEU. These flight decks are one of the best ways to conduct resupply and deploy troops when at sea rapidly. This method is referred to as fly on/fly off, or if done by crane, lift on/lift off.

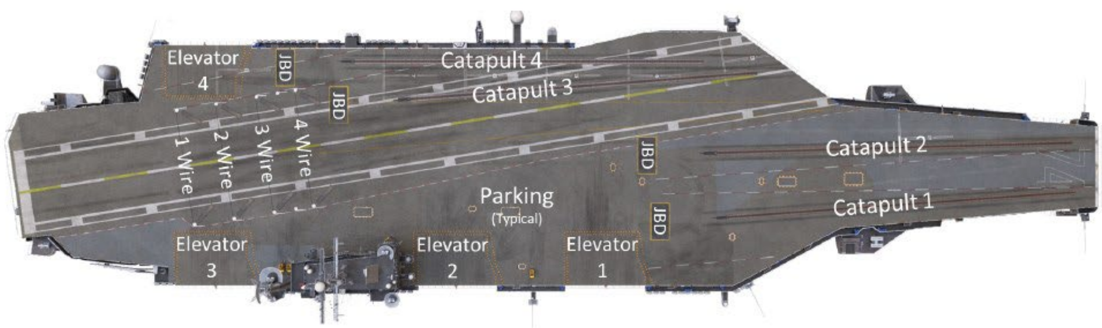

Figure 17. Aircraft Carrier. Source: Navy (2009).

Figure 18. Hanger Bay Door and Elevator. Source: USNI (2006).

According to the Navy (2009), the Organization for Embarkation and Assignment to Shipping (OE&AS) worksheet is a component of the embarkation plan that is typically created as a worksheet (Table 3). Its purpose is to aid in the distribution of units and supplies among assigned ships. The worksheet includes information about the capacity of each ship, which is obtained from the Ships Loading Characteristics Pamphlet (SLCP). The SLCP format is established by Naval Surface Force Commanders Pacific and Atlantic (NSFCPA). Embarkation officers use the SLCP to determine the capacity of each ship, including berthing, landing craft, aircraft, square and cubic foot, hazardous material, and fuel capacities. To account for factors such as space limitations and cargo size, broken stowage factors are applied when determining the amount of available space (Navy, 2009).

Table 3. OE&AS Worksheet. Source: Navy (2009).

ARG/MEU	LHD-7 - USS IWO JIMA *(1458 pax/1893 capacity)*	LPD-21 - USS NEW YORK *(659 pax/699 capacity)*	LSD-43 - USS FT MCHENRY *(377 pax/407 capacity)*
PRIMARY UNITS	• **CE (with FCE) – CapSet III+** • BLT HQ – **CapSet IV** • ACE HQ - **CapSet IV** • CLB Det • MRF Det (Force Recon Plt) (VBSS/Raid) (x-deck to LPD)	• **CLB HQ – CapSet IV** • ACE Det	• **BLT Det** • CLB Det
MANEUVER ELEMENTS	• Rifle Co 3/6 (Vertical Assault) (2 x Plt TSC) • 1 CAAT Plt (Pre-boat) • 1 x LAR Plt (5 x LAVs + 1 x MEWSS) • BLT Sniper Plt (-) • 81mm Mortar Platoon (TRAP Force) • Arty Btry (Rein) (4 x M777) • CEB Plt (attached out by squad to each rifle company) • Det, CLB: Trans Spt, Engr, Maint, EOD, Supply, Food Services • FARP Det • 3 x EOD TM • 1 x MEWSS (collection)	• Rifle Co 3/6 (1 x TSC Plt) • 1 CAAT Plt (Pre-boat) • LAR Co (-) (14 x LAVs) 2 are preboat • 4 X EFSS • CEB Det • CLB (-): Trans Spt, Eng, Maint, EOD, Supply, Health Services, Food Services • 5 x CRRCs (MRF) • 2 x EOD TM • 1 x Medium Crawler Tractor	• Rifle Co 3/6 (Rein) (Mech) • AAV Plt (14 x AAV) 4 are preboated on 2 LCACs • Tank Plt w/ M88 Retriver ,Humvee an Trlr • CLB (-): Trans Spt, Engr, Maint, Supply • 1 x EOD TM, • 1 x TRAM (CLB), •2 x LVSR Refuel, (1 is preboated) •1 x Maint Cntct Trk (CLB), •1 x MC Line Charge Trlr (BLT) • 1 x MRC-145 (LFSP) preboated <u>Mobile MAP on Spot 1/Boat Deck</u> 7 x MTVR (3 CLB, 4 BLT) 4 x Gun Trucks, 1 x TRAM w/Bucket (BLT) 4 x H2O SIXCONs, mobile loaded 1 x AMK-36 WRECKER 2 x MTVR TRLRS (M105/M149) 1 x M9 ACE (boat deck) 3 x MRC-145/148 4 x ATFP QUADCONS 1 x Common 22 Trlr (BLT)
ACE	• 8 x MV-22 • 6 x AV-8B • 4 x AH-1W • 3 x UH-1Y • 4 x CH-53E • MACG Det (ASE Det) • MWSS Det	• 4 x MV22	• LAAD Det (x-deck for DATF) 3 x HMMWV Boat Deck, personnel on IWO. Must x-Deck to utilize.
NAVAL SUPPORT	• 2 x MH-60S (VBSS Top Down / SAR) • 1 x LCU (Pre-boat) CAAT 2 and LFSP • 1 x LCU (BMU Pre-boat) w/ 2 x LARC, 1 x MTVR, 1 x Water Bull, 1 x Dozer, 1 x HMMWV • Fleet Surgical Team	• 2 x LCAC (1 x Pre-boat, 1 x Empty) • 2 x NSW/MRF RHIB • Med CAPSET (TBD) • CLZ (Pre-boat)	• 3 x LCAC (3 x Pre-boat) • 1 x PTM kit available • 1 x 7m RHIB • CLZ (Pre-boat)
MISSIONS	• Air and Surface-based Raid, AF/Port Seizure, site reinforcement, Co/Plt Sized QRF and TRAP • NLW Security Force • NEO & HADR (medium) • MASSCAS (BLT) • MEB / JTF Amphibious Advance Force Operations / Enabler • TSC • Strike • FARP/ISB • VBSS • Water Production: TWPS, 2 x LWPS (max ~40K gal per day, max 9K gal storage) • I-Level Comm & Optics • A/DACG • Intermediate Supply	• Limited Air-based Raid, AF/Port seizure, site reinforcement, Co (-)/Plt Sized QRF and TRAP • Surface-based Raid, AF/Port seizure, site reinforcement, QRF, TRAP • NLW Security Force (TBD) • NEO • HADR (Heavy) • MASSCAS (CLB) • TSC • VBSS (X-Deck) • Water Production: TWPS, 2 x LWPS (max ~40K gal per day, max 9K gal storage) • A/DACG • Intermediate Supply • Welding • LAV repair	• Surface-based Raid, Reinforcement / QRF • HA/DR (light) • Hasty NEO • TSC • VBSS (X-Deck) • Water Production: 1 x LWPS (max ~2.8K gal per day, max 3K gal storage) • Welding • Helicopter Support Team • Intermediate Supply

The following steps helped guide the As-Is process model that we used to estimate the productivity of the current logistical inventory control process. Embarkation is executed in accordance with the detailed and comprehensive embarkation and staging plans. According to the Navy (2009), It generally proceeds with the following basic requirements:

Preparation of Embarkation Points and Embarkation Areas: Designated personnel inspect, improve, and otherwise prepare embarkation areas and embarkation points for use.

Establishment of Embarkation Control Offices: Embarkation control offices must be created for the group, unit, and team during marshalling and embarkation. These offices should be functional and operational. Typically, the embarkation team control office is situated near the pier or on the out-loading beach, while the group and unit control offices are centrally located in the embarkation zones. The personnel stationed in here provide guidance and information to ensure smooth embarkation.

Embarkation Communications Facilities: The Landing Force (LF) arranges or provides communication facilities for use between various areas, including embarkation zones, base camps, forces at sea, control offices, intermediate staging areas, and cargo assembly areas.

Movement to Embarkation Area: Personnel, vehicles, equipment, and supplies are moved to the embarkation area/points on a schedule consistent with the planned on-load.

Assembly of Cargo in the Embarkation Area: Cargo and vehicles are assembled in the embarkation area/points in the order in which they will be on-loaded (i.e., first on will be positioned "deepest" in the ship's storage locations, thereby making it the last to debark during off-load).

Loading Details and Working Parties: Personnel are assigned to fulfill various responsibilities during embarkation execution, to include the "ship's platoon" (working detail that supports the ship's company with the on-load), assistants to the TEO, and working details ashore.

Cargo Handling Gear: The Commander Amphibious Task Force (CATF) retains responsibility for the provision of equipment to facilitate the on-load of equipment, to include forklifts, pallet jacks, trailers, cargo nets and slings, and vehicle lifting slings/ spreader bars. LF assets typically are utilized to assist as available.

The process of executing embarkation on a particular ship can be tiresome, and it is essential to have personnel who are knowledgeable about cargo handling and storage procedures, as well as the loading plan. Diligent and detailed planning is necessary to ensure that all supervisory personnel understand the plan and can facilitate the process smoothly.

Resupply at Sea (RAS): An order is released through NAVLOG systems to request items. These items are then confirmed with suppliers through Fleet Commands and sent to the ship via the most expeditious manner. RAS usually occurs via vertical replenishment conducted by helicopters or other rotary/tiltrotor aircraft or by Standard Tensioned Replenishment Alongside Method (STREAM), wherein lines are used to connect the ships and shuttle fuel and bulk goods between the ships. When conducting RAS, there is little to no accountability because the transaction must occur rapidly; therefore, receipts and trust are the primary means of accountability of these items until they are in the hanger bay for counting.

Resupply at Port: The same order is sent through NAVLOG to the Fleet Command, where supplies are sent to the destination port. Not all orders can be filled. Once the MEU sends out its order, the Fleet Command will send back what it can provide; even with this confirmation, all equipment and supplies may not be delivered due to the available resources. Once at the port, the NAVLOG on the ship will conduct a thorough count and turnover with the suppliers on the pier/port to determine what the MEU is receiving. (Navy, 2009).

B. KVA THEORY

1. Introduction

Finding a metric that can measure productivity performance accurately and objectively takes time and effort. Knowledge Value Added (KVA) "provides a framework for managing and maximizing a return on knowledge assets" (Housel et al., 1994, p. 252). KVA supports the Business Process Reengineering (BPR) approach to improving the optimization of core processes. "The purpose of BPR is to radically improve the company's core processes to increase process capacity and demand for products and services" (Housel et al., 1994, p. 252). It is increasing an organization's processes efficiency by increasing productivity in the process workflow. Housel et. al. (1994), discuss that when implementing BPR, there has to be a clear understanding of how processes produce cost and value, to create meaningful measures of the efficiency of a process reengineering project. The value added of RFID technology in EABO logistical processes examined in the current research,will be estimated and explored using the KVA methodology.

Dr. Thomas Housel and Valery Kanevsky created the KVA methodology; this theory has been published worldwide in many books, book chapters,and articles about business process reengineering and knowledge management. Housel & Bell (2001, p. 95). defined knowledge as "something that enables a person or machine to solve problems of a certain type." For instance, "a set of logical rules or a computer program that can be used to solve the problem is knowledge; in the case of people, they can have knowledge, but they are a knowledge source rather than knowledge itself." KVA uses common units of output as well as the cost to produce those outputs as a way to estimate the Return on Investment (ROI) in for each process. (Housel & Bell, 2001; Seaman, Housel, & Mun, 2008). This project will use KVA to assess the productivity of the current As-Is process for MEU onload and offloads and two To-Be models that include the implementation of RFID technology.

2. Return on Knowledge

a. Measuring ROK

Housel & Bell (2001) stated, that completing a KVA analysis will produce a return-on-knowledge (ROK) ratio that will allow a user to approximate the added value by a given knowledge asset despite its location in a process. Knowledge utilized in the subprocess of a core process will be translated into numerical format based on its difficulty to learn, or time to learn (the more difficult the knowledge is to learn, the more time it takes the average learner to learn how to produce the process output) , and those numbers will be used to estimate the amount of common unit outputs in a given process accordingly. Creating this numerical form for each step will give managers of a given process a clear understanding of where the innefficiencies are in each process.

3. KVA Theory Overview

a. Fundamental Assumptions of KVA

The KVA theory assumes, by the principle of replication, that if a given organization has the knowledge needed to change in a given process input into a process output, it can measure the tranformations of the inputs into outputs by the amount of knowledge it takes to make the changes. “By definition, if we have not captured the knowledge required to make the changes necessary, we will not be able to produce the output as determined by the process. This tests to determine if the amount of knowledge required to produce an output has been accurately estimated” (Housel & Bell, 2001, p. 94). The fundamental KVA assumptions can be summarized in Figure 19.

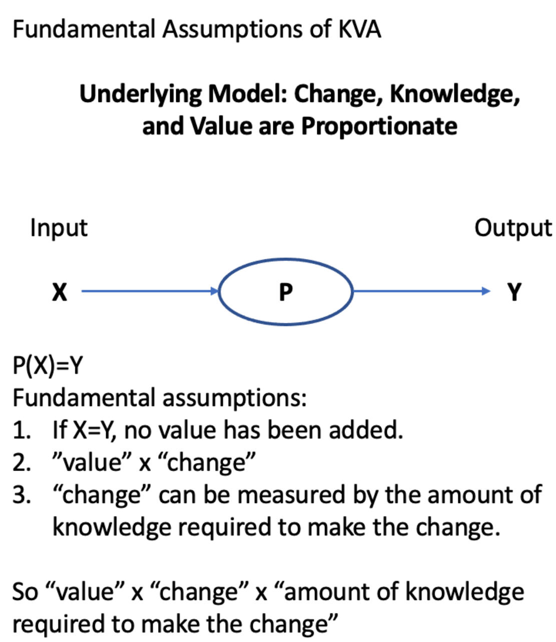

Figure 19. KVA Assumptions. Source: Housel (2001, p. 94).

Additionally for purposes of simplification, the KVA theory can be broken down into nine steps. Table 4 breaks down these steps along with clearly defined data collection bullets. The KVA theory allows for a few different approaches to measuring the value of said knowledge within a process. The three approaches are learning time, process instructions, and the binary query method. For this project, we will use the learning time approach to represent our To-Be model on Table 5.

According to Housel (2009, p. 94), "Learning time can be defined as the amount of time needed to learn how to a process is completed and to arrive at certain outputs. It is a more convenient way to estimate the amount of knowledge in a given process."

Table 4. KVA Framework. Source: Rios et al. (2006, p. 8).

Data Collection	KVA Methodology
• Collect baseline data • Identify sub- processes • Research market comparable data • Conduct market analysis • Determine key metrics	**Step 1**: Calculate time to learn. **Step 2**: Calculate value of Output (K) for each sub-processes. **Step 3**: Calculate Total K for process. **Step 4**: Derive Proxy Revenue Stream. **Step 5**: Develop the Value Equation Numerator by assigning revenue streams to sub-processes. **Step 6**: Develop value equation denominator by assigning cost to sub-processes. **Step 7,8,9**: Calculate metrics: Return on Investment (ROI) Return on Knowledge Assets (ROKA) Return on Knowledge Investments (ROKI)

4. KVA Analysis Summary

The KVA analysis in this research will compare the current As-Is process for MEU on-load and off-load with the proposed To-Be process with the addition of RFID. With the assumption that the analysis will show all the benefits of this technological addition, with metrics such as efficiency, time decreased per task, and inventory control.

Table 5. Three Approaches to KVA. Source: Housel and Bell (2001, p. 95).

Steps	Learning time	Process description	Binary query method
1	Identify core process and its sub-processes.		
2	Establish common units to measure learning time.	Describe the products in terms of the instructions required to reproduce them and select unit of process description.	Create a set of binary yes/no questions such that all possible outputs are represented as a sequence of yes/no answers.
3	Calculate learning time to execute each sub-process.	Calculate number of process instructions pertaining to each sub-process.	Calculate length of sequence of yes/no answers for each sub-process.
4	Designate sampling time period long enough to capture a representative sample of the core process's final product/service output.		
5	Multiply the learning time for each sub-process by the number of times the sub-process executes during sample period.	Multiply the number of process instructions used to describe each sub-process by the number of times the sub-process executes during sample period.	Multiply the length of the yes/no string for each sub-process by the number of times this sub-process executes during sample period.
6	Allocate revenue to sub-processes in proportion to the quantities generated by step 5 and calculate costs for each sub-process.		
7	Calculate ROK, and interpret the results.		

C. RECENT KVA FINDINGS

1. "Potential Utilization of Passive RFID to Improve Asset Accountability in the Marine Corps" (Medeiros & Zukowski, 2021)

a. Overview

The Marine Corps uses the Consolidated Memorandum Receipt (CMR) to keep track of their assets, which requires a labor- and time-intensive manual process. A study was conducted comparing the current CMR process to an RFID-enhanced process. The study found that the RFID-enhanced process could be 15 times more efficient in terms of time, resulting in a "cost savings of approximately $31,000 per implementation"

(Medeiros, 2021, p. 46). The researchers recommend, "conducting physical trials to confirm the effectiveness of using RFID technology in the CMR accountability process."

b. Analysis

The analysis suggests that the RFID-enhanced CMR process model is significantly more efficient than the current manual process model. The researchers found that the To-Be process model saves time by eliminating the need for physical layout and human reading and comprehension of serial numbers. This results in a time savings of 102.7 hours per company or 1,232.6 hours across all twelve communication line companies annually. In terms of cost, the To-Be process model can save up to $31,568.09 per implementation and $402,777.60 annually across all twelve communication line companies (Medeiros, 2021). The researchers recommend that the Marine Corps conduct physical trials to confirm the effectiveness of the RFID technology and implement the To-Be process model to increase efficiency and shift labor hours to higher-value tasks.

c. Conclusion

The conclusions discuss the current inventory process used by the Marine Corps, which is time and labor-intensive, and relies on manually reading serial numbers to account for assets. The summary also highlights the benefits of passive RFID technology, which has been shown to reduce inventory inaccuracies, misplacement, and shrinkage in commercial organizations and military applications. A pilot test conducted by the Blount Island Command using passive RFID "demonstrated an 87% reduction in time to account for equipment, and an average read accuracy of 94%" (Medeiros, 2021, p. 49).

The researchers conducted "a simulation using Savvion modeling software to compare the physical As-Is CMR inventory process with an RFID-enhanced To-Be CMR inventory process utilizing the Blount Island Command as a case study." The simulation results showed that the As-Is process takes an average of 5.5 hours and costs $2,032.46 to inventory 154 pieces of equipment (Medeiros, 2021, p. 49). On the other hand, the To-Be process takes an average of 22.1 minutes and costs $88.55 to account for 154 pieces of equipment. The researchers estimated that the annual cost of the To-Be process model, including a fixed one-time cost of $7,310.12 per instance, would be $9,081.04 (Medeiros, 2021).

The analysis demonstrates a significant difference in both time and cost between the As-Is and To-Be process models, indicating that the adoption of passive RFID technology could bring significant benefits to the Marine Corps inventory process.

2. “The Concurrent Implementation of Radio Frequency Identification and Unique Item Identification at Naval Surface Warfare Center, Crane, in as a Model for a Navy Supply Chain Application” (Obellos, Colleran, & Lookabill, 2007)

a. Overview

Obellos et al., (2007, p. 35) introduces the issue of inadequate asset visibility in military logistics and how it affects combat readiness. The absence of automated identification systems results in “a lack of standardized and accurate information regarding the movement of material in the theater of operations and continental United States.” (Obellos et al. 2007, p.35). Asset visibility is highlighted as a critical tool to “manage capacities and available assets across the supply chain,” supporting warfighter requirements. The project aims to “identify typical Navy Supply material operational processes at Naval Surface Warfare Center Crane and develop a concurrent implementation plan of RFID and UID technologies that best fit NSWC Crane” (Obellos et al. 2007, p.91). The scope of the project includes producing an effective implementation plan and a KVA/ ROI analysis for RFID/UID technologies at the organizational level.

b. Analysis

The thesis Obellos et al., (2007) presents an examination of the current inventory process and a proposed inventory process utilizing RFID/UID technology. The analysis reveals that several sub-processes in the current inventory process are manual, resulting in high sub-process costs and minimal return on investment. The analysis identifies these sub-processes as potential areas for improvement through intelligent automation with RFID/ UID technology. “Implementation of this technology reduces labor and time requirements for conducting inventories,” leading to increased output, improved asset visibility, and enhanced customer service (Obellos et al., 2007, p. 92). The KVA analysis shows that the implementation of RFID/UID technology significantly increases return on investment, resulting in a total improvement of 212% (Obellos et al., 2007). The manpower gains from decreased labor and time requirements can be utilized in other areas of operations. The analysis highlights the advantages of implementing RFID/UID technology in the inventory process.

c. Conclusions

In this study, "the implementation of RFID and UID technology in military supply chain operations" is found to have significant benefits for the Navy, especially at NSWC Crane. The study concludes that concurrent implementation of RFID and UID technology can help NSWC Crane comply with DOD mandates and achieve numerous benefits. The implementation of these technologies will increase the efficiency of the inventory process and improve the accuracy of the output (Obellos et al., 2007, p. 92). This, in turn, leads to better operations efficiency and customer service. Furthermore, the study suggests that the implementation of RFID/UID technology can significantly increase the return on knowledge (ROK) and ROI ratios. With this implementation, local asset visibility can improve, and enterprise-wide visibility can be achieved, which is crucial in planning and acting in support of war fighters. Overall, the study concludes that the implementation of RFID/UID technology can drive improvements in operational readiness and help achieve Total Asset Visibility (TAV) for the Navy and DOD.

3. "Estimating the ROI on Implementation of RFID at the Ammunition Storage Warehouse and the 40th Supply Depot KVA as a Methodology" (Jung & Baek, 2009)

a. Overview

The Ministry of National Defense (MND) plans to introduce RFID technology in "seven Ammunition Storage Warehouses and five Air Force Supply Depots to improve productivity and reduce overhead costs" (Jung et al.,. 2009, p. 1). However, accurately determining the ROI of the RFID implementation has been a challenge, with past estimates having a failure rate of 70% (Jung et al., 2009). As the MND moves towards technologyintensive forces to better manage limited resources, there is a need to estimate scalable ROI to avoid wasteful spending. To address this, the authors proposed using the KVA theory. The authors conducted proofs of concept on the ASW and Air Force 40th Supply Depot, to "provide decision-makers in the MND with a hurdle rate to make informed decisions on RFID investments" (Jung et al., 2009, p. 3). The goal is to provide an objective means of determining the ROI of RFID investments and to help decision-makers make informed choices on the use of RFID technology in the MND.

b. Analysis

The information presented in the analysis discusses the ROI hurdle rates and IT ROI comparisons for two case studies. The authors discovered that both case studies exhibited an expected improvement range of 272% to 394% for similar types of logistic operations that have the potential to enhance with RFID technology (Jung et al., 2009). This range can help decision-makers determine the expected performance improvement range when considering implementing RFID in other logistic operations in the MND.

In addition, the research findings can assist decision-makers in estimating the ROI for current and potential IT investments by comparing the IT ROI improvement. The two case studies revealed an increase in ROI after implementing RFID, and the 40th Supply Depot case study had a significantly higher ROI due to transferring sub-process output to RFID implementation. The analysis also compared the present study to previous research on RFID at the Naval Postgraduate School (NPS). The ROI for the MND cases was nearly double the NPS's projected ROI for their To-Be models. This suggests that decision-makers can expect even higher ROI based on the actual ROIs from the current study compared to the ROI estimates from prior studies.

c. Conclusions

The study suggests that the MND needs to find ways to evaluate new IT acquisition projects, and that "RFID has the potential to improve logistics processes" (Jung et al., 2009, p. 51). The KVA methodology is recommended as a promising way to evaluate the benefits of RFID implementation in a more objective manner than the BSC approach used in the past. The study provides two case studies to demonstrate the application of the KVA methodology and provides a notional hurdle rate for the ROI expectation using RFID technology. The study also highlights the unique aspect of being based on real RFID implementation data and suggests that the projected improvement from RFID technology in the DOD are likely conservative.

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IV. ANALYSIS

Within this chapter, a thorough analysis was conducted to generate the As-Is model utilizing the KVA framework to establish an As-Is productivity performance baseline for future modeling. Two To-Be models were carefully constructed with inputs from the expertise of subject matter experts (SME) in the field of embarkation. Assumptions used to generate the estimates for each model were outlined to guide the scope of the research and determine potential increases in ROI, ROK, reductions in cost, and cycle time reductions by moving from the As-Is to the To-Be models. Additionally, rough market comparable estimates were generated to monetize the the value of each process output including the outputs generated by the potential RFID technology implementations. This allowed for the generation of the resulting ROI estimates that require a monetized numerator for this financial accounting performation ratio. Also, the cost estimates for each process allowed for a comprehensive comparison between the three models in terms of cost savings over a one, ten, and twenty-year span.

A. ASSUMPTIONS

There were many assumptions that had to be made before conducting the analysis of this study for both the As-Is and the two To-Be performance models (as is the case for all productivity analysis techniques). These can be seen in Table 6 and 7. One major assumption that should be recognized specifically is the potential RFID property tags would be placed correctly and tested prior to their acquisition and deployment in the three process models.

Table 6. As-Is Assumptions for Analysis

As-Is Assumptions
Hourly wages are based on 260 workdays/year and eight hour/day
Hourly wages are based on 2023 basic pay rate table provided by DFAS without additional allowances
All Marines in the process possess the basic Microsoft suite skills and minimum high school reading level
Rank order of difficulty to learn was estimated by rank order with 10 as the most difficult to learn and 1 is the least difficult to learn for a given subprocess
Denominator, cost of labor, is equal to the basic pay divided by the working days multiplied by the number of hours worked in a day
Total times a given process is used per year is based off the number of MEU's that depart each year for exercises and deployments
The alternative to RFID and As-Is process includes physically laying out and counting all equipment by hand.
Learning time is related to someone who has no background knowledge of the processes and has not completed any relevant tasks and also has no tacit knowledge of how to execute the processes to produce the desired outputs
The number of entry ways per ship is based on the flight deck, hanger bay, and well-deck entry ways. Three is the average entry point for each ship across the MEU.
Sufficient infrastructure required per ship – two interrogates per entry way, two scanner per entry way for redundancy, one antenna per ship, a AMS TAC suite per MEU.
All RFID tags are place on the equipment at the point of origin and are all accounted for prior to leaving.
Travel to and from EAB's are uncontested and are primarily an administrative movement.

Table 7. Expected Process Assumptions

Expected Process Performance Results Assumptions of the To-Be models
Decreased completion time per task
Decreased personnel needed to complete task
Decreased long term cost for processes
Increase accountability for MEU equipment in EABO
The time spent training these new systems regarding learning time are not factored into the overall cost as they are accounted for in the labor time and cost per use for each process execution of the RFID technology expenses provided the denominator for the ROK and ROI estimates.
As stated in Medeiros' (2021, p. 33) research, "the Marine Corps will place the requisite amount of trust in RFID technology to see an adequate return."
The As-Is process and To-Be processes will not have the same number of subprocesses because some the processes will be combined into a smaller number of processes facilitated by the use of the RFID technology
The time taken to individually tag the military equipment with RFID was not accounted for, it was challenging to attain the time information related to this step (for example, in some cases the vendors would tag their equipment)
The information gathered regarding learning time, actual completion time, rank of difficulty to learn and weighted rank of difficulty learn are all accurate based on subject matter expert findings and tests of reliability of the estimates.
Market comps were generated using a simple method based on what the external for-profit market would pay to generate the outputs of the processes. The market comp aggregate was used to generate a price per common unit of output allowed allocation of the market comp aggregate revenue estimate among all processes.
There were multiple options for pricing. The most cost-effective quote was used for the technology.
1000 passive tags per company based on Medeiros (2021) prior research-MEU was used for 10 companies.
The previous RFID Cases and thesis from NPS and the DOD all contain accurate and reliable information that can be used for analysis.

1. Learning Curve

When implementing changes to a process, smaller incremental changes are generally easier to manage and result in a shorter learning curve than large sweeping changes. This is because smaller changes allow individuals and organizations to adapt gradually, with less disruption and confusion, and provide more opportunities to learn and refine the new process (Waddell, Cummings, & Worley, 2016). On the other hand, large changes can be overwhelming, require significant resources and time to implement, and can lead to resistance and pushback. This prior research finding indicated that the incremental To-Be approach would have a lower learning curve.

One study conducted by researchers at the University of Warwick found that gradual incremental changes were more effective in improving organizational performance than large-scale changes (Waddell et al., 2016). The study looked at a variety of industries, including healthcare, manufacturing, and service, and found that smaller changes resulted in a shorter learning curve and better adoption of new processes.

In the reduction cost and cycle time for the integration of the new models, there are small incremental changes projected to be made to the As-Is process, and the information technology was assumed to incorporate the learning time of the manual processing done by the process human labor. With less change, there is a shorter learning curve, making the models less risky and more intuitive.

2. Cost Assumptions

In this study, we have identified some of the infrastructure costs associated with RFID implementation, such as electricity, gasoline, water, food, and other consumable goods. These costs are spread as a constant across all of the processes, to ensure a reasonable and accurate estimate of the total implementation cost.

When comparing the implementation cost of the DOD to that of the industry, it is clear that the potential investment in the RFID system and its component parts will be significant. According to Frost & Sullivan (2016), organizations of similar size comparable to the USMC can expect to invest approximately $3,000,000 initially, with an additional 15% annual investment for maintenance and upgrades.

Break even analysis used:

Discount rate = 8%

Inflation rate = 4%

Based on risk, time to implement, and overall investment

Ships	21				
Entry Points	63				
	Amount Per Ship	Price Per Unit	Total Neede	Total Price	
Antenna	2	$ 2,314.20	42	$ 97,196.40	
Interrogator	6	$ 1,000.00	126	$ 126,000.00	
Scanner	3	$ 2,192.50	63	$ 138,127.50	
AMS TAC	1	$ 38,018.24	7	$ 266,127.68	
Passive Tags	3,333	$ 0.30	69993	$ 20,997.90	
Active Tags	1,000	$ 17.50	17500	$ 306,250.00	
AMS Service Support	1	$ 456,218.88	1	$ 456,218.88	Yearly Cost
				$ 1,410,918.36	Total Investment FY01
				$ 954,699.48	Without Software FY01

Figure 20. RFID System Estimate Cost Indexed by Actual Dollar Amount

The cost estimates from Figure 20 we derived from multiple sources. The Mast mount antenna and AMS TAC price estimates were derived from SME in the fleet. Where the cost estimates for the interrogator and handheld scanner were derived from Mederios et. al. Lastly, the passive and active tags estimates were derived from average prices from multiple mark comps. The results from the break even analysis resulted in a break even point of less than one year, outlined in Appendix A.

B. PROCESS AND MODELING

(1) Data

The following information contained in the KVA spreadsheets includes a description of all the critical columns in Appendix B for the As-Is, Incremental To-Be, and the Radical To-Be models.

(2) Processes

1. Prepare Inventory: This step is the very first task in the process. It includes all necessary personnel and time needed to pack, prepare, and organize the gear needed to be transported to the ships/POE.

2. Create Manifest of Equipment: This step currently requires individuals to create a document listing of all the cargo and personnel that will be transported to the ship/POD.

3. Send Manifest to Craft Master/NAVLOG: The individual that finalizes the manifest, will then send the completed version to the naval side of the operation (Craft master). This individual is the SME that will prepare the manifested information for proper load onto the ships.

4. Conduct Counts, Properly Mark, and Move Equipment: Marines will thoroughly go through with the completed EDL and manifest and confirm that all gear is where it should be, as well as determining that nothing is missing.

5. Assemble Cargo, Load Equipment and Supplies: All the equipment and supplies that has arrived at the POE will be loaded onto its respected ship.

6. Assign Equipment to Tenders Mission essential equipment is loaded on tenders in the most tactically efficient manner.

7. Load and Account Tenders: Tenders are expeditiously loaded while aboard the ship, and all equipment loaded is accounted for by personnel aboard.

8. Movement to Port/Beach: Tenders move the equipment to the Port or Beach of debarkation/assault.

9. Unload, Account and Move the equipment to FOB: Equipment is moved from tenders to the FOB for use. When the Marines unload the tenders and move them to their final destination, all items must be accounted for.

10. Monitor Inventory and send to MEU: Inventory is monitored by hand to ensure its timely replenishment. Reports are routinely sent back to the ship for resupply requests and the process repeats

- Number of Employees

The 'Number of Employees' Column signifies the number of personnel to complete a specific process/task. The number of personnel involved in each process is based upon the number of Marines needed, grouped by rank, for each task.

- Rank of Difficulty (to learn)

All the processes are ranked in order of difficulty to learn by a naive common referent point learner, where 1 = easiest to learn and 10 = hardest to learn. This learning time ordering estimate was ranked by SME in the field that we interviewed, based on the difficulty of learning each process. The difficulty of each process is also denoted by the relative learning time column adjacent to this column. The most complex tasks are assumed to take the longest to learn by the naïve common referent learner.

- Relative Learning Time (RLT)

The RLT was derived from the relative distribution of 100 units of learning time (e.g., in hours, days, weeks or months). In this process case, we used hours. How long it took a naïve referent point learner Marine to learn how to perform each of the processes, including learning to manually perform what is currently automated (using this approach it was possible to have common referent point for estimating the amount of knowledge embedded in the automation).

- Actual Learning Time (ALT)[1]

The ALT (hours) is the time it would take to train the naive individual learner to perform each of the process. This common unit data was used for calculating the amount of knowledge used to produce the outputs for each process. The three learning time estimates were correlated to establish the reliability of the estimates.

- Percentage Automation

This number is a representation of the automation used in each process. The percent automation is measured on a scale from 1–100%, 1% being no automation and 100% being fully autonomous.

- Times Performed in a Year

The times performed in a year column represents the number of times each of these processes is completed annually. This number is based on estimates from the SME and the number of times in a year a MEU deploys. For our study, the times performed annually number will remain constant across all models.

- Average Time to Complete

The average time to complete a given process column is an estimated number based on subject matter experts in the fleet, the time needed for each of the individuals in the process to complete the task. This cost estimate is noted in salary hours multiplied by the amount of time actually used to complete the process tasks.

[1] Learning time is one of several ways that can be used to describe all process outputs in common units. The cost to train someone to perform process tasks would be incorporated in the denominator of a productivity ratio. With KVA, the learning time estimates are simply a fast way to describe all process outputs in common units allowing for comparison of the productivity of all processes from a common reference point numerator value.

- Knowledge (Learning Time) per Process (Knowledge perprocess = Human Learning Time + IT (Human Learning time * % Automation))

The learning time was calculated based on the of combination of human and IT equivalent learning time hours. Actual average learning time * the number of employees to complete that task. Then, the estimate included the percentage automation * human leaning time. In the To-Be models, the knowledge contained in the RFID automation resulted in less need for manual operators (i.e., lowering the labor costs for given processes) to perform the functions that would be transferred to the RFID technology.

- Total Knowledge (Learning Time) per Year= (Total Knowledge = Learning Time * Times a process is performed in a Year)

The total knowledge value represents the amount of knowledge in each process. This value is determined by total learning time* the number of times performed in a year.

- Total Market Comparison Surrogate Revenue per Year

This is the total surrogate revenue divided by the total number of learning time hours (i.e., common units of output) which provided a revenue or price per knowledge unit market comparable estimate. Given the resulting revenue or price per common unit of knowledge, the total aggregate surrogate revenue estimate can be allocated in terms of the number of units of knowledge for each process.

- Human Cost/Yr

Human cost/Hr * average time to complete * times performed in a year.

- Information Technology (IT) Learning Time

The IT Learning time column is relative learning time for a given process * percent automation.

- Return on Knowledge (ROK)

The ROK is a ratio between the total revenue and the total cost for each process. This ratio allows for comparison of expenses and revenues (i.e., cost, benefits) for each process.

- Return on Investment (ROI)

The ROI is a ratio between (Revenue-Investments)/Investments or Revenue-process cost/ process cost.

- Pay grade

To calculate the average y salary per hour, we used an average base pay for each rank. We used 260 annual working days in a year and eight working hours per day.

- Market Comparable Revenue

To calculate a total market comp surrogate revenue value, we took the average yearly salary and multiplied it by 1.7 due to the acceleration rate based on what the DOD actually pays out to service members. Then we took that number and multiplied it by 1.5 to get the punitive value that external market would place on completing the entire process. The assumption was that the for-profit market would pay 50% more for the process outputs than the actual amount the DOD paid for the same outputs.

C. KVA ON AS-IS MODEL

The KVA analysis for the As-Is model provides the current process baseline, without an RFID system and its associated personnel and cost. Table 8 outlines the total personnel and various ranks associated with those personnel to complete this process. The total number of personnel required to complete these processes is 96. Also outlined is the associated rank of difficulty and relative learning time for a naive common referent point learner. The total Actual Learning Time (i.e., value) for this process is 16.5 learning time hours. The As-Is model is based on nine total executions per year with a total completion time of 36.17 hours.

Table 8. Personnel Per Process

Process	Number of Employee								Number of Employees(Total)
	E 1 - E 3	NCO	SNCO	CWO	O1	O2	O3	O 4	
1. Prepare Inventory	4	2	1	0	2	0	1	0	10
2. Manifest Equipment	4	0	1	0	1	0	1	0	7
3. Send Manifest to Craft Master/NAVLOG	1	0	0	0	0	0	1	0	2
4. Conduct Counts, Properly Mark, and Move Equip to BOG/POG	12	4	2	0	1	0	1	0	20
5. Assemble Cargo, Load Equipment & Supplies	6	2	1	1	1	0	0	0	11
6. Assign Equipment to Tenders	2	2	1	0	1	0	0	1	7
7. Load and Account Tenders	6	1	1	0	1	0	1	0	10
8. Movement to Port/Beach	6	1	1	0	1	0	1	0	10
9. Unload, account, and move to FOB	6	1	1	0	1	0	1	0	10
10. Monitor Inventory and send to MEU	6	1	1	0	0	0	1	0	9
Total	53	14	10	1	9	0	8	1	96

The Total LT (TLT) for all of the processes is 212.6 hours. The total revenue for this model is $188,546.49 with the expenses at $125,679.66 (Figure 21). The Total K is 1913.4, this number was calculated by multiplying the Total LT by the number of times performed in a year (number of executions [9]). For example, the sub-process "Manifest Equipment" has a TLT of 18.2, multiplied by nine, to equal a Total K of 163.8 for this subprocess. TLT is calculated by adding the human K and IT K, based on the percent automation. For "Manifest Equipment," there are seven people needed to complete this task, with an Actual Average Learning Time of two hours. Seven times two is 14 Human K with a 30% automation for 4.2 IT K, a total of 18.2 K for this process combined from human and IT K. The overall ROK and ROI[2] is 150% and 50% (due to the 50% additional value used to estimate the market comp value for the overall process)[3] with a correlation of .91 for Order of Difficulty to Actual Learning Time and .90 for Relative Learning Time to actual average training time. The As-Is based model produced a $98.54 Revenue per LT unit which will be the standard unit price for all three models in the following analysis.

[2] ROI = (Revenue-Investments)/Investments (not Cost Savings/Baseline Costs which is not a ratio since all the information is in the denominator).

[3] ROK and ROI are always 100% correlated.

As-Is Model	Expenses	Revenues	Cost Savings	ROI
1 Year Projection - 9 Times Fired	$ 125,697.66	$ 188,546.49	$ 62,848.83	50%
1 Year Projection - 20 Times Fired	$ 279,328.13	$ 418,992.19	$ 139,664.06	50%
10 Year Projection - 9 Times Fired	$ 1,256,976.58	$ 1,885,464.86	$ 628,488.29	50%
10 Year Projection - 20 Times Fired	$ 2,793,281.28	$ 4,189,921.92	$ 1,396,640.64	50%

Figure 21. As-Is Surrogate Revenues, Cost Savings and ROI

D. MARKET COMPS

Non-profit organizations like the DOD can produce market-comparable information by using a standard unit of measurement to describe their procedures and then comparing those to the standard units of output used by for-profit businesses. "Market comparable data from the commercial sector can be used to estimate a price per common unit of output constant, allowing for revenue estimates of process outputs for non-profits. This also provides a common-units basis to monetize benefit streams regardless of process analyzed" (Rios et al., 2006, pp. 10–11). The acceleration rate of 70% was used, a 1.7 multiplier based on what the DOD actually pays its employees besides base pay to include BAS, BAH, retirement, medical, and taxes. Additionally, these accelerated rates were multiplied by 1.5 to calculate the market comps. Table 9 shows market comp data used for calculations.

Revenue was calculated by multiplying the expenses, wages paid to workers, by 1.5 to estimate the market comps for the As-Is Model. The result was a surrogate price per common unit of output (i.e., learning time) of $98.54. the same price per unit was used for the two To-Be models with the assumption that the market would pay the same for a common unit of output regardless of the model used to produce total learning time estimates.

Table 9. Market Comp Data

Pay Grade	Yearly Salary($)	Yearly salary/hr($)	Mkt Comparable Revenue	Mkt Comparable Revenue/hr
E-1 - E-3	$26,460.00	$12.72	$67,473.00	$32.44
NCO	$38,034.00	$18.29	$96,986.70	$46.63
SNCO	$53,652.00	$25.79	$136,812.60	$65.78
CWO1-3	$66,528.00	$31.98	$169,646.40	$81.56
O1	$43,644.00	$20.98	$111,292.20	$53.51
O2	$57,276.00	$27.54	$146,053.80	$70.22
O3	$77,640.00	$37.33	$197,982.00	$95.18
O4	$92,712.00	$44.57	$236,415.60	$113.66

E. KVA ON TO-BE MODEL

The Incremental To-Be Model incorporated the use of RFID technology to optimize the processes. The To-Be Model introduced RFID detection for active and/or passive tags at all entry ways onto and off of the ship as outlined by our costs. Additional benefits include implementation for accountability from movement at the point of origin to the beach or port of departure, onto the ship. As well as the implementation from the ship to the shore and back. All equipment aboard the MEU will travel in and out of these entry ways, all equipped with specialized RFID equipment to meet the mission.

The new process reduced the manpower hours needed (i.e., cost to produce the process outputs). The KVA methodology only counts knowledge in use. So, in this case, the learning time (i.e., procedural knowledge) required to produce the process outputs (calibrated in common units of output) was moved from the manual operator to the RFID technology. The increased automation of these processes allocated more common units of output to technology (away from manual labor) and produced an increase ROI and ROK of 359% and 259%, from a baseline of 150% and 50%, based on nine executions of the process per year, with outlined revenues in Table 10.

Two of the processes were combined in this model, reducing the total number of processes from ten to nine. The processes combined from As-Is: "Manifest Equipment" & "Send Manifest to Craft Master/NAVLOG" to "Scan Equipment to AMS." Other changes included reducing "Conduct Counts, Properly Mark, and Move Equip to BOG/POG" to "Properly Mark and Move Equipment to BOG/POG." "Monitor Inventory and send to MEU" changed to "Reports sent to the MEU," because there is no longer a need to manually monitor inventory and create reports back to the MEU. There was not a loss of information with these combinations, the common units of output were embedded in and produced by the automation.

Table 10. Incremental To-Be Cost Savings and ROI

Incremental To-Be Model	Expenses	Revenues	Cost Savings	ROI
1 Year Projection - 9 Times Fired	$ 52,554.99	$ 188,546.49	$ 135,991.49	259%
1 Year Projection - 20 Times Fired	$ 116,788.87	$ 418,992.19	$ 302,203.32	259%
10 Year Projection - 9 Times Fired	$ 525,549.92	$ 1,885,464.86	$ 1,359,914.94	259%
10 Year Projection - 20 Times Fired	$ 1,167,888.72	$ 4,189,921.92	$ 3,022,033.20	259%

In the Radical To-Be Model, the personnel required was less than 25% of the original personnel required in the As-Is and less than 28% of the personnel required for the incremental. The total personnel needed for the Radical Model is 21 with an Actual Average Learning time of 6.5 hours for the human and the remainder of the process knowledge, i.e., learning time or common units of output, was embedded in the RFID system with and average time to complete the overall process in 10 hours. The total revenues were $188,546.49 and the total expenses were $13,831.83 with an ROK and ROI of 1363% and 1263%. There was no knew knowledge added to this process, instead IT streamlined the process and reduced the manpower hours needed to complete, reducing the overall expenses. This resulted in a lower denominator. Using the KVA methodology insured that no value, or information was lost due to reducing the costs of the process.

The Radical To-Be Model utilized further trust in RFID technology and reduced the total number of processes from nine in the incremental, to four. "Scan equipment to AMS" and "Properly Mark and Move Equipment to BOG/POG" were combined to "Scan Equipment auto send PVCT to AMS-TAC." "Assemble Cargo, Load Equipment & Supplies," "Assign Equipment to Tenders," and "Load and Account Tenders," all combined to "Load Ship/Tenders & Verify." "Movement to Port/Beach," "Unload, account, and move to FOB," and "Reports sent to MEU," all combine to "Movement to Port/Beach/FOB."

Table 11. Radical Model Cost Savings

Radical Model	Cost Saving Projections		
ROK/ROI - 1363%/1263%	Expenses	Revenues	Cost Savings
1 Year Projection - 9 Times Fired	$ 13,831.83	$ 188,546.49	$ 174,714.65
1 Year Projection - 20 Times Fired	$ 30,737.41	$ 418,992.19	$ 388,254.79
10 Year Projection - 9 Times Fired	$ 138,318.33	$ 1,885,464.86	$ 1,747,146.54
10 Year Projection - 20 Times Fired	$ 307,374.06	$ 4,189,921.92	$ 3,882,547.86
1 Year Projection - 231 Times Fired	$ 217,541.83	$ 4,591,038.95	$ 4,373,497.12
10 Year Projection - 231 Times Fired	$ 2,175,418.29	$ 45,910,389.49	$ 43,734,971.20
20 Year Projection - 231 Times Fired	$ 4,350,836.58	$ 91,820,778.99	$ 87,469,942.41

The base models were built based on our assumptions of nine iterations per year. We extrapolated this information for 20 process executions per year based on the work ups conducted during EABO to 20 times per year. Table 11 represents the cost savings for based on these baseline and extrapolated costs. Furthermore, the data was then calculated over a 10-year period using a straight-line multiplier with the cost savings outlined in Table 12. Finally, the radical model was used to project a 10 year and 20-year projection based on 231 executions per year. This number is based on of 21 deployments (seven MEUs- three per MEU), across an estimated 11 islands in the island chain for EABO. The ROIs for the multiyear estimates were straightline extrapolations and, while the absolute values changed, the resulting ROIs stayed the same across the estimates. The absolute values were useful in estimating the potential cost savings using the new technology without any attendant loss of value in the processes.

"Prepare Inventory" remained constant at 21 while the other process repetitions executed accounted for activity post-deployment. The ROK and ROI for this estimate was 2110% and 2010% with a cost savings of $43,734,971.20 over ten years and $87,469,942.41 over 20 years. With an initial investment of $3,000,000, the break-even point would be .77 years, outlined in Appendix A. With an initial investment of $954,699.00, the break-even point will be .24 years.

Table 12. Model Comparison for Cost Savings

Radical Model	Expenses	Revenues	Cost Savings	ROI
1 Year Projection - 9 Times Fired	$ 13,831.83	$ 188,546.49	$ 174,714.65	1263%
1 Year Projection - 20 Times Fired	$ 30,737.41	$ 418,992.19	$ 388,254.79	1263%
10 Year Projection - 9 Times Fired	$ 138,318.33	$ 1,885,464.86	$ 1,747,146.54	1263%
10 Year Projection - 20 Times Fired	$ 307,374.06	$ 4,189,921.92	$ 3,882,547.86	1263%
1 Year Projection - 231 Times Fired	$ 217,541.83	$ 4,591,038.95	$ 4,373,497.12	2010%
10 Year Projection - 231 Times Fired	$ 2,175,418.29	$45,910,389.49	$43,734,971.20	2010%
20 Year Projection - 231 Times Fired	$ 4,350,836.58	$91,820,778.99	$87,469,942.41	2010%

As-Is Model					
Cost Saving Projections	Projection	Times Fired	Expenses	Revenues	Cost Savings
1 Year Projection - 9 Times Fired	1 Year	9	$ 125,697.66	$ 188,546.49	$ 62,848.83
1 Year Projection - 20 Times Fired	1 Year	20	$ 279,328.13	$ 418,992.19	$ 139,664.06
10 Year Projection - 9 Times Fired	10 Year	9	$ 1,256,976.58	$ 1,885,464.86	$ 628,488.29
10 Year Projection - 20 Times Fired	10 Year	20	$ 2,793,281.28	$ 4,189,921.92	$ 1,396,640.64
Incremental To-Be Model					
Cost Saving Projections	Projection	Times Fired	Expenses	Revenues	Cost Savings
1 Year Projection - 9 Times Fired	1 Year	9	$ 52,554.99	$ 188,546.49	$ 135,991.49
1 Year Projection - 20 Times Fired	1 Year	20	$ 116,788.87	$ 418,992.19	$ 302,203.32
10 Year Projection - 9 Times Fired	10 Year	9	$ 525,549.92	$ 1,885,464.86	$ 1,359,914.94
10 Year Projection - 20 Times Fired	10 Year	20	$ 1,167,888.72	$ 4,189,921.92	$ 3,022,033.20
Radical Model					
Cost Saving Projections	Projection	Times Fired	Expenses	Revenues	Cost Savings
1 Year Projection - 9 Times Fired	1 Year	9	$ 13,831.83	$ 188,546.49	$ 174,714.65
1 Year Projection - 20 Times Fired	1 Year	20	$ 30,737.41	$ 418,992.19	$ 388,254.79
10 Year Projection - 9 Times Fired	10 Year	9	$ 138,318.33	$ 1,885,464.86	$ 1,747,146.54
10 Year Projection - 20 Times Fired	10 Year	20	$ 307,374.06	$ 4,189,921.92	$ 3,882,547.86
1 Year Projection - 231 Times Fired	1 Year	231	$ 217,541.83	$ 4,591,038.95	$ 4,373,497.12
10 Year Projection - 231 Times Fired	10 Year	231	$ 2,175,418.29	$ 45,910,389.49	$ 43,734,971.20
20 Year Projection - 231 Times Fired	20 Year	231	$ 4,350,836.58	$ 91,820,778.99	$ 87,469,942.41

F. RESULTS

The Incremental To-Be Model and Radical To-Be Model are two different approaches to process improvement that were applied to the EABO specific scenario in this case. The Incremental To-Be Model utilized RFID technology to streamline processes and reduce manpower hours; i.e., reduce costs, while maintaining the same amount of value calibrated in knowledge units; i.e., common units of output. This led to an increase in ROI and ROK by significantly reducing the denominator of the ratio and increasing the numerator with the increased number of total executions of the logistic process.

The Radical To-Be Model further relied on RFID technology and reduced the number of processes even further, resulting in significant cost savings and a higher ROI and ROK than the Incremental To-Be Model.

The data presented shows that the Radical To-Be Model is a more efficient approach for improving this core logistical process compared to the Incremental To-Be Model. The Radical To-Be Model reduced personnel requirements to less than 25% of the original personnel required in the As-Is, resulting in a significant cost savings of $174,714.68 per nine executions a year; almost triple the As-Is for a one-year period with nine executions per year. The total revenues and expenses are also presented, along with the ROI and ROK for each model, providing a clear picture of the financial impact of the process improvements.

Furthermore, projections were made for 10 and 20 years using the Radical To-Be Model, demonstrating the long-term financial benefits of implementing this model. The ROK and ROI projections for the Radical To-Be Model were significantly higher than those for the Incremental To-Be Model, indicating that the Radical To-Be Model is a more efficient approach to process improvement in the long term.

1. Nine Times Executed per Year

Nine total process executions per year were used in relation to the number of exercises that take place in a given year and the number of MEUs that depart for a deployment in a fiscal period to include the work-up cycle and other exercises, as seen in Table 13.

Table 13. One Year Projection for Nine Times Executed

1 Year Projection - 9 Times Fired	AS IS		Incremental To Be		Radical To Be	
	ROK	ROI	ROK	ROI	ROK	ROI
1. Prepare Inventory	181%	81%	181%	81%	181%	81%
2. Manifest Equipment	195%	95%	1062%	962%		
3. Send Manifest to Craft Master/NAVLOG	1022%	922%			13964%	13864%
4. Conduct Counts, Properly Mark, and Move Equip to BOG/POG	127%	27%	518%	418%		
5. Assemble Cargo, Load Equipment & Supplies	73%	-27%	105%	5%		
6. Assign Equipment to Tenders	73%	-27%	291%	191%		
7. Load and Account Tenders	487%	387%	750%	650%	650%	550%
8. Movement to Port/Beach	108%	8%	108%	8%		
9. Unload, account, and move to FOB	649%	549%	1230%	1130%	3193%	3093%
10. Monitor Inventory and send to MEU	273%	173%	3367%	3267%		
Total ROK/ROI	150%	50%	359%	259%	1363%	1263%
	Human	IT	Human	IT	Human	IT
Knowledge Hr/Process	194	18.6	72.5	140.1	26.5	189.1
Revenue per Knowledge Unit:	$98.54		$98.54		$98.54	
TLT	212.6		212.6		212.6	
Total Knowledge (Common units)	1913.4		1913.4		1913.4	
Expenses	$125,697.66		$52,554.99		$13,831.83	
Revenues	$188,546.49		$188,546.49		$188,546.49	
Denominator	$125,697.66		$52,554.99		$13,831.83	
Numerator	$188,546.49		$188,546.49		$188,546.49	
Correlation	Corre/ R.O.D. & A.A.T.P.	Correl R.L.T. & A.A.T.P.	Correl R.O.D. & A.A.T.P.	Correl R.L.T. & A.A.T.P.	Correl R.O.D. & A.A.T.P.	Correl R.L.T. & A.A.T.P.
	0.9128	0.8952	0.8758	0.8282	0.9898	0.9898

In the As-Is for nine executions per year, as a base, had expenses of $125,697.66 with revenues of $188,546.49, a cost savings of $62,848.83, with a 10-year projection of $628,488.29. The Incremental To-Be projected expenses of $52,554.99 with revenues of $188,546.49 and an annual cost savings of $135,991.49, with a 10-year projection of $1,359,914.94. The Radical To-Be model had expenses of $13,831.83, revenues of $188,546.49, and a cost savings of $174,714.65, projected over 10 years to $1,747,146.54. The Radical To-Be expenses were reduced from roughly $126,000 to just under $14,000 per year, as seen in Table 14.

Table 14. One Year Nine Times Executed Cost Savings

Cost Saving Projections					
	Expenses	Revenues	Cost Savings	ROK	ROI
As-Is 1 Year Projection - 9 Times Fired	$ 125,697.66	$ 188,546.49	$ 62,848.83	150%	50%
Incremental 1 Year Projection - 9 Times Fired	$ 52,554.99	$ 188,546.49	$ 135,991.49	359%	259%
Radical 1 Year Projection - 9 Times Fired	$ 13,831.83	$ 188,546.49	$ 174,714.65	1363%	1263%

2. Twenty Executions per Year

Twenty executions per year were used in relation to the number of exercises that take place in a given year and the assumption of increased MEU deployments over the next few years with the new EABO MEU concept. Force Design 2030 will increase the USMC's presence abroad and will increase the number of ships that deploy in a fiscal year (USMC, 2018).

In the As-Is for 20 executions per year, as a baseline, had expenses of $279,328.13 with revenues of $418,992.19, a cost savings of $139,664.06, with a 10-year projection of $1,396,640.64 (Table 15). The Incremental To-Be projected expenses of $116,788.87 with revenues of $418,992.19 and an annual cost savings of $302,203.32, with a 10-year projection of $3,022,033.20. The Radical To-Be model had expenses of $30,737.41, revenues of $418,992.19, and a cost savings of $388,254.79, projected over 10 years to $3,882,547.86. The Radical To-Be expenses were reduced from roughly $280,000 to just under $31,000 per year.

Table 15. One Year 20 Times Executed Cost Savings

Cost Saving Projections					
	Expenses	Revenues	Cost Savings	ROK	ROI
As-Is 1 Year Projection - 20 Times Fired	$ 279,328.13	$ 418,992.19	$ 139,664.06	150%	50%
Incremental 1 Year Projection - 20 Times Fired	$ 116,788.87	$ 418,992.19	$ 302,203.32	359%	259%
Radical 1 Year Projection - 20 Times Fired	$ 30,737.41	$ 418,992.19	$ 388,254.79	1363%	1263%

3. 231 Executions per Year

Finally, the Radical To-Be model was used to forecast a 1 year, 10 year, and 20-year projection based on 231 executed per year (Table 16). This number is based on of 21 deployments across the 7 MEUs, one deployment per MEU with three ships per MEU, across an estimated 11 islands in the island chain for EABO.

The Radical To-Be with 231 executions per year had expenses of $217,541.83 with revenues of $4,591,038.95, a cost savings of $4,373,497.12, with a 10-year projection of $43,734,971.20, and a 20 year projected savings of $87,469,942.41.

Table 16. One Year 231 Times Executed Cost Savings

Cost Saving Projections					
	Expenses	Revenues	Cost Savings	ROK	ROI
1 Year Projection - 231 Times Fired	$ 217,541.83	$ 4,591,038.95	$ 4,373,497.12	2110%	2010%

4. Total Knowledge and Learning Time

Total K allocated to IT in the As-Is was 112.5, Incremental To-Be 585, Radical To-Be 738. Table 17 shows the difference in Total K, per year, by execution, between the Human and IT Total K.

Table 17. Total K Comparison

Total K	IT	Human	% IT
As-Is (9)	112.5	1800.9	6.2%
Incremental To-Be (9)	585	1328.4	44.0%
Radical To-Be (9)	738	1175.4	62.8%
As is (20)	250	4002	6.2%
Incremental To-Be (20)	1300	2952	44.0%
Radical To-Be (20)	1640	2612	62.8%
Radical To-Be (231)	16842	29748.6	56.6%

One of the primary reasons for the subsequent reductions in cost, is the ease with which this technology can be learned and implemented – small learning curve. As evidence from Clayton Christensen (2015), the renowned innovative technology professor, RFID is a mature and sustaining technology, not a disruptive technology on the "bleeding edge." This mature technology will reduce the overall risk of incorporation.

In conclusion, the data presented demonstrates that the Radical To-Be Model is a more efficient approach to process improvement compared to the Incremental To-Be Model. Primarily because it resulted in significant cost savings, reduced personnel requirements, and higher ROI and ROK. The long-term projections further support the superiority of the Radical To-Be Model, making it a valuable approach to consider in similar process improvement scenarios.

5. Cycle Time

The cycle time reduction between models resulted from streamlined processes, reduced manpower and individual completion time (Table 18). IT effectively reduced workload and allowed for allocation of time to other tasks. It's important to note that cycle time reduction doesn't change process output, but it does save on manpower hours by decreasing completion time. This process is routine, and as cycle time is reduced, additional iterations are unnecessary. Reducing cycle time in the EABO context can provide a critical competitive advantage when the battle tempo increases.

Table 18. Cycle Time

Cycle Time	Average Time to Complete (Hours)
As-Is	36.17
Incremental To-Be	20.2
Radical To-Be	10

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V. CONCLUSIONS

Based on our analysis of the problem, the USMC should immediately adopt this technology. The ROI and cost savings outlined in the research conclude that this is a good investment for the USMC. The reduction in cost and the time-savings is directly attributed to the inclusion of RFID technology in the processes for EABO operations. The radical To-Be model is low risk and has a small learning curve to reach full maturity of the new system with a potential cost savings of $4.3 million in the first year, as outlined in Table 19. The breakeven analysis determined that this technology would pay for itself within the first year and therefore is a must for adoption. In the sections following, hurdle rates for adoptions are discussed as well as critical information to consider for the implementation of this new technology. It is important to note that some of the equipment required for RFID implementation may already be in place at various USMC units, which could reduce the overall implementation cost.

It is crucial to approach RFID implementation with a thorough understanding of the costs involved. Our estimate is based on a full inventory system overhaul, starting from a bare architecture to ensure a comprehensive estimate. However, it is worth noting that the potential benefits of RFID implementation may far outweigh the costs, and the long-term gains in efficiency and cost savings may make it a worthwhile investment for the USMC, or any organization trying to enhance its supply chain management.

Table 19. One Year Projections for Cost Savings and ROI

1 Year Projections for Cost Savings and ROI						
As-Is Model	Projection	Times Fired	Expenses	Revenues	Cost Savings	ROI
1 Year Projection - 9 Times Fired	1 Year	9	$ 125,697.66	$ 188,546.49	$ 62,848.83	50%
1 Year Projection - 20 Times Fired	1 Year	20	$ 279,328.13	$ 418,992.19	$ 139,664.06	50%
Incremental To-Be Model						
1 Year Projection - 9 Times Fired	1 Year	9	$ 52,554.99	$ 188,546.49	$ 135,991.49	259%
1 Year Projection - 20 Times Fired	1 Year	20	$ 116,788.87	$ 418,992.19	$ 302,203.32	259%
Radical Model						
1 Year Projection - 9 Times Fired	1 Year	9	$ 13,831.83	$ 188,546.49	$ 174,714.65	1263%
1 Year Projection - 20 Times Fired	1 Year	20	$ 30,737.41	$ 418,992.19	$ 388,254.79	1263%
1 Year Projection - 231 Times Fired	1 Year	231	$ 217,541.83	$ 4,591,038.95	$ 4,373,497.12	2010%

A. CONCLUSIONS

1. Hurdle Rates as a Benchmark for Investing

Incorporation of RFID in this new construct appears beneficial with dramatic cost savings. When deciding whether or not to implement a new technology, businesses will typically use hurdle rates to determine whether or not to invest. A hurdle rate, also known as a minimum acceptable rate of return (MARR), is the minimum rate of return that an investor or company requires before investing in a project (Kenton, 2023). The hurdle rate is used as a benchmark to evaluate the profitability of an investment opportunity, and it helps investors and companies to determine whether an investment will generate a sufficient return to justify the risk taken (Kenton, 2023).

As stated by Kenton (2023, p. 3), "Typically, a hurdle rate is based on a conservative rate of return such as the risk-free rate compared to the internal rate of return of a given project." In Jung (2009, p. 3) and Nelson's (2010) analysis of the cost of RFID, when RFID was implemented, the authors used "a notional expectation that the ROI of projects." This deviates from the conventional definition of a hurdle rate but is employed to establish a higher benchmark for the ROI of RFID projects, thereby creating a more ambitious standard for the anticipated performance of this technology in future projects.

As suggested by Jung et al. (2009, p. 53), "These results also suggested that projected improvement from RFID technology in the DOD may be overly conservative," meaning that the calculations presented in this thesis are a conservative estimate and that in the DOD, more often than not the ROI and ROK surpass the estimates.

Nelson (2010) explained in his thesis that the data indicates the estimates provided in the KVA analysis for the Navy AITS case were too low and did not accurately reflect the actual outcomes demonstrated in the Korean Armed Forces case. This means that the actual benefits from implementing RFID technology were greater than what was anticipated based on the KVA analysis projection of a 44% ROI. The author suggests that decision-makers may have concluded that investing in RFID technology would not be effective based on this low projection. However, the author argues that a more accurate estimation of the expected return is 166%, as determined using Modern Portfolio Theory

(MPT). The author supports this argument by comparing the KVA analysis data to the actual implementation data from the Korean ASW & 40SD case studies, which showed a higher return on investment.

Jung et al. (2009) stated in his research that a hurdle rate of 209% was expected and can be used for RFID in the DOD. Per the ROIs calculated in this study of 259% (Incremental To-Be [9]), 1263% (Radical To-Be [9]), and 2010% (Radical To-Be [231]), the hurdle rate is surpassed, and the technology is worth the investment.

2. Net Gain on Lost Gear in the DOD

Based on industry standards, it has been estimated that the Marine Corps' projected savings resulting from gear loss prevention efforts will amount to 15% of total current losses per Fiscal Year. While specific information regarding the Marine Corps lost and missing equipment during Fiscal Year is not publicly available, a comparison with similar industries provides an approximate estimate of annual savings of up to $45,000 (Sullivan, 2005). Although this data was not initially factored into our analysis, it is a valuable piece of information to consider when evaluating various risk factors associated with equipment management.

3. Cost Optimization Concerns

It is crucial to consider both cost savings and safety when exploring cost optimization strategies in the Marine Corps. However, the implementation of RFID for the MEU is a promising solution that does not compromise effectiveness or safety. It is important to recognize that the resources at hand for the Marine Corps encompass not only monetary assets but also the lives of those who serve. In this regard, the adoption of RFID technology does not pose a significant risk to personnel safety, as it does not significantly increase the EM spectrum footprint. In fact, the EM radiation emitted by RFID devices is negligible when compared to the broader EM footprint of MEUs. As such, the deployment of RFID devices is a cost-effective solution that will not only lead to significant cost-savings but also improve the overall efficiency and safety of Marine Corps operations.

B. DISCUSSION

1. Supports Strategy for EABO

The reduction in costs for logistic tracking and inventory through the implementation of RFID technology can support the strategy for EABO in multiple ways. EABO is a concept that emphasizes the ability to rapidly deploy military forces and supplies to remote locations, such as islands or coastlines, to establish a temporary operating base. In this context, reducing costs associated with logistics and inventory management is critical for ensuring that resources are available where and when they are needed. One way that RFID can support EABO is by providing real-time visibility of inventory levels and locations, which can help to prevent stockouts and overstocking. This is achieved by attaching RFID tags to items or containers, which can then be read by RFID readers located throughout the supply chain. This allows for the automatic tracking of items as they move through the supply chain, reducing the need for manual tracking and reducing the likelihood of human error. Another benefit of RFID technology is that it can help to reduce manpower hours required for conducting logistics operations. This is because RFID technology enables automatic tracking of inventory, reducing the need for manual inventory checks and reducing the time required to locate specific items. This can be particularly beneficial in EABO scenarios where time is of the essence and rapid deployment is critical.

To implement RFID technology in EABO, RFID tags would need to be attached to items or containers, and RFID readers would need to be installed throughout the supply chain, including on ships, aircraft, and at temporary operating bases. The EM signature of RFID tags enables them to be read wirelessly from a distance, which makes them a particularly useful technology for inventory tracking in dynamic and rapidly changing environments like EABO.

2. Extensible beyond EABO

The experience of improving logistics by reducing time spent on inventory in the USMC/EABO is highly extensible beyond just EABO. The benefits and advantages of RFID technology in logistics management are not limited to any specific geographical location or operation type. The same advantages of RFID technology in improving inventory management, reducing manpower hours, and enhancing operational efficiency can be applied to all USMC logistics operations worldwide. The USMC has a global presence with operations in various regions worldwide, ranging from training, humanitarian assistance, to combat operations. Each of these operations requires a robust logistics management system to ensure the timely and efficient movement of personnel and equipment to the operational area. The use of RFID technology can greatly enhance the logistics management system across all these operations.

For example, in combat operations, real-time visibility of inventory levels and locations is critical to ensuring that the right supplies are available at the right time and place. This helps to maintain the operational tempo and sustain the combat forces in the field. Similarly, in humanitarian assistance and disaster relief operations, the ability to track inventory levels and locations can help ensure that aid is delivered to the affected population in a timely and efficient manner. Moreover, RFID technology can help reduce the risk of errors and losses in all USMC logistics operations. It enables automated inventory management, which reduces the need for manual labor, minimizing the risk of human errors. The technology can also help prevent the loss of equipment and supplies by providing real-time visibility of inventory levels and locations, enabling timely response to any anomalies.

3. Help Provide Data for Auditing

The U.S. Navy and Marine Corps face numerous challenges when it comes to logistics auditing. One significant issue is the lack of accurate and timely data on inventory levels and locations, making it difficult to conduct effective audits. The implementation of RFID technology can help solve this problem by providing real-time data on inventory levels and locations, which can be used to develop controlled digital data for auditing. By using RFID tags on inventory items, the U.S. Navy and Marine Corps can automatically track their movement and location within the supply chain. This data can be integrated into a centralized database, which can be accessed by auditors to verify the accuracy of inventory records. The real-time nature of this data also means that audits can be conducted more frequently, improving the accuracy and timeliness of the audit process.

The use of RFID technology can also help reduce shrinkage, which is a significant concern for the Navy and Marine Corps. By having better inventory control, they can more accurately track their assets, reducing the risk of theft, loss, or misplacement. This is similar to what retailers like Amazon and Walmart have done with their inventory management systems, which have been shown to reduce shrinkage and improve overall inventory accuracy. By implementing RFID technology, the U.S. Navy and Marine Corps can develop a controlled digital data trail for auditing, which can help improve the accuracy and efficiency of their logistics operations. This will ultimately lead to better mission readiness and improved operational effectiveness, as the Navy and Marine Corps will have a clearer picture of their inventory levels and locations, enabling them to make better-informed decisions.

4. Standard Practice

RFID technology has become a standard practice across many industries, including retail, manufacturing, healthcare, and logistics. It is a proven technology that can provide significant benefits for inventory management, supply chain visibility, and operational efficiency. The incorporation of RFID technology in the Navy and Marine Corps logistics operations has the potential for enormous improvements in all logistics inventory issues and processes.

C. LIMITATIONS, RECOMMENDATIONS AND CALLS FOR FUTURE RESEARCH

1. Limitations

The results presented in this thesis are based on a model and may not necessarily reflect real-world data. The accuracy and applicability of the model may vary depending on the assumptions and limitations inherent in the methodology used.

Since the proposed approach has not been implemented and tested in the real-world yet, there is no empirical evidence to support the effectiveness of the method. The outcomes may differ from those predicted by the model due to unforeseen factors or variables that were not accounted for in the model.

The concept of EABO (or any other novel approach) is still in its infancy, and there may be many unknown factors or limitations associated with its implementation. The proposed methodology may need further refinement or modification to improve its effectiveness and applicability in practical scenarios.

The sample size and scope of this research are limited, and therefore, the generalizability of the findings may be limited as well. The results may not be applicable to other populations or contexts beyond the scope of this study.

This research is subject to certain biases or limitations inherent in the data collection and analysis methodology. These may include selection bias, measurement error, or confounding variables that were not accounted for in the analysis. Additionally, any information, data, recommendations, or opinions garneed from subject matter experts regarding pricing and manpower needed may be inflated or deflated due to rapid changes happening with the Marine Corps and DOD writ-large.

2. Recommendations and Calls For Future Research

In order to validate the results obtained in this research, future studies should conduct the proposed experiment on a large or small scale. This will provide the opportunity to test the effectiveness of the proposed methodology in real-world scenarios and to evaluate its impact on operational performance, efficiency, and cost.

Based on the results of this research, it is recommended that future studies explore the implementation of RFID technology on a MEU for exercises in the Pacific region, including units on Okinawa, Guam, Japan, and Hawaii. This will provide a suitable environment to test the applicability and effectiveness of the proposed approach in a variety of operational scenarios.

Future research should focus on testing and evaluating the proposed methodology for real-world scenarios, including scenarios that involve dynamic and unpredictable factors. This will help to identify the potential limitations and challenges of the approach and provide insights into how it can be improved to better meet the needs of operational environments.

In addition to the above recommendations, future research should explore the integration of the proposed methodology with other technologies, such as GPS, satellite communication, and sensor networks. This will enable a more comprehensive and integrated approach to tracking and managing military assets, and improve the overall effectiveness and efficiency of military operations.

Further research should also focus on evaluating the potential benefits of the proposed methodology from the perspective of various stakeholders, including military personnel, commanders, and civilian decision-makers. This will help to identify the key drivers and motivations for implementing the approach and provide insights into the potential barriers and challenges to its adoption and implementation.

Lastly, using the current Russo-Ukrainian conflict to determine factors that led tototal equipment loss on the battlefield. Drone capabilities in conjunction with RFID and push logistics can be a force multiplier for the future fighting forces in EABO. Many lessons from this conflict can be applied directly to the RFID and EABO problem set.

APPENDIX A. BREAK-EVEN ANALYSIS

Radical To-Be (231)		Year							
		0	1	2	3	4		Assumed Discount Rate	8%
		(only dev costs)		Operations Costs					
		2024	2025	2026	2027	2028	Total		
Benefits									
	Reduction in Time		4,591,039	4,591,039	4,591,039	4,591,039	18,364,156	*Assumed sales increase each year*	*0%*
								Assumed constant over the years	
								Assumed constant over the years	
Total Benefits			**4,591,039**	**4,591,039**	**4,591,039**	**4,591,039**	**18,364,156**		
PV Total Benefits (8% rate of return)			**4,250,962**	**3,936,076**	**3,644,515**	**3,374,551**	**15,206,103**	*PV= Cash flow amount/(1+Rate)^n*	
Development Costs									
	Antenna	97,196	0	0	0	0	97,196		
	Interrogator	126,000	0	0	0	0	126,000		
	Scanner	138,128	0	0	0	0	138,128		
	AMS TAC	266,128	0	0	0	0	266,128		
	Passive Tags	20,998	0	0	0	0	20,998		
	Active Tags	306,250	0	0	0	0	306,250		
Total Development Costs		**954,699**	**0**	**0**	**0**	**0**	**954,699**		
Operational Costs									
	Labor		217,542	217,542	217,542	217,542	870,167		
	Software		456,219	456,219	456,219	456,219	1,824,876		
								Assumed labor cost increase each year	4%
Total operational costs			**673,761**	**673,761**	**673,761**	**673,761**	**2,695,043**		
Total Costs		**954,699**	**673,761**	**673,761**	**673,761**	**673,761**	**3,649,742**	*(Dev costs + Ops costs)*	
PV Total Costs		**954,699**	**623,853**	**577,641**	**534,853**	**495,234**	**3,186,280**	*PV= Cash flow amount/(1+Rate)^n*	
(Total Benefits) - (Total Costs) =		**(954,699)**	**3,917,278**	**3,917,278**	**3,917,278**	**3,917,278**	**14,714,413**	*net Benefits*	
Net Present Value (NPV) =							**12,019,823**	*PV total benefits - PV Total Costs*	
							Feasible		
Cumulative Net Cash Flow =		**(954,699)**	**2,962,579**	**6,879,857**	**10,797,135**	**14,714,413**		*Year 1 + Year 2 (TB - TC)*	
Return on Investment (ROI) =		403%	*ROI = (TB-TC)/TC*						
Break Even Point (years) =		0.24	*BEP = #yrs neg + 1st postive year (net benefits - cumulative cash flow)/net cash flow*						

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APPENDIX B. DATA ANALYSIS KVA AS-IS

Process	Number of Employee								Number of Employees(Total)	Rank of Difficulty (to learn)	Relative learning time	Actual Average Learning Time(hr)	Percentage Automation	Times performed in a year	Average Time to complete	Knowledge(hr)/Process		Tot K/Process	Total K/Yr	Mkt Comp Rev/Hr	Tot Mkt Comp Rev/Yr	Human Cost/Hr	Human Cost/Yr	Automation Tools	IT LT
	E1-E3	NCO	SNCO	CWO	O1	O2	O3	O4								Human	IT								
1. Prepare Inventory	4	2	1	0	2	0	1	0	10	2	20	1	50%	21	2	10	5	12	252	$ 491	$ 123,728	$ 491	$ 20,621	Software Program	10
2. Scan Equipment autosend PVCT to AMS-TAC	1	0	0	1	0	0	0	0	2	4	40	3	90%	231	1	6	101.7	107.7	24878.7	$ 114	$ 2,836,165	$ 114	$ 26,334	Software Program	36
3. Load Ship/Tenders & Verify	3	0	1	0	0	0	0	0	4	3	30	2	90%	231	6	8	35.05	43.05	9944.55	$ 163	$ 1,621,878	$ 163	$ 226,046	Software Program	27
5. Movement to Port/Beach/FOB	2	1	1	0	1	0	0	0	5	1	10	0.5	90%	231	1	2.5	47.35	49.85	11515.35	$ 231	$ 2,657,596	$ 231	$ 53,312	Software Program	9
Total	10	3	3	1	3	0	1	0	21	10	100	6.5		714	10	26.5	189.1	212.6	46590.6	$ 999	$ 7,239,366	$ 999	$ 326,313		

Process	TLT	Total K	Expenses	Revenues	Denomiator	Numerator	ROK	ROI
1. Prepare Inventory	12	252	$ 13,747.52	$ 24,832.09	$ 13,747.52	$ 24,832	181%	81%
2. Scan Equipment autosend PVCT to AMS-TAC	107.7	24878.7	$ 17,555.96	$ 2,451,547.75	$ 17,555.96	$ 2,451,548	13964%	13864%
3. Load Ship/Tenders & Verify	43.05	9944.55	$ 150,697.11	$ 979,936.22	$ 150,697.11	$ 979,936	650%	550%
5. Movement to Port/Beach/FOB	49.85	11515.35	$ 35,541.24	$ 1,134,722.89	$ 35,541.24	$ 1,134,723	3193%	3093%
Total	212.6	46590.6	$ 217,541.83	$ 4,591,038.95	$ 217,541.83	$ 4,591,038.95	2110%	2010%

Allocation	Total K IT	Cost IT	ROK
5.64%	210	N/A	N/A
50.66%	8316	N/A	N/A
20.25%	6237	N/A	N/A
23.45%	2079	N/A	N/A
	16842		

CORRELATION:	Order of Difficulty to Actual Learning Time	0.989778267
CORRELATION:	Relative Learning Time to Actual Avg Training	0.989778267
CORRELATION:	ROI to ROK	1
Revenue Per K		$ 98.54

Pay Grade	Yearly Salary($)	Yearly salary/hr($)	Mkt Comparable Revenue	Mkt Comparable Revenue/hr
E1-E3	$26,460.00	$12.72	$67,473.00	$32.44
NCO	$38,034.00	$18.29	$96,986.70	$46.63
SNCO	$53,652.00	$25.79	$136,812.60	$65.78
CWO1-3	$66,528.00	$31.98	$169,646.40	$81.56
O1	$43,644.00	$20.98	$111,292.20	$53.51
O2	$57,276.00	$27.54	$146,053.80	$70.22
O3	$77,640.00	$37.33	$197,982.00	$95.18
O4	$92,712.00	$44.57	$236,415.60	$113.66

Note : Hourly wage = Base Pay / (260 working days in a year * 8 working hours per day)

Knowledge(%)	
Human	IT
20%	80.00%
90%	10.00%
10%	90.00%
10%	90.00%
50%	50.00%
50%	50.00%
10%	90.00%
50%	50.00%
90%	10.00%

Ave Mkt Com	$ 98,334.90
Ave Cost/Person	$ 66,286.38

	E1-E3	NCO	SNCO	CWO1-3	O1	O2	O3	O4
Yearly Salary	$26,460	$38,034	$53,652	$66,528	$43,644	$57,276	$77,640	$92,712
Yearly Salary/hr	$12.72	$18.29	$25.79	$31.98	$20.98	$27.54	$37.33	$44.57
Mkt revenue/hr	$32.44	$46.63	$65.78	$81.56	$53.51	$70.22	$95.18	$113.66

Assumptions

A day is equal to 8 working hours; 40 working hours per week; 4 weeks per month; 365 days per year
Ranking Order of Difficulty 10 is the most difficult to learn and 1 is the least difficult to learn.
There are 260 working days per year
Automation does not add on to the output
Hourly wage is calculated from the 2023 basic pay table provided from DFAS
Hourly Wage is equal to the Basic Pay divided by working days times the amount of hours worked in a day
Numerator is equal to the ratio of knowledge of each process and total knowledge multiplied by the total revenue. — 7 MEUs - each do a work up and deployment with 3 iterations for each
Times used per year is based off the number of MEUs that depart each year for exercises and deployments
All Marines possess a minimum of a high school reading level — 21 Deployments
All Marines possess basic office suite knowledge (outlook/word/excel/powerpoint...) — 11 Islands
Hourly wages based off basic pay rate without BAH — 231 Total Fires

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APPENDIX C. DATA ANALYSIS KVA TO-BE INCREMENTAL

Process	Number of Employee								Number of Employees(Total)	Rank of Difficulty (to learn)	Relative learning time	Actual Average Learning Time(hr)	Percentage Automation	Times performed in a year	Average Time to complete	Knowledge(hr)/Process		Tot K/Process	Total K/Yr	Mkt Comp Rev/Hr	Tot Mkt Comp Rev/Yr	Human Cost/Hr	Human Cost/Yr	Automation Tools	IT LT
	E1-E3	NCO	SNCO	CWO	O1	O2	O3	O4								Human	IT								
1. Prepare Inventory	4	2	1	0	2	0	1	0	10	3	5	1	20%	9	2	10	2	12	108	$ 491	$ 53,026	$ 491	$ 8,838	Software Program	1
2. Scan Equipment to AMS	3	0	0	1	0	0	1	0	5	5	10	1	90%	9	1	5	14.7	19.7	177.3	$ 274	$ 48,591	$ 274	$ 2,467	Software Program	9
3. Properly Mark and Move Equip to BOG/POG	6	2	1	0	1	0	1	0	11	8	20	1.5	90%	9	5	16.5	71.5	88	792	$ 502	$ 397,865	$ 502	$ 22,606	Software Program	18
4. Assemble Cargo, Load Equipment & Supplies	4	2	1	1	1	0	0	0	9	9	20	1.5	40%	9	8	13.5	10.7	24.2	217.8	$ 424	$ 92,315	$ 424	$ 30,517	Software Program	8
5. Assign Equipment to Tenders	2	2	1	0	1	0	0	1	7	1	5	0.5	50%	9	0.5	3.5	0.35	3.85	34.65	$ 391	$ 13,551	$ 391	$ 1,760	Software Program	2.5
6. Load and Account Tenders	4	1	1	0	1	0	0	0	7	7	20	1	60%	9	1	7	8	15	135	$ 296	$ 39,915	$ 296	$ 2,661	Software Program	12
7. Movement to Port/Beach	6	1	1	0	1	0	1	0	10	2	5	0.5	50%	9	1.5	5	0	5	45	$ 456	$ 20,508	$ 456	$ 6,152	Software Program	2.5
8. Unload, account, and move to FOB	6	1	1	0	1	0	0	0	9	6	10	1	75%	9	1	9	21	30	270	$ 361	$ 97,347	$ 361	$ 3,245	Software Program	7.5
9. Reports sent to MEU	2	1	1	0	1	0	1	0	6	4	5	0.5	90%	9	0.2	3	11.85	14.85	133.65	$ 326	$ 43,566	$ 326	$ 587	Software Program	4.5
Total	37	12	8	2	9	0	5	1	74	45	100	8.5		81	20.2	72.5	140.1	212.6	1913.4	$ 3,520	$ 806,684	$ 3,520	$ 78,832		

Process	TLT	Total K	Expenses	Revenues	Denomiator	Numerator	ROK	ROI
1. Prepare Inventory	12	108	$ 5,891.79	$ 10,642.32	$ 5,891.79	$ 10,642	181%	81%
2. Scan Equipment to "universal system"	19.7	177.3	$ 1,644.37	$ 17,471.15	$ 1,644.37	$ 17,471	1062%	962%
3. Properly Mark and Move Equip to BOG/POG	88	792	$ 15,070.65	$ 78,043.70	$ 15,070.65	$ 78,044	518%	418%
4. Assemble Cargo, Load Equipment & Supplies	24.2	217.8	$ 20,345.00	$ 21,462.02	$ 20,345.00	$ 21,462	105%	5%
5. Assign Equipment to Tenders	3.85	34.65	$ 1,173.23	$ 3,414.41	$ 1,173.23	$ 3,414	291%	191%
6. Load and Account Tenders	15	135	$ 1,773.99	$ 13,302.90	$ 1,773.99	$ 13,303	750%	650%
7. Movement to Port/Beach	5	45	$ 4,101.54	$ 4,434.30	$ 4,101.54	$ 4,434	108%	8%
8. Unload, account, and move to FOB	30	270	$ 2,163.26	$ 26,605.81	$ 2,163.26	$ 26,606	1230%	1130%
9. Reports sent to MEU	14.85	133.65	$ 391.17	$ 13,169.87	$ 391.17	$ 13,170	3367%	3267%
Total	212.6	1913.4	$ 52,554.99	$ 188,546.49	$ 52,554.99	$ 188,546.49	359%	259%

Allocation	Total K IT	Cost IT	ROK
5.64%	9	N/A	N/A
9.27%	81	N/A	N/A
41.39%	162	N/A	N/A
11.38%	72	N/A	N/A
1.81%	22.5	N/A	N/A
7.06%	108	N/A	N/A
2.35%	22.5	N/A	N/A
14.11%	67.5	N/A	N/A
6.98%	40.5	N/A	N/A
	585		

CORRELATION:	Order of Difficulty to Actual Learning Time	0.875811312
CORRELATION:	Relative Learning Time to Actual Avg Training	0.828176686
CORRELATION:	ROI to ROK	1
Revenue Per K		$ 98.54

Pay Grade	Yearly Salary($)	Yearly salary/hr($)	Mkt Comparable Revenue	Mkt Comparable Revenue/hr
E-1 - E-3	$26,460.00	$12.72	$67,473.00	$32.44
NCO	$38,034.00	$18.29	$96,986.70	$46.63
SNCO	$53,652.00	$25.79	$136,812.60	$65.78
CWO1-3	$66,528.00	$31.98	$169,646.40	$81.56
O1	$43,644.00	$20.98	$111,292.20	$53.51
O2	$57,276.00	$27.54	$146,053.80	$70.22
O3	$77,640.00	$37.33	$197,982.00	$95.18
O4	$92,712.00	$44.57	$236,415.60	$113.66

Knowledge(%)	
Human	IT
20%	80.00%
90%	10.00%
10%	90.00%
10%	90.00%
50%	50.00%
50%	50.00%
10%	90.00%
50%	50.00%
90%	10.00%

Ave Mkt Com	$ 98,547.17
Ave Cost/Person	$ 66,294.60

	E1-E3	NCO	SNCO	CWO1-3	O1	O2	O3	O4
Yearly Salary	$26,460	$38,034	$53,652	$66,528	$43,644	$57,276	$77,640	$92,712
Yearly Salary/hr	$12.72	$18.29	$25.79	$31.98	$20.98	$27.54	$37.33	$44.57
Mkt revenue/hr	$32.44	$46.63	$65.78	$81.56	$53.51	$70.22	$95.18	$113.66

Note : Hourly wage = Base Pay / (260 working days in a year * 8 working hours per day)

Assumptions

A day is equal to 8 working hours; 40 working hours per week; 4 weeks per month; 365 days per year
Ranking Order of Difficulty 10 is the most difficult to learn and 1 is the least difficult to learn.
There are 260 working days per year
Automation does not add on to the output
Hourly wage is calculated from the 2023 basic pay table provided from DFAS
Hourly Wage is equal to the Basic Pay divided by working days times the amount of hours worked in a day
Numerator is equal to the ratio of knowledge of each process and total knowledge multiplied by the total revenue.
Times used per year is based off the number of MEUs that depart each year for exercises and deployments
All Marines possess a minimum of a high school reading level
All Marines possess basic office suite knowledge (outlook/word/excel/powerpoint...)
Hourly wages based off basic pay rate without BAH

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APPENDIX D. DATA ANALYSIS TO-BE RADICAL

Process	Number of Employee								Number of Employees(Total)	Rank of Difficulty (to learn)	Relative learning time	Actual Average Learning Time(hr)	Percentage Automation	Times performed in a year	Average Time to complete
	E 1 - E 3	NCO	SNCO	CWO	O1	O2	O3	O 4							
1. Prepare Inventory	4	2	1	0	2	0	1	0	10	2	20	1	50%	9	2
2. Scan Equipment autosend PVCT to AMS-TAC	1	0	0	1	0	0	0	0	2	4	40	3	90%	9	1
3. Load Ship/Tenders & Verify	3	0	1	0	0	0	0	0	4	3	30	2	90%	9	6
4. Movement to Port/Beach/FOB	2	1	1	0	1	0	0	0	5	1	10	0.5	90%	9	1
Total	10	3	3	1	3	0	1	0	21	10	100	6.5		36	10

Process	Knowledge(hr)/ Process		Tot K/Process	Total K/Yr	Mkt Comp Rev/Hr	Tot Mkt Comp Rev/Yr	Human Cost/Hr	Human Cost/Yr	Automation Tools	IT LT
	Human	IT								
1. Prepare Inventory	10	5	12	108	$ 491	$ 53,026	$ 491	$ 8,838	Software Program	10
2. Scan Equipment autosend PVCT to AMS-TAC	6	101.7	107.7	969.3	$ 114	$ 110,500	$ 114	$ 1,026	Software Program	36
3. Load Ship/Tenders & Verify	8	35.05	43.05	387.45	$ 163	$ 63,190	$ 163	$ 8,807	Software Program	27
4. Movement to Port/Beach/FOB	2.5	47.35	49.85	448.65	$ 231	$ 103,543	$ 231	$ 2,077	Software Program	9
Total	26.5	189.1	212.6	1913.4	$ 999	$ 330,259	$ 999	$ 20,748		

Process	TLT	Total K	Expenses	Revenues	Denomiator	Numerator	ROK	ROI
1. Prepare Inventory	12	108	$ 5,891.79	$ 10,642.32	$ 5,891.79	$ 10,642	181%	81%
2. Scan Equipment autosend PVCT to AMS-TAC	107.7	969.3	$ 684.00	$ 95,514.85	$ 684.00	$ 95,515	13964%	13864%
3. Load Ship/Tenders & Verify	43.05	387.45	$ 5,871.32	$ 38,179.33	$ 5,871.32	$ 38,179	650%	550%
4. Movement to Port/Beach/FOB	49.85	448.65	$ 1,384.72	$ 44,209.98	$ 1,384.72	$ 44,210	3193%	3093%
Total	212.6	1913.4	$ 13,831.83	$ 188,546.49	$ 13,831.83	$ 188,546.49	1363%	1263%

Allocation	Total K IT	Cost IT	ROK
5.64%	90	N/A	N/A
50.66%	324	N/A	N/A
20.25%	243	N/A	N/A
23.45%	81	N/A	N/A

CORRELATION:	Order of Difficulty to Actual Learning Time	0.989778267
CORRELATION:	Relative Learning Time to Actual Avg Training	0.989778267
CORRELATION:	ROI to ROK	1
Revenue Per K		$ 98.54

Pay Grade	Yearly Salary($)	Yearly salary/hr($)	Mkt Comparable Revenue	Mkt Comparable Revenue/hr
E-1 - E-3	$26,460.00	$12.72	$67,473.00	$32.44
NCO	$38,034.00	$18.29	$96,986.70	$46.63
SNCO	$53,652.00	$25.79	$136,812.60	$65.78
CWO1-3	$66,528.00	$31.98	$169,646.40	$81.56
O1	$43,644.00	$20.98	$111,292.20	$53.51
O2	$57,276.00	$27.54	$146,053.80	$70.22
O3	$77,640.00	$37.33	$197,982.00	$95.18
O4	$92,712.00	$44.57	$236,415.60	$113.66

Knowledge(%)	
Human	IT
20%	80.00%
90%	10.00%
10%	90.00%
10%	90.00%
50%	50.00%
50%	50.00%
10%	90.00%
50%	50.00%
90%	10.00%

Ave Mkt Com	$ 98,934.90
Ave Cost/Person	$ 66,286.38

	E1-E3	NCO	SNCO	CWO1-3	O1	O2	O3	O4
Yearly Salary	$26,460	$38,034	$53,652	$66,528	$43,644	$57,276	$77,640	$92,712
Yearly Salary/hr	$12.72	$18.29	$25.79	$31.98	$20.98	$27.54	$37.33	$44.57
Mkt revenue/hr	$32.44	$46.63	$65.78	$81.56	$53.51	$70.22	$95.18	$113.66

Note : Hourly wage = Base Pay / (260 working days in a year * 8 working hours per day)

Assumptions

A day is equal to 8 working hours; 40 working hours per week; 4 weeks per month; 365 days per year
Ranking Order of Difficulty 10 is the most difficult to learn and 1 is the least difficult to learn.
There are 260 working days per year
Automation does not add on to the output
Hourly wage is calculated from the 2023 basic pay table provided from DFAS
Hourly Wage is equal to the Basic Pay divided by working days times the amount of hours worked in a day
Numerator is equal to the ratio of knowledge of each process and total knowledge multiplied by the total revenue.
Times used per year is based off the number of MEUs that depart each year for exercises and deployments
All Marines possess a minimum of a high school reading level
All Marines possess basic office suite knowledge (outlook/word/excel/powerpoint...)
Hourly wages based off basic pay rate without BAH

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APPENDIX E. DATA ANALYSIS TO-BE RADICAL – 231 EXECUTIONS

Process	Number of Employee								Number of Employees(Total)	Rank of Difficulty (to learn)	Relative learning time	Actual Average Learning Time(hr)	Percentage Automation	Times performed in a year	Average Time to complete	Knowledge(hr)/Process		Tot K/Process	Total K/Yr	Mkt Comp Rev/Hr	Tot Mkt Comp Rev/Yr	Human Cost/Hr	Human Cost/Yr	Automation Tools	IT LT
	E 1 - E 3	NCO	SNCO	CWO	O1	O2	O3	O 4								Human	IT								
1. Prepare Inventory	4	2	1	0	2	0	1	0	10	2	20	1	50%	21	2	10	5	12	252	$ 491	$ 123,728	$ 491	$ 20,621	Software Program	10
2. Scan Equipment autosend PVCT to AMS-TAC	1	0	0	1	0	0	0	0	2	4	40	3	90%	231	1	6	101.7	107.7	24878.7	$ 114	$ 2,836,165	$ 114	$ 26,334	Software Program	36
3. Load Ship/Tenders & Verify	3	0	1	0	0	0	0	0	4	3	30	2	90%	231	6	8	35.05	43.05	9944.55	$ 163	$ 1,621,878	$ 163	$ 226,046	Software Program	27
5. Movement to Port/Beach/FOB	2	1	1	0	1	0	0	0	5	1	10	0.5	90%	231	1	2.5	47.35	49.85	11515.35	$ 231	$ 2,657,596	$ 231	$ 53,312	Software Program	9
Total	10	3	3	1	3	0	1	0	21	10	100	6.5		714	10	26.5	189.1	212.6	46590.6	$ 999	$ 7,239,366	$ 999	$ 326,313		

Process	TLT	Total K	Expenses	Revenues	Denominator	Numerator	ROK	ROI
1. Prepare Inventory	12	252	$ 13,747.52	$ 24,832.09	$ 13,747.52	$ 24,832	181%	81%
2. Scan Equipment autosend PVCT to AMS-TAC	107.7	24878.7	$ 17,555.96	$ 2,451,547.75	$ 17,555.96	$ 2,451,548	13964%	13864%
3. Load Ship/Tenders & Verify	43.05	9944.55	$ 150,697.11	$ 979,936.22	$ 150,697.11	$ 979,936	650%	550%
5. Movement to Port/Beach/FOB	49.85	11515.35	$ 35,541.24	$ 1,134,722.89	$ 35,541.24	$ 1,134,723	3193%	3093%
Total	212.6	46590.6	$ 217,541.83	$ 4,591,038.95	$ 217,541.83	$ 4,591,038.95	2110%	2010%

Allocation	Total K IT	Cost IT	ROK
5.64%	210	N/A	N/A
50.66%	8316	N/A	N/A
20.25%	6237	N/A	N/A
23.45%	2079	N/A	N/A
	16842		

CORRELATION:	Order of Difficulty to Actual Learning Time	0.989778267
CORRELATION:	Relative Learning Time to Actual Avg Training	0.989778267
CORRELATION:	ROI to ROK	1
Revenue Per K		$ 98.54

Pay Grade	Yearly Salary($)	Yearly salary/hr($)	Mkt Comparable Revenue	Mkt Comparable Revenue/hr
E-1 - E-3	$26,460.00	$12.72	$67,473.00	$32.44
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O2	$57,276.00	$27.54	$146,053.80	$70.22
O3	$77,640.00	$37.33	$197,982.00	$95.18
O4	$92,712.00	$44.57	$236,415.60	$113.66

Knowledge(%)	
Human	IT
20%	80.00%
90%	10.00%
10%	90.00%
10%	90.00%
50%	50.00%
50%	50.00%
10%	90.00%
50%	50.00%
90%	10.00%

Ave Mkt Com	$ 98,934.90
Ave Cost/Person	$ 66,286.38

	E1-E3	NCO	SNCO	CWO1-3	O1	O2	O3	O4
Yearly Salary	$26,460	$38,034	$53,652	$66,528	$43,644	$57,276	$77,640	$92,712
Yearly Salary/hr	$12.72	$18.29	$25.79	$31.98	$20.98	$27.54	$37.33	$44.57
Mkt revenue/hr	$32.44	$46.63	$65.78	$81.56	$53.51	$70.22	$95.18	$113.66

Note : Hourly wage = Base Pay / (260 working days in a year * 8 working hours per day)

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All Marines possess basic office suite knowledge (outlook/word/excel/powerpoint…)
Hourly wages based off basic pay rate without BAH

7 MEUs - each do a work up and deployment with 3 iterations for each

21	Deployments
11	Islands
231	Total Fires

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