NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

MBA PROFESSIONAL REPORT

Assessment of RFID Investment in the Military Logistics Systems Through The Cost of Ownership Model (COO)

By: Ahmet Ozdemir
Mustafa Ali Bayrak
March 2010

Advisors: **Geraldo Ferrer**
Keebom Kang

Approved for public release; distribution is unlimited.

REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.			
1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** March 2010	**3. REPORT TYPE AND DATES COVERED** MBA Professional Report	
4. TITLE AND SUB TITLE: Assessment of RFID Investment in the Military Logistics Systems Through The Cost of Ownership Model (COO)			**5. FUNDING NUMBERS**
6. AUTHOR(S) Ahmet Ozdemir, Mustafa Ali Bayrak			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES The views expressed in this report are those of the author(s) and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release, distribution is unlimited			**12b. DISTRIBUTION CODE**

13. ABSTRACT *(maximum 200 words)*

Radio Frequency Identification (RFID) is an emerging technology that has been recently used in numerous business and public fields. Most military applications of RFID have focused on logistics systems. Since RFID investment requires high initial cost and its benefits are hard to see in the short term, it needs an appropriate investment decision model.

The purpose of this research is to propose a Cost of Ownership (COO) model for RFID integration into the Military Logistics System (MLS). The study primarily focuses on the question, whether the cost of integrating and operating the Turkish Naval Logistics System (TNLS) with RFID is worth investing. The results of this study provide a strategic roadmap allowing decision makers to determine if the logistics system considered is a good candidate for RFID technology integration based on the comparison of the COOs of the current and the RFID integrated MLS. This study also enlightens possible cost parameters and their impacts on the total cost of RFID technology implementation in MLS.

14. SUBJECT TERMS Radio Frequency Identification, RFID, Cost of Ownership, COO, Military Logistics System, Life Cycle Cost, LCC, Supply Chain, Cost Benefit Analysis, Turkey			**15. NUMBER OF PAGES** 140
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UU

THIS PAGE INTENTIONALLY LEFT BLANK

Appropriate for public release; distribution is unlimited

ASSESSMENT OF RFID INVESTMENT IN THE MILITARY LOGISTICS SYSTEMS THROUGH THE COST OF OWNERSHIP MODEL (COO)

Ahmet Ozdemir, Captain, Turkish Army
Mustafa Ali Bayrak, Lieutenant Junior Grade, Turkish Navy

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF BUSINESS ADMINISTRATION

from the

NAVAL POSTGRADUATE SCHOOL
March 2010

Authors: _____________________________________
Ahmet Ozdemir

____
Mustafa Ali Bayrak

Approved by: _____________________________________
Geraldo Ferrer, PhD, Lead Advisor

____
Keebom Kang, Support Advisor

____
William Gates, Dean
Graduate School of Business and Public Policy

THIS PAGE INTENTIONALLY LEFT BLANK

ASSESSMENT OF RFID INVESTMENT IN THE MILITARY LOGISTICS SYSTEMS THROUGH THE COST OF OWNERSHIP MODEL

ABSTRACT

Radio Frequency Identification (RFID) is an emerging technology that has been recently used in numerous business and public fields. Most military applications of RFID have focused on logistics systems. Since RFID investment requires high initial cost and its benefits are hard to see in the short term, it needs an appropriate investment decision model.

The purpose of this research is to propose a Cost of Ownership (COO) model for RFID integration into the Military Logistics System (MLS). The study primarily focuses on the question, whether the cost of integrating and operating the Turkish Naval Logistics System (TNLS) with RFID is worth investing. The results of this study provide a strategic roadmap allowing decision makers to determine if the logistics system considered is a good candidate for RFID technology integration based on the comparison of the COOs of the current and the RFID integrated MLS. This study also enlightens possible cost parameters and their impacts on the total cost of RFID technology implementation in MLS.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

AAIT	Automatic Asset Identification Technology
AD	Acceptance Document
C	Customer
C&C	Checking and Counting
CAM	Customer Asset Control Manager
CAMP	Customer Asset Management Personnel
CAP	Customer Asset Control Personnel
CBA	Cost Benefit Analysis
CC	Customer Custodian
CEA	Cost Effectiveness Analysis
COO	Cost of Ownership
DC	Depot Custodian
DoD	Department of Defense
EPC	Electronic Product Code
GDP	Gross Domestic Product
GPS	Global Positioning System
HQ	Headquarter
IAD	Inspection and Acceptance Document
IAM	Inventory Acceptance Manager
IC	Inspection Custodian
ICC	Inventory Control Center
ICM	Inventory Control Manager

IDN	Identification Number
IMMS	Integrated Materiel Management System
IRR	Internal Rate of Return
IT	Inspection Team
JIT	Just in Time
LCC	Life Cycle Cost
MLS	Military Logistics System
MoD	Ministry of Defense
MSC ICM	Main Supply Command Inventory Control Manager
MSC SCO	Main Supply Command Stock Control Office
MSC SCO	Main Supply Command Stock Control Office
MSC	Main Supply Command
NL	Non-Conformance List
NPV	Net Present Value
O&S	Operating and Support
PO	Procurement Office
PP	Payback Period
R&D	Research and Development
RD	Receipt Document
RF	Radio Frequency
RFID	Radio Frequency Identification
ROI	Return on Investment
SCM	Supply Chain Management
SCO	Stock Control Office

SIN	Stock Identification Number
SRD	Send and Receive Document
SSC IM	Sub Supply Command Inventory Manager
SSC SCO	Sub Supply Command Stock Control Office
SSC SCO	Sub Supply Command Stock Control Office
SSC	Sub Supply Command
TLC	Through Life Cost
TN	Transaction Number
TNLS	Turkish Naval Logistics System
TOC	Total Ownership Cost
UID	Unique Identification
USA	United States of America
USAF	United States Air Force
WC	Warehouse Custodian
WLC	Whole Life Cost

THIS PAGE INTENTIONALLY LEFT BLANK

ACKNOWLEDGMENTS

We would like to sincerely thank our advisors, Dr. Geraldo Ferrer and Dr. Keebom Kang, who encouraged us to work on this topic and supported us with their comments, advice, and experience. Without their opinions, this research would not have been possible. In addition, we would like to thank our nation and the Turkish Armed Forces for providing us with this academic opportunity.

- Ahmet Ozdemir, Mustafa Ali Bayrak

I would like to express my gratitude to my wife, Saniye, my daughter, Ece, and my son, Sedat, who have supported me throughout this MBA project and continue to support me in my military career. Thanks to their unwavering support and encouragement, I was able to delve deeply into this topic to develop this MBA project. Furthermore, I would like to thank Mustafa Bayrak for his untiring commitment through this ordeal.

- Ahmet Ozdemir

I would like to thank Ahmet Ozdemir for his continuous and creative effort.

- Mustafa Ali Bayrak

THIS PAGE INTENTIONALLY LEFT BLANK

EXECUTIVE SUMMARY

Economic crises, global competition, and shrinking resources have inevitably replaced the traditional way of doing business with sound practices in the world. In addition, a decreasing share of the Turkish Ministry of Defense (MoD) in the budget allocation and increasing operations have forced military services to seek efficient solutions in order to acquire, operate, and sustain warfare capabilities. Today's military notably requires high-technology weapon systems, platforms, and equipment that rely on a wide range of complex logistics support. Therefore, logistics systems have to keep up with technological improvements. Radio Frequency Identification (RFID), one of the emerging technologies, has been recently used in numerous business fields. Since RFID investment requires a high initial cost, and its benefits are hard to see in the short term, it needs an appropriate decision model to justify its investment.

This study examined the cost of ownership of a RFID-integrated military logistics system. The study primarily focused on the question of whether the cost of integrating and operating the Turkish Naval Logistics System (TNLS) with RFID was worth the investment. To answer this question, the authors developed a Cost of Ownership (COO) model. The main result of the study revealed that the cost of ownership of a RFID-integrated logistics system is less than that of the current logistics system despite its huge initial integration cost.

Moreover, this study identified the key cost parameters that have significant impact on the cost of ownership. The study indicated that lifetime of the system, discount rate, inflation rate, holding cost, ordering cost, quantity of demand, and labor reduction rates are delicate parameters that should be considered in the decision-making process.

Finally, the results of the study indicated that the Turkish Navy should incorporate its logistics system with RFID technology. Hence, the Turkish Navy would reduce the total expenditure needed to operate its logistics system as well as enjoy the immeasurable benefits from RFID technology. Moreover, the model developed in this study can be used as a basis to evaluate investment in RFID technology integration in other business processes.

THIS PAGE INTENTIONALLY LEFT BLANK

I. INTRODUCTION

A. OVERVIE W

Improvements in information processing, data transfer speeds, and communication technologies have enabled business practices to change and evolve throughout time. Global competition drives companies to reduce their costs, concentrate on their core abilities, and respond to customer needs promptly. On the other hand, shrinking available resources, economic instability, emerging economies of new countries, increasing population, and increasing public scrutiny induces government organizations to spend taxpayers' money effectively and wisely. Therefore, companies, non-profit organizations, and governments are looking for better ways to increase efficiency of their operations. Some concepts such as lean six sigma and just-in-time (JIT) have led organizations to be leaner and more proactive, eliminate non-value added processes, and reduce inventories.

Logistics has been one of the most important business functions in today's world. Most managers seek ways to increase the efficiency of their organizations by improving their logistics operations. According to Logistics Today journal, the total logistics cost incurred by organizations in the United States of America (USA) in 2006 was 1,397 trillion dollars, corresponding to approximately 10% of the gross domestic product (GDP) of the USA. This total logistics cost is higher than the combined annual USA government expenditure in social security, health services, and defense in 2007. Therefore, increasing effectiveness in logistics systems could be a way for business organizations to decrease their costs and in turn enjoy higher profits. On the other hand, non-profit and government organizations could provide better services and spend saved money in other social fields.

Order processing, transportation, and inventory management are main activities in a logistics system. Order processing could be a time-consuming activity if an organization does not have appropriate and up-to-date technology. For instance, bar code scanning technology helps retailers to identify products that have low inventories and thus allows them to update inventory levels and replenish these products. However, Radio Frequency Identification (RFID) technology has been implemented in future stores to improve the accuracy, speed, and full automation of these processes. Transportation is critical to meet customer demand and supply essential parts on time (Ghiani, Laporte, & Roberto, 2004). Inventory management plays a key role in cost reduction. The objective of inventory management is to determine optimum stock levels in order to minimize total operating cost while keeping processes working.

RFID technology implementation in logistics systems aims to increase effectiveness and efficiency in transportation, inventory management, and order processing activities. Although RFID technology implementation has some benefits, it requires substantial initial purchase and implementation costs. Therefore, organizations have to primarily analyze their processes, find areas to apply RFID technology, and assess and justify their decisions by using various investment decision models.

B. STATEMENT OF THE PROBLEM

Supply commands have to keep huge amounts of inventory in order to meet customer demand because of the lack of traceability and asset visibility in the current Military Logistics System (MLS). As a result of keeping massive inventories, supply commands have to endure high inventory holding and processing costs. Moreover, the rise of the number of incidents of missing or misidentified assets has indicated a significant need for better control in inventory management. RFID appears to be a promising technology that provides a solution that enhances the traceability and visibility of assets.

The integration of RFID technology into the current MLS requires high initial purchase and implementation costs. On the other hand, the monetary benefits of RFID technology solutions in terms of operating costs could be observed in the long run. Decision makers need an investment decision model in order to identify cost parameters and their impacts on the total cost of the system throughout the system lifetime.

C. PURPOSE OF THE PROJECT

The purpose of the project is to propose a Cost of Ownership (COO) model for RFID implementation in MLS. The results of this study provide a strategic roadmap allowing decision makers to determine if the logistics system considered is a good candidate for RFID technology implementation based on the comparison of the COO models of the current and the RFID-integrated MLS. This study makes clear the possible cost parameters and their impacts on total cost of RFID technology solution in Military Logistic Systems.

D. RESEARCH QUESTIONS

- What are the general benefits obtained from RFID technology integration? Is there any limitation of the technology that makes the decision makers hesitate implementing it?
- What are the cost parameters pertinent to RFID technology? How can these cost elements be categorized?
- What are the cost parameters specific to MLS in RFID technology implementation?
- How much is the cost of ownership of both the current logistics system and the RFID-integrated logistics system? Is there any difference between the COO models and how can these differences be concluded?
- Is it worth investing in RFID integration? Is there any gain resulting from the RFID integration in terms of the cost of ownership?
- What is the payback period? How long does it take to compensate the initial construction cost?
- Is there any cost parameter that affects the results more than the others do?

E. ORGANIZATION OF THE PROJECT

This study starts with a literature review to explain RFID technology and investment decision methods. Then, the authors describe the MLS that is used in the model. Afterwards, the COO model is developed for RFID technology investment in MLS. Finally, the authors run the model, analyze the results, conduct a sensitivity analysis, and make recommendations.

THIS PAGE INTENTIONALLY LEFT BLANK

II. BACKGROUND

A. AUTOMATIC ASSET IDENTIFICATION TECHNOLOGIES

In today's world, optimizing logistics operations has a high priority for the success of organizations. Operations and supply management requires getting work done quickly, efficiently, without error, and at a low cost (Jacobs, Chase, & Aquilano, 2009). Automatic Asset Identification Technologies (AAIT) plays a crucial role in this effort by increasing visibility and traceability, reducing response time, improving processes and operations, and most importantly, reducing the investment in inventory. Most commonly used automatic identification technologies can be listed as basic labels, barcodes, Unique Identification (UID), and RFID technology.

The first Gulf War was the major turning point in the utilization of AAIT. The U.S. Army took a big lesson from the first Gulf War related to the importance of tracking and identifying supplies. During the war, the U.S. Army lacked the ability to track and identify supplies (Vance, 2003). The United States Air Force (USAF) General (ret.) Walter Kross, Director of Ops & Logistics of the U.S. Transportation Command during the first Gulf War, stated that:

> During the Gulf War, we simply did not have good information on anything. We did not have good tracking; we had no real asset visibility. Materiel would enter the logistics pipeline based on murky requirements, and then it could not really be tracked in the system.... We lacked the necessary priority flows to understand where and when things were moving. It was all done on the fly, on a daily basis... It truly was brute force. Generally speaking, if front-line commanders weren't sure of what they had or when it would get there, they ordered more...The result was the oft-referenced iron mountains of shipping containers. We had too much, and, worse yet, we did not know what was where. (SaviTechnology, 2003)

Lessons learned from the first Gulf War led the U.S. Army to change its concept of identifying and tracking material and initiate new projects to gradually integrate AAIT into its logistics system. These endeavors seem to be the pioneer of a more visible and easily traceable MLS.

1. RFID Technology

RFID is the name of the technology that uses radio frequencies to determine the unique identification information of an object via the RFID tag affixed to it. This technology is basically used to identify, track, and manage materials that have an RFID tag on it.

RFID technology is one of the tools that perform the automatic collection of data similar to bar code technology. However, RFID technology differs from bar code technology in that it is more automatic and capable of performing higher-speed operations (Brown, 2007). RFID enables the system to identify the items from a distance, and unlike earlier barcode technology, it does so without requiring a line of sight. RFID tags may contain a larger set of unique identification information than barcodes. Furthermore, RFID technology can discern many different tags located in the same general area without human assistance.

2. History of RFID Technology

The first RFID system was used in World War II. The Germans, Japanese, Americans, and British were all using radar for early warning of an impending airplane while it was a couple miles away. However, they were not able to identify whether they were enemy and friendly airplanes. The Germans established the first passive RFID system to identify friendly airplanes. The German pilots were rolling their planes as they returned to the base and it was changing the radio signal reflected back, so the radar crew on the ground was aware that a friendly airplane was approaching. Then, the British developed the first active RFID system. They put a transmitter on every plane. When the transmitter on the airplane received a signal from the ground, it began broadcasting a signal back to be identified by the radar crew (RFID-Journal, 2009).

RFID technology has so far been used in a variety of applications. RFID application implemented by Gap Inc. in 2001was the first use of RFID technology in the retail supply chain. Furthermore, big players such as Marks & Spencer, Gillette, Tesco, Metro AG, and Wal-Mart have implemented RFID applications in their retail supply chains.

RFID has widely been used in military applications as well. The biggest military RFID application was implemented by the Department of Defense (DoD). In October 2003, the DoD established the policy for the use of RFID and initiated a strategy to take maximum advantage of the inherent life-cycle asset management efficiencies that can be realized with the integration of RFID throughout the DoD. Moreover, the DoD announced that its 43,000 suppliers would be required to implement RFID at the pallet and case level by 2005 (Gaukler, Seifert, & Warren, 2007).

3. Components

RFID technology works based on the receiving of preprogrammed information stored in the RFID tag through a reader. Figure 1. displays how an RFID system works. RFID requires a tag (transponder), a reader (interrogator), and an antenna (coupling device). Typically, the reader is connected to a host computer that runs the RFID middleware in it. This simple architecture can be seen as the

basic structure of the full spectrum of RFID-enabled solutions, whether simple or complex (Bhuptani & Moradpour, RFID Field Guide, 2005).

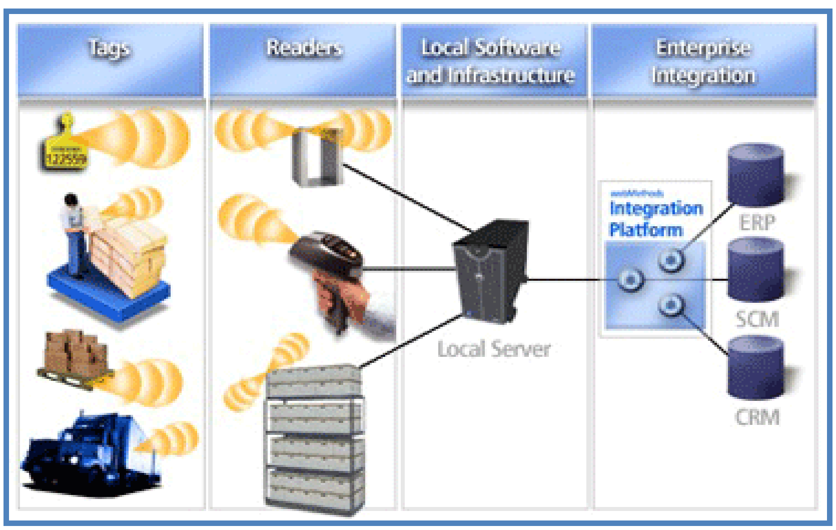

Figure 1. RFID Infrastructure (From www.olympic-data-capture.com)

a. RFID Tags

A RFID tag is also called a transponder. It is a small microchip-antenna composition that can be attached on an item to identify it. The chip is made up of a radio receiver, a radio modulator that is used to send a response signal back to the reader, control logic, a memory system, and a power system.

RFID tags are programmed with unique identification information such as the identification (ID) number, manufacturing date, expiration date, etc. When a tag is in the electromagnetic zone broadcasted by a reader it sends the identification information as radio signals back to the reader. RFID tags may have different shapes depending on the application and the environment in which they are used. Figure 2. displays a sample set of RFID tags.

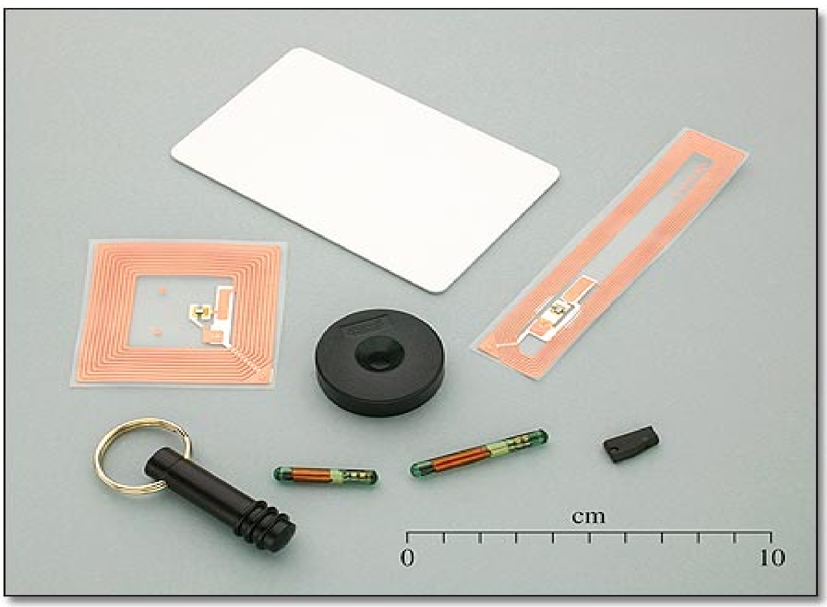

Figure 2. RFID Tag Types (From openlearn.open.ac.uk)

RFID tags can be classified into three groups based on the way they perform radio frequency transmission and their support for specialized tasks (Lahiri, 2005).

- Passive
- Active
- Semi-passive (semi-active)

Active tags can send signals using their own transmitter. The power for performing transmission comes from the on-board battery. Passive tags get their power from the signal transmitted by the reader. Using this power, they broadcast the data they have to the reader. In light of this information, it can be said that active tags have greater range, data capacity, and processing power. Moreover, they could be used and integrated with other devices such as a Global Positioning System (GPS), thermometer, hygrometer, etc. On the other hand, passive tags can produce a weaker signal, because they get their power from the reader. They need to get a stronger signal in order to broadcast the data they have. Briefly, passive tags can only function in presence of a reader. Semi-passive RFID tags can be considered passive tags, because they use the same way of radio frequency transmission as passive tags. The difference is that they have an internal power source, which is used for additional functions. With the help of this power source, semi-passive tags can both monitor the environmental conditions such as temperature, humidity, etc. and extend the tags' signal range.

The selection criteria for active, passive, or semi-passive tags are important. These criteria include, but are not limited to, the communication distance, durability, storage needs, tag performance, reusability, cost, and security requirements.

b. Antennas

The purpose of the antenna is to convert energy between flowing electricity and broadcast radio waves. Both readers and tags have antennas. The design of the reader antenna contributes to the complexity of an RFID system, because reader antennas may vary greatly in size and dimension, depending on the system's particular application requirements. As the conduit for data communication between the tag and the reader, the design and placement of the antenna is crucial in determining the coverage zone, range, and communication reliability (Tedjasaputra, 2006). Some of the antennas used in RFID readers may be internal, whereas most of them tend to be external.

c. Readers

RFID readers are also called interrogators. The basic role of the RFID readers in the system is to communicate with the RFID tags. The RFID reader with its attached antenna generates a radio signal and broadcasts it. When a tag is in the effective zone, it releases the identification data stored in it. The reader decodes the data and sends it to the host computer for storing or processing, or retains it for future usage. Some readers can have the ability to write data into the microprocessor of the tag.

Readers can be small, handheld devices or large readers placed at the warehouse doors. Figure 3. displays some examples of RFID readers.

Figure 3. Examples of RFID Readers (from www.google.com images)

d. Middleware

Middleware is used to integrate the existing software with the RFID technology. Middleware is the software loaded on the RFID host computer that bridges the communication between all the information gathered by the RFID readers and existing back-end system or application software such as a warehouse management system, enterprise resource planning software, or manufacturing execution system.

Middleware can be seen as the central nervous system of RFID technology and provides the core functionalities such as sharing the obtained data both inside and outside of the enterprise, managing massive data produced by the RFID system, and providing the filtering and aggregation logic (Lahiri, 2005).

4. Benefits and Limitations of RFID Technology

RFID technology is and will continue to be one of the hot topics in operations and supply chain management. It will potentially receive widespread adoption in the long term and organizations that have experimented with this technology have already found benefits. However, besides its benefits RFID technology has some limitations, which prevents it from gaining wide use in supply chain operations.

a. Benefits

The initial benefits gained from RFID integration in a warehouse or distribution center is mainly derived from automating manual processes and effectively using greater amounts of data. RFID technology provides various benefits and solves many different problems. For example, using RFID tags to automate the receiving operation not only reduces labor cost for that function, but also enhances accuracy and helps decrease the amount of time that an item spends in a distribution center. RFID provides corresponding benefits that accrue at various RFID tagging levels, ranging from pallet tagging to item tagging as displayed in Figure 4.

Figure 4. Benefits at Different Levels of Tagging (From FKILogistex, 2005)

Although, the benefits gained from RFID technology will vary depending on the level of the tagging, there will be general benefits that will be accrued. These benefits are interdependent and can be described as a chain of benefits as displayed in Figure 5.

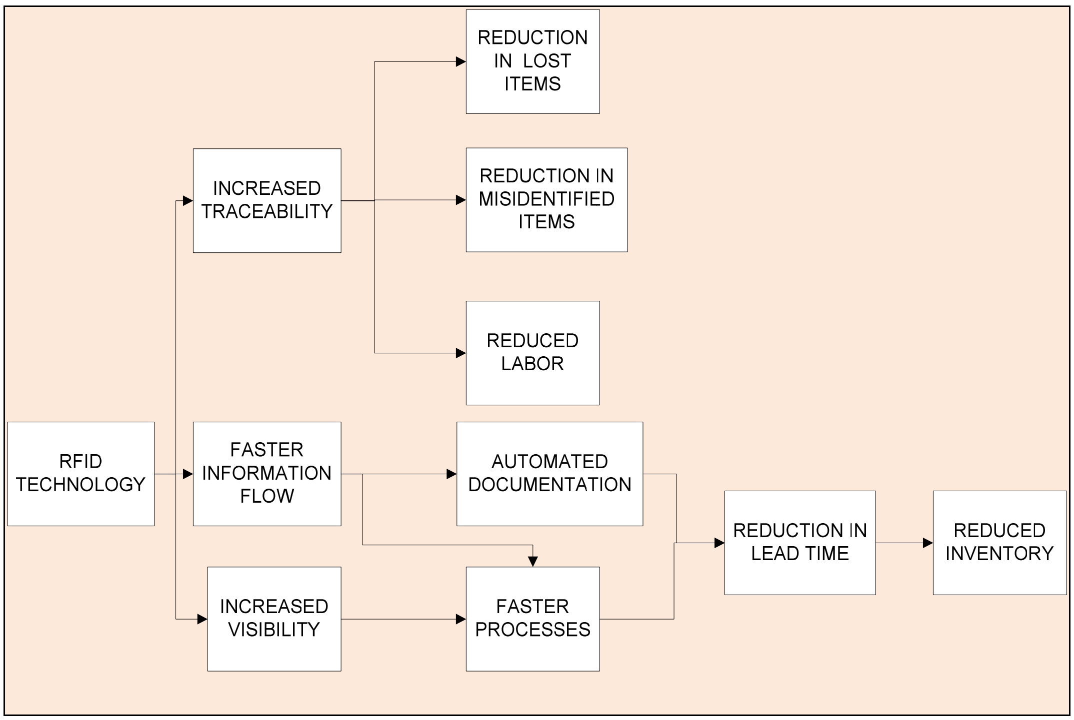

Figure 5. Benefit Chain of RFID Technology

First, RFID technology supports the information in the supply chain by increasing the visibility. Visibility describes the ability of anyone to have access to inventory, orders, raw materials, and receiving and delivery points at any time. The real-time nature of RFID provides the latest information in order to make the best decision (Jones & Chung, 2007). In addition to better visibility, RFID will help the information to flow quickly throughout the supply chain. Another benefit of RFID technology will be increased traceability. Traceability can be explained as the capability of identifying and counting the items, following their movements, and helping the related personnel to determine the location of the items in a warehouse/depot. Traceability is related to the

RFID's fundamental attribute of not requiring direct line of sight when reading the tags and its ability to communicate all the tags in the effective zone of its radio signal in milliseconds.

Faster information flow will result in a reduction of the required time and efforts to document the activities. Furthermore, better visibility and faster information flow will lead to faster processes throughout the supply chain, thus helping managers in their decision-making and assisting users in the system in accessing the information faster and easier. As to the increased traceability, it will reduce the labor in both the receiving and delivery points responsible for identifying, counting, locating, documenting, and managing the movements of the items.

> The major cost component for typical distribution centers is labor, accounting for around 50-80% of their total distribution costs. According to some surveys, RFID technology can reduce the receiving check-in time by 60-93% and it could also yield labor savings of up to 36% in order picking and a 90% reduction in verification costs for shipping processes. These figures demonstrate the significance of labor in supply chains and that even small reductions can deliver considerable financial savings. (Katina & Luke, 2005)

Automated documentation and faster processes will reduce the lead time between the major actors in the supply chain, result in a reduction in the safety stock level or reorder point depending on the inventory concept used, and reduce the level of inventory accordingly.

b. Limitations

Despite its benefits, RFID technology is still an immature technology and has some limitations. RFID technology is undergoing many rapid changes; however, those changes can spell inconvenience for the unwary (Lahiri, 2005).

In many manufacturing facilities and distribution centers, barcode systems have been used for many years. Since barcode systems are commonly accepted, mature and efficient enough and represent a substantial investment, it can be difficult to justify a change to RFID. In any organization, moving from a familiar and trusted technology to a new one poses a challenge, especially when it requires process change. Therefore, resistance to change is one of the big challenges for deciding to invest in RFID technology.

Cost of the technology is another limitation for the decision makers to justify. For example, the average cost of writing a barcode on an object is nearly five to ten times cheaper than putting an RFID tag on it. Moreover, a barcode scanner is two to three times cheaper than an RFID reader is. High initial construction cost, hardware and software costs, and the cost of the integration with the existing system compel managers to decide whether it is worth investing this significant amount of money in an immature technology. Moreover, the benefits accrued from the integration are difficult to realize and calculate in the short term.

The physical properties of the products that are subject to tagging and other environmental factors such as moisture can affect the reliability of readers. Liquids absorb radio frequency signals while metals reflect them. As a result, the material used to make the tagged item can significantly affect the performance of the reader. Furthermore, external factors like radio frequency (RF) noise from nearby electric motors can have an impact on performance.

Data overload and data noise are other challenges to deal with. Data overload results from continuously scanning the RFID tags in the range and sending them to the host computer. Thus, the network capacity, the features of the host computer and the quality of the middleware will be determinant factors in preventing data overload. Data noise is a consequence of the torrent of the RFID data, especially in the overlapping areas. Moreover, the read rates are not 100%, due to unreadable, damaged, or missing tags. In addition, mistakes can happen because the reading is based on proximity. To prevent inaccurate data from being transmitted to enterprise applications, a successful RFID solution must be able to deal with erroneous or missing information (Solidsoft, 2006).

Finally, privacy concerns may be a limitation for RFID technology. Some privacy advocates have stated their concerns about the potential of RFID technology to seriously infringe on personal privacy. Beth Givens, director of the Privacy Rights Clearinghouse, an advocacy organization in San Diego, said the following:

> If ever there was a technology calling for public-policy assessment, it is RFID,…RFID is essentially invisible and can result in both profiling and locational tracking of consumers without their knowledge or consent, …So far, the development and implementation of RFID has been done in a public-policy void. What is needed is a formal technology assessment process to be done by some sort of a nonpartisan body comprised of all stakeholders, including consumers, … The unique information contained in each RFID tag could also be captured by various readers and used to track a person's movements through tollbooths, public transportation and airports. (Vijayan, 2003)

Obviously, of particular concern is the use of RFID technology without informing the consumer of its presence and the way it is being used. Vendors and users of RFID should be committed to using the technology responsibly and be vigilant about any perceived or actual misuse of personal data (Solidsoft, 2006).

B. RFID TECHNOLOGY IMPLEMENATION ISSUES

RIFD is a relatively simple technology providing intensified capabilities compared to other technologies such as barcode technology. Modern supply chains have many problems related to the lack of precise and integrated data. RFID provides important potential solutions to these problems. Seymour, Lambert-Porter, & Willuweit (2008) categorize implementation issues for RFID technology applications into five categories, as displayed in Figure 6. The first category is the RFID technology itself, which might invoke some problems in terms of cost and resources, usefulness, complexity, accuracy, and infrastructure issues. The second category is the inter-organizational issues in regards to concerns about security, customer needs, and intensity of information change. The third category is the personnel-related issues such as management support, resistance to change, and experience. The fourth category is the intra-organizational issues including organizational culture, training and support, and organizational-wide readiness. Lastly, environmental factors such as standardization of RFID tags and a coding system as well as an unwillingness to collaborate among vertical or horizontal supply chain partners might result in negative impacts on RFID technology implications. Decision makers should consider these issues and prospective solutions as well as an implementation strategy beforehand for the success of an RFID application.

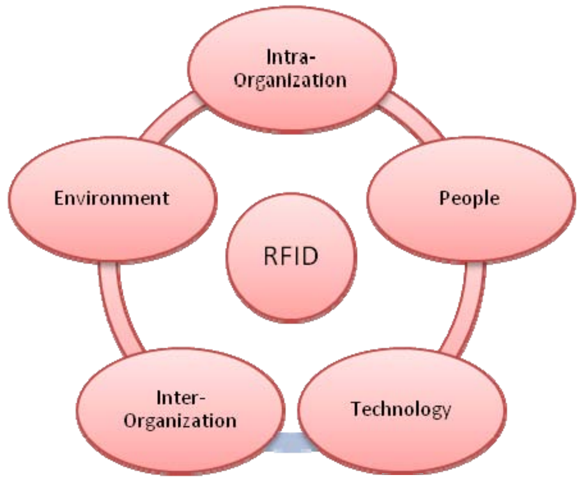

Figure 6. RFID Implementation Issue Categories (After Seymour, Lambert-Porter, & Willuweit, 2008)

The maturity level of an organization could be another consideration for the success of RFID implementation in addition to those issues aforementioned. In most cases, the maturity level of the organization plays an important role in the success of RFID technology implementation into Supply Chain Management (SCM). A SCM Logistics Maturity Model has been developed to determine the maturity level of an organization's SCM. This model consists of five sequential life stages. The model starts with the pilot studies stage where an organization is incapable of providing a stable environment for RFID technology-based infrastructure development. Then, the logistics projects stage comes after the pilot studies stage has been accomplished successfully and the organization is ready and capable to implement its strategies, goals, and objectives. The third stage is the organizational operations stage where a documented, new logistics system management is being developed and personnel go for training for the new RFID-based logistics system process. Following this stage, the organization reaches the logistics visibility stage where metrics have been developed to test logistics visibility within the supply chain. The organizational level stage is the last stage where the focus is on continuous process improvement (Myerson, 2006).

In their study, Jaska and Reyes (2007) propose guidelines to organizations for RFID technology implementation. They propose eight steps that need to be adapted, depending on organization type, including understanding what RFID can and cannot do, analysis of the current system, building a return on investment (ROI) business case, requirement analysis, prototype testing, implementation, and monitoring and continuous improvement. These steps can help managers minimize RFID implementation risks.

C. COST-RELATED ISSUES

Even as RFID technology gets more mature every day, it is still considered as an expensive solution. Since RFID technology implementation has various system variables that in turn alter from one industry to another, it is very difficult to define the cost breakdown structure for RFID implementation (Randal, 2007). However, there are some studies that attempt to define and develop a model for RFID implementation. Szmerekovsky & Zhang (2008) tried to weigh the determined costs and benefits of RIFD implementation against the fixed costs of RFID implementation in a mathematical model by studying the effects on manufacturers and retailers of attaching RFID tags at the item level in a vendor-managed inventory system. Many authors designate general cost factors that every organization bears when they deploy RFID technology to their processes. Bhuptani *et al*. (2005) categorizes the cost of RFID deployment into three areas: hardware, software, and services.

1. Hardware Costs

Hardware costs consist of tags, readers, host computers, network equipment, and antennas.

Types of tags generally determine the tag prices. Besides that, the shapes and sizes of tags, dependent upon the RFID applications, have impact on tag prices. In addition to these two factors, other factors such as capability of being rewritable, range capability, and on-board memory availability can affect tag prices (Bhuptani &

Moradpour, 2005). The cost of a passive tag seems relatively less than active tags. Even though passive tag prices seem very low, the aggregated cost of tags becomes crucial depending on where RFID technology is applied. Especially, item-level tagging requires quite excessive amounts of tags that are usually made up of passive tags. The cost of a passive tag depends on its frequency, design of the antenna, the amount of memory, and packaging around its transponder. The cost of passive tags ranges from five cents when purchased in high volume to several dollars. On the other hand, the cost of an active tag depends on the size of the battery included, the amount of memory on the microchip, and the packaging around the transponder. The cost of active tags ranges from $10 to $100 or more (RFID System Components and Costs, n.d.). When the number of tags needed is considered then the question of which partner should pay for the RFID tag attachment to items or pallets in the supply chain emerges as an important issue. The work of Gaukler *et al.* (2007) shows that when the manufacturer is the driving force, RFID tag cost can be borne by either a manufacturer or a retailer. On the other hand, when the retailer is the driving force, both a retailer and a manufacturer can maximize their benefits by agreeing on an optimal solution. The DoD and Wal-Mart mandates require their vendors affix RFID tags on their products. Therefore, vendors should consider the cost of the label printers, encoders, etc. as cost factors. However, the DoD still incurs tag costs and related label printer costs.

The immobilized RFID reader price ranges from $200 to $5,000. The variability results from the reader's range, multi-frequency flow, and antenna capability. On the other hand, the handheld RFID reader combines antenna and reader in the same appliance. The price for the handheld RFID reader ranges from $300 to $2,000. Yet, the effectiveness of the RFID reading capability might not be the same as the immobilized RFID readers.

In terms of antennas, there are two applications. One is connected to the RFID chip and the other is connected to the reader. The cost of the antenna connected to the chip might be considered within the RFID tag cost. Conversely, the cost of the antenna connected to the reader varies depending on size, range, and directional output. The cost ranges from five hundred dollars to thousands of dollars. Additional features such as the special design of antennas can add to the primary cost. In addition, Electronic Product Code (EPC) compliant or non-EPC compliant features can change the ultimate price of the antenna.

RIFD applications need local and integrator servers to run. The cost of a server starts at $2,000 and goes up in price.

2. Software Costs

Middleware is an important cost driver. The price of middleware varies in the range of $25,000 to $800,000. The type of RFID technology implementation and application area identifies the cost of middleware. In addition, the RFID middleware appliance might cost from $8,000 to $20,000 per device.

3. Service Costs

Service costs consist of both installation costs and support and maintenance costs. Installation of readers and antennas, connection to the host computer, and setting up the infrastructure elements should be done with intense care since they can greatly impact the performance of the system. The environment where the RFID reader and antenna is to be set up varies from one application to another. Getting high performance from an RFID application rests on how well it is installed and tuned. The RFID engineer should tune the antenna and reader to get higher performance from radio frequencies. Maintenance and support costs also vary depending on an organization's definition of depreciation strategy, and how well current processes meet requirements. Software service costs might cost up to 15 % of the license costs.

D. INVESTMENT DECISION METHODS

An investment project starts with an idea for increasing shareholder's wealth by producing a new product or improving existing production or service processes in the business world. On the other hand, in the public sector, an investment project requires an assessment of economic efficiency to use resources. Bodie & Merton (2000) indicate that when an investment project requires expenditure, initiation of a new product line, reduction in labor costs, or replacement of the existing system in order to expand capacity or lower operating costs, cost becomes the objective of the investment.

The purpose of RFID investments in MLS could most likely target the reduction of operating costs such as inventory and labor. Whatever the goal of an investment is, it still needs to be compared to the current processes or alternative investments for justification. The decision of any investment can be assessed by various methods. These methods have their own characteristics. Whichever method is chosen, it is crucial to know the limitations and advantages of that method. Some investment decisions might vary depending on the method that is used for the assessment. Cost- benefit analysis (CBA), cost effectiveness analysis (CEA), net present value (NPV), payback period (PP), and internal rate of return (IRR) are some methods that have been used to assess and evaluate the investment opportunities.

Cost-benefit analysis (CBA) is the most used principal analytical model to evaluate public investment decisions. CBA requires identifying the project, recording all tangible or intangible costs and benefits, expressing them in money terms, adjusting for the time value of money, then calculating net benefits by subtracting total costs from total benefits and finally, choosing the alternative. The fundamental rule of CBA is to select the alternative that produces the greatest net benefit. In this method, if a net benefit of a single project is greater than $0 then this project should be adopted since net benefits are maximized. A benefit/cost ratio is sometimes used instead of net benefits. If the ratio is greater than one then the project can be chosen. This method does not work when choices are made among mutually exclusive projects or when resources are constrained (Stokey & Zeckhauser, 1978).

Cost- effectiveness analysis (CEA) compares the costs and effects of two or more alternatives. CEA is often used where a CBA is unsuitable. As a rule, the CEA is expressed in terms of a ratio where the denominator is a gain in terms of various units and the numerator is the cost in terms of money. CEA is commonly used in infrastructure asset management instead of a CBA where the objective is to sustain the current standards of service (Cost Effectiveness Analysis, 2009). For instance, in defense and health protection expenditures, it is difficult to value benefits in monetary units. CEA is a suitable method only when either the cost of alternative projects are similar and thus only benefits are compared or benefits of alternative projects are similar, thus only costs are compared (Stokey & Zeckhauser, 1978).

Net present value (NPV) is mainly used in capital budgeting to analyze the profitability of an investment or project. NPV is defined as the difference between the present value of the future cash inflows from an investment and the cost of investment. Present value of the expected cash flows is computed by discounting them at the targeted rate of return (NPV Definition). If the net present value of a single project is greater than $0, then this project is chosen. Among many projects, a project with higher net present value is chosen. The main advantage of NPV is that the scattered different cash flows of a project over many years can be discounted to a certain year and compared to those of other projects. Therefore, NPV enables one to make systematic comparisons between costs and benefits that are incurred and realized at different stages in time (Stokey & Zeckhauser, 1978).

Payback period method focuses on the period that is the length of time within which the first initial investment can be recovered. In other words, the goal of this model is to find out how long it will take until the amount of cash inflows equal the total initial investment. Then, the investment having the shortest payback period is preferred (Garrison, Noreen, & Brewer, 2008). This method can be used if the benefits are easy to determine and the cash inflows are evenly distributed from the beginning of the investment. Moreover, this method can be used as a tool to help one consider the worthiness of an investment. If the investment will not provide a payback within a specified period of time, one does not need to consider it further (Stokey & Zeckhauser, 1978). Even though this method is easy to calculate and understand, it has some weaknesses. First, it only uses the cash flows before the cutoff date and ignores all the cash flows afterwards. Thus, it does not measure all the income. Secondly, it does not consider the time value of the cash inflows.

Internal rate of return (IRR) is the discount rate that makes the present value of the future cash inflows equal to the present value of cash outflows (Bodie & Merton, 2000). In other words, IRR is the discount rate that results in an NPV of zero. IRR and

NPV calculations are too similar and will give the same answer if properly used. The IRR rule is based on the fact that one should accept an investment project if the appropriate discount rate is less than the IRR. The reason is if the discount rate is less than the IRR then the project will have a positive NPV, meaning that it is worth investing in the project (Brealey, Myers, & Allen, 2008). IRR should not be used to compare mutually exclusive projects, which are alternative ways of doing the same thing. IRR can be a helpful tool to help one decide whether it is worth investing in a single project. However, if used to compare two or more competing projects it would not always be true to say that the project with the highest IRR is the best project. The basic criteria of IRR is based on the assumption that a single project having a greater rate of return than the appropriate discount rate should be undertaken by the decision makers (Stokey & Zeckhauser, 1978).

E. COST OF OWNERSHIP METHOD

The forecast or prediction of the total cost of investment alternatives is very valuable in making qualitative decisions. The cost of ownership (COO) is a concept to foresee the future financial obligations and liabilities that will have to be incurred to own the system. COO includes not only purchase costs but also the overall cost of the system over its lifetime. COO can be calculated via three different ways: life cycle cost (LCC), through life cost (TLC), and whole life cost (WLC). All these three ways are the same in general but each one serves different objectives and applications. LCC is a technical process that compares the cost of the relative features of two or more alternatives. TLC is a financial or budgetary process that estimates the cost of a single alternative over its intended lifetime by financial accounting period. WLC is a prediction of the total required resources to purchase an alternative over its intended lifetime. It can be said that WLC includes TLC as well as costs of the infrastructure and training (Jones, 2006).

In this study, the authors will use LCC to calculate COO for the RFID applications. The main objective of conducting cost analysis is to estimate how much each alternative will cost during its projected lifetime. The LCC model determines the total cost of acquisition and ownership of the system over its intended lifetime to the government. LCC has been named the defense system total ownership cost (TOC) throughout the DoD acquisition environment.

The structure of LCC components varies depending on the system types. LCC for major weapon systems includes the cost of research and development (R&D), investment, operating & support (O&S), and disposal. R&D costs embrace the costs of prototypes, engineering development, equipment, test hardware, contractor system test and evaluation, government support to the test program, and related environmental safety, training, and data. Secondly, the cost of investment (acquisition) that occurs during the low-rate initial production, production, and deployment phases comprises the cost of procuring the major equipment and its support elements, which includes training, data, initial spares, war reserve spares, and military construction costs. Thirdly, operating and support costs embrace the costs that are incurred to operate, maintain, and support alternate system capability. Costs for personnel, consumable and repairable material, and all levels of maintenance, facilities, and supporting investment are parts of the operating and support cost. Finally, disposal cost is the cost of getting rid of excess or surplus property or material from inventory. It includes costs of demilitarization, detoxification, redistribution, transfer, donation, sales, salvage or destruction, as well as the costs of hazardous waste disposition and environmental cleanup (Office of Aerospace Studies, 2004).

The distribution of these cost categories throughout the LCC differs from one system to another. As seen in Table 1. the historical cost distribution of cost types, O&S, and disposal cost comprises 70% of all ship acquisition costs, whereas for space systems it is only 15%.

System Type	**R&D**	**Investment**	**O&S Disposal**
Space	18	66	16
Fixed Wing Aircraft	20	39	41
Rotary Wing Aircraft	15	52	33
Missiles	27	33	39
System Type	**R&D**	**Investment**	**O&S Disposal**
Electronics	22	43	35
Ships	1	31	68
Surface Vehicles	9	37	54

Table 1. Historical Cost Distribution Data (From Office of Aerospace Studies, 2004)

III. MILITARY LOGISTICS SYSTEM

A. OVERVIEW

Military logistics is one of the essential and key factors for the fate of a war in the military. The Department of Defense Dictionary of Military and Associated Terms (Joint Publication 1-02) defines logistics as follows:

> Logistics is the science of planning and carrying out the movement and maintenance of forces. In its most comprehensive sense, those aspects of military operations which deal with: a. design and development, acquisition, storage, movement, distribution, maintenance, evacuation, and disposition of materiel; b. movement, evacuation, and hospitalization of personnel; c. acquisition or construction, maintenance, operation, and disposition of facilities; and d. acquisition or furnishing of services.

Management of military logistics is considered one of the oldest business processes in history. The sustainment and support of military personnel and equipment have been a principal concern of commanders since ancient times. Yet, applications of technological improvements in logistics systems have been considered far behind those in weapon systems. In recent years, there have been many attempts to improve the performance of military logistics systems because of improvements in information, identification, and tracking technologies. Today, the complexity and number of logistics organizations involved in providing materiel, maintenance, and transportation services to operations make it essential for logisticians to fully understand the structures and interrelationships, and adapt to rapidly changing logistics business practices and ever-improving technological developments.

The emphasis on quality performance, timeliness of material and service delivery, and satisfying customer needs is essential to sustain organizational objectives. Therefore, required changes in business practices enabled by technological advancements must occur in the existing organizational environment with all of its structural barriers and inefficiencies. The overall mission of MLS is to provide responsive and cost-effective support to war fighters and other units. War fighters cannot win battles without having a highly agile and responsive logistics system that will effectively support their needs. It is essential that MLS use efficient business processes supported by up-to-date technologies.

B. DESCRIPTION OF THE CURRENT MLS

In this study, the authors used the Turkish Naval Logistics System (TNLS) as a MLS model in order to implement RFID technology and apply the COO model. The TNLS consists of various components to manage materiel support, maintenance, and transportation issues. In order to simplify the study, the authors' main focus was on the supply chain that executes the materiel support mission in the TNLS.

Supply Chain Management (SCM) in TNLS is not very different from a commercial SCM as displayed in Figure 7. The supply chain starts with the suppliers that provide contracted materiel to the Main Supply Command (MSC), where quality inspection and storage activities take place. Then, materiel flows from the MSC to the Sub Supply Command (SSC) and from there to the customers who are the end users in military units.

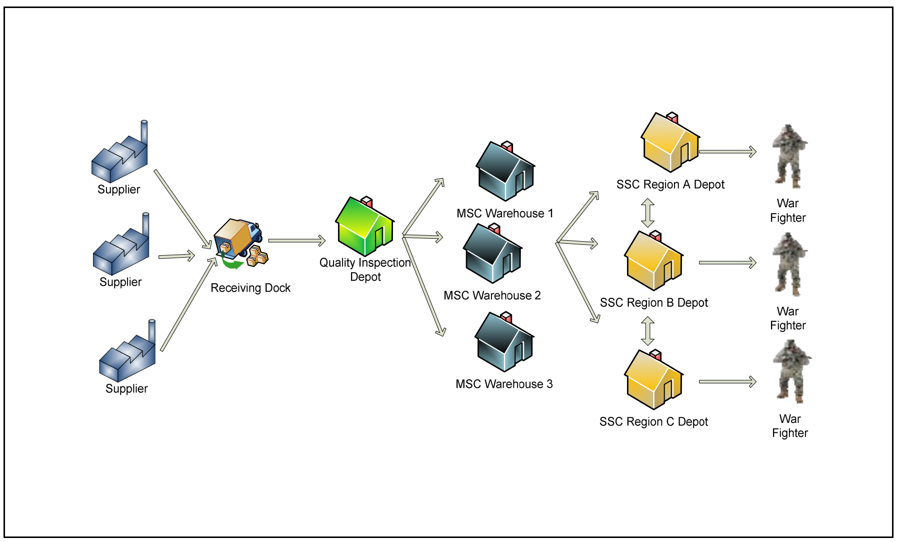

Figure 7. Supply Chain Flow

SCM is composed of supply commands including a MSC and twelve SSCs that are located in different regions in order to support the naval facilities and bases. The

MSC includes twenty-five warehouses that are located in the same region. Depending on its supportive capabilities, each SSC has five to twenty depots. Each supply command consists of inventory management, procurement, and transportation offices. These offices are broken into units that execute different and specified job descriptions. The number of personnel holding the positions and their job descriptions could vary subject to the supply command's workload.

The way the supply chain flows depends on both materiel categories and the policy of the Navy. The authors will broadly explain the general process in this chapter. The SCM commences when aggregated needs of SSCs are contracted out to suppliers. The MSC usually procures and stocks most of the naval materiel, then ships them to SSCs. The main mission of SSCs is to support customers under their responsible regions. Customers could be any visiting ships, military units in the designated region, or other SSCs. In addition to acquiring materiel from the MSC, each SSC has its own procurement department to purchase not only authorized materiel to meet regional requests but also items with the purchase order given from headquarters (HQ) to meet other regions' needs.

1. Supply Chain Phases

The materiel and information flow are composed of three consecutive phases in SCM as displayed in Figure 8. In this supply chain model, each phase follows a successive order sequence. The first phase takes place between suppliers and the MSC, the second phase occurs among the MSC and the SSC or SSCs, and the last phase takes place between the SSC and customers.

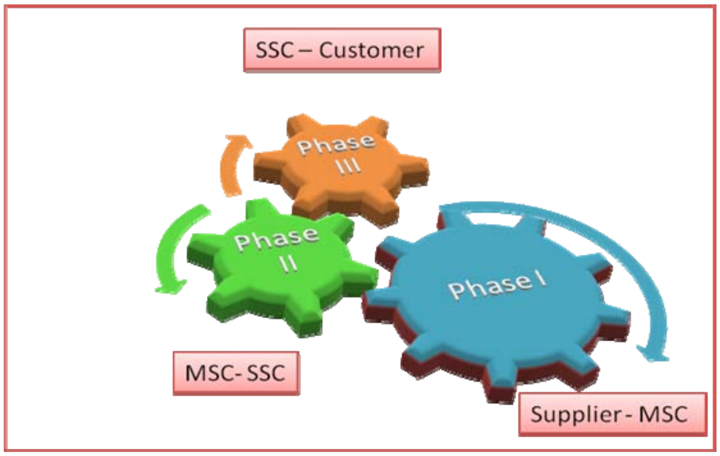

Figure 8. Supply Chain Phases

The first phase begins with the purchase orders sent from the main supply command stock control office (MSC SCO) to the procurement office (PO). PO contracts out to numerous suppliers for different items. After getting contracts, the MSC SCO sends orders to suppliers in order to inform them to ship materiel to the MSC. Once materiel arrives at the MSC, an inspection custodian (IC) receives the shipment by checking and counting each materiel. After that, he or she makes workers carry the materiel into the inspection depot. In the meantime, the IC prepares and gives a copy of the receipt document (RD) to both the supplier and later the inventory acceptance manager (IAM). After receiving the RD, the IAM prepares and sends the inspection and acceptance document (IAD) to the inspection team (IT). Later, the IT inspects materiel according to the terms in the contract and then sends the results of the inspection and their decision on the results to the IAM. If the IAM agrees with results, he or she prepares the acceptance document (AD) and sends it to the MSC SCO and warehouse custodians (WC). An authorized WC, the assigned person that signs the AD and takes over the title of the item's ownership by counting items in the inspection depot, makes workers transfer items into his or her responsible warehouse. Meanwhile, the WC returns the AD to the MSC inventory control manager (MSC ICM). In turn, the MSC ICM controls and approves the AD and submits it to the MSC SCO. As soon as the MSC SCO gets the AD, the SCO enters the stock identification number (SIN) of the materiel and its amount, as well as its price, into the integrated materiel management system (IMMS). Subsequently, the MSC SCO sends necessary payment documents to the PO. When the PO disburses to the supplier, the first phase ends at this point. The flow diagram of the first phase is displayed in Figure 9.

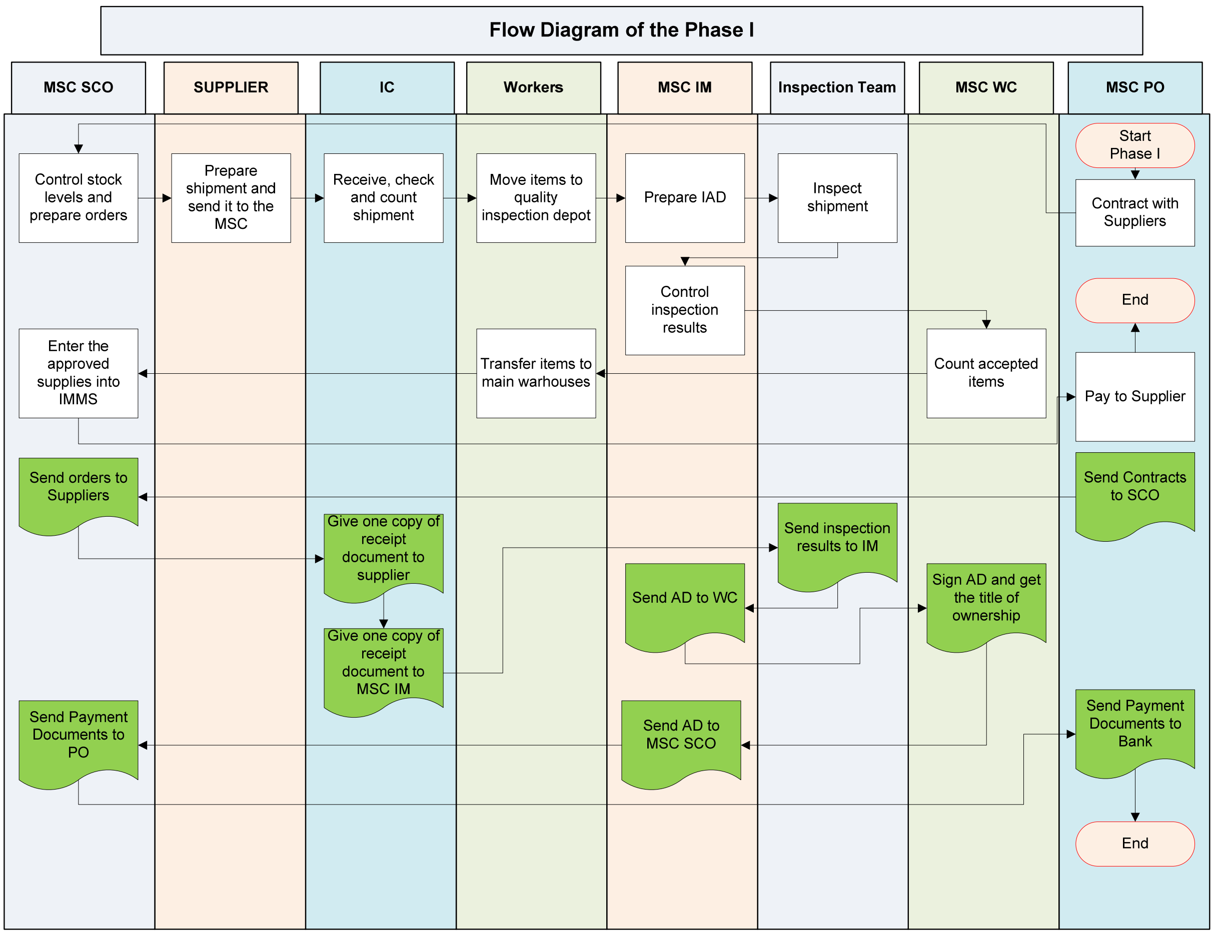

Figure 9. The First Phase Flow Diagram

The second phase of the supply chain process takes place between the MSC and SSC or among SSCs. The authors will only explain the process between the MSC and SSC since the same process applies to the transaction among SSCs. This phase is initiated when the MSC SCO closes pending requisitions from SSCs in the system by selling the materiel to the SSCs. Following this, the MSC SCO prints the send and receive document

(SRD) and sends it to the WC. When the WC gets the SRD, he or she finds the materiel in the warehouse and prepares it for hauling. Once ready, the shipment is controlled and counted by the transporter, who is generally a ranked military person. If the transporter agrees on each item and their SRD, then workers embark materiel into vehicles. When the vehicle arrives to the SSC, a depot custodian (DC) checks and counts each materiel, and compares them to each SRD in order to identify them. If the DC agrees on each materiel, then workers unload and carry shipped materiel from the vehicle to the depots. In the meantime, the DC signs the SRD and hands it over to the SSC SCO. The SSC SCO processes the SRD by entering some information such as the materiel's SIN, seller MSC ID, and the quantity of the materiel delivered into the SSC's IMMS. Then, the SCC inventory manager (SSC IM) controls and approves the transaction and sends the SRD back to the MSC. After the MSC SSO gets back the SRD, the TN given by the SSC is entered into the MSC's IMMS and the transaction is closed. The second phase ends here. The second phase is displayed in Figure 10.

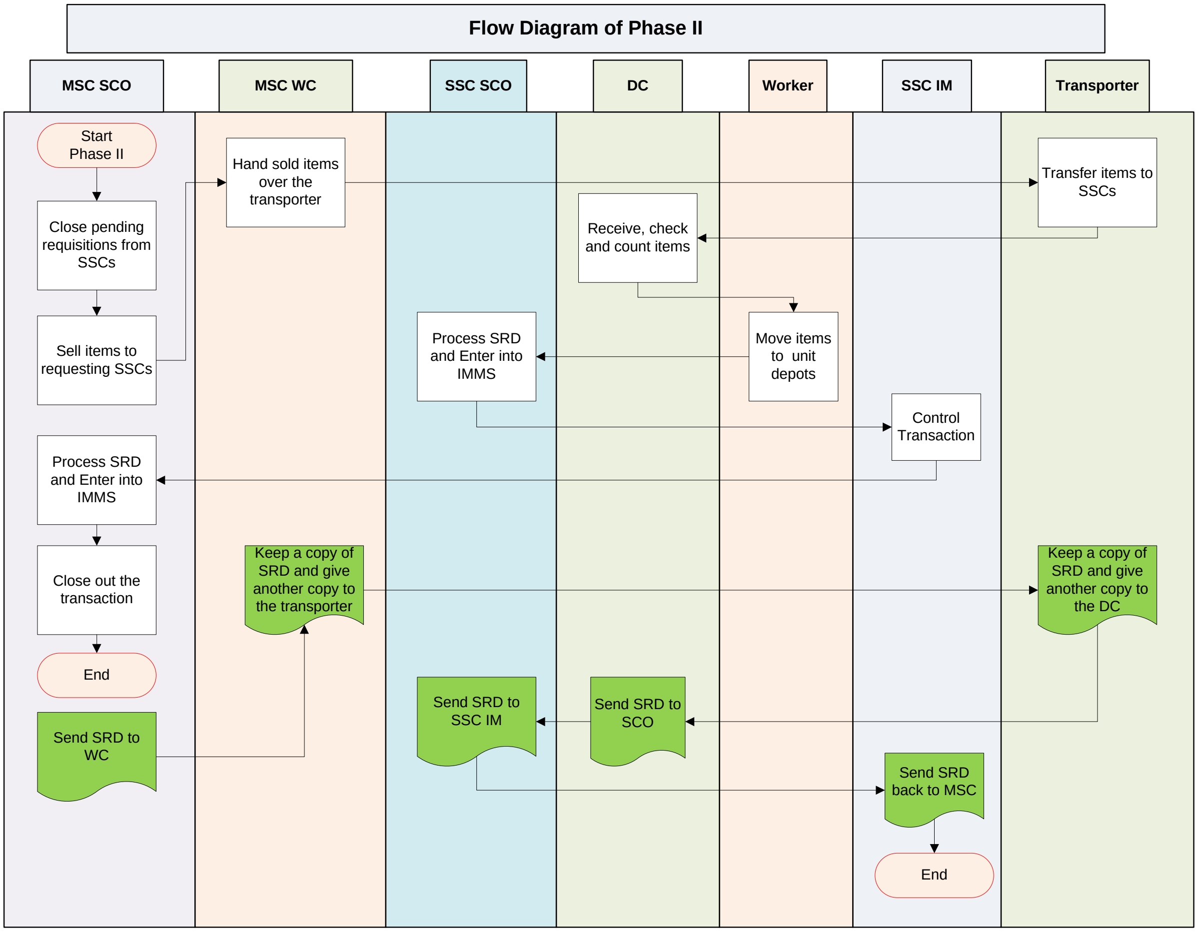

Figure 10. The Second Phase Flow Diagram

The third phase takes place between the SSC and customers. This phase begins when the SSC SCO closes pending requisitions from customers (C) in the system by selling the materiel to Cs. Following this, the SSC SCO prints the SRD and sends it to the DC. When the DC gets the SRD, he or she finds the materiel in the depot and prepares it for hauling. Once ready, the shipment is controlled and counted by the transporter. If the transporter agrees on each item and their SRD, then workers embark materiel into vehicles. When the vehicle arrives to Cs, a customer custodian (CC) checks and counts each materiel, and compares them to each SRD. If the CC agrees on each materiel, then workers unload and carry shipped materiel from the vehicles to the customer storage area. In the meantime, the CC signs the SRD and hands it over to customer asset control personnel (CAP). CAP process the SRD by entering the materiel's SIN, seller SSC ID, and the quantity of the materiel delivered into the C's IMMS. Then, the customer asset control manager (CAM) controls and approves the transaction and sends the SRD back to the SSC. After the SSC SSO gets back the SRD, the TN by the C is entered into the SSC's IMMS and the transaction is closed. Eventually, the third phase, as well as all supply chain events, ends at this point. The third phase is displayed in Figure 11.

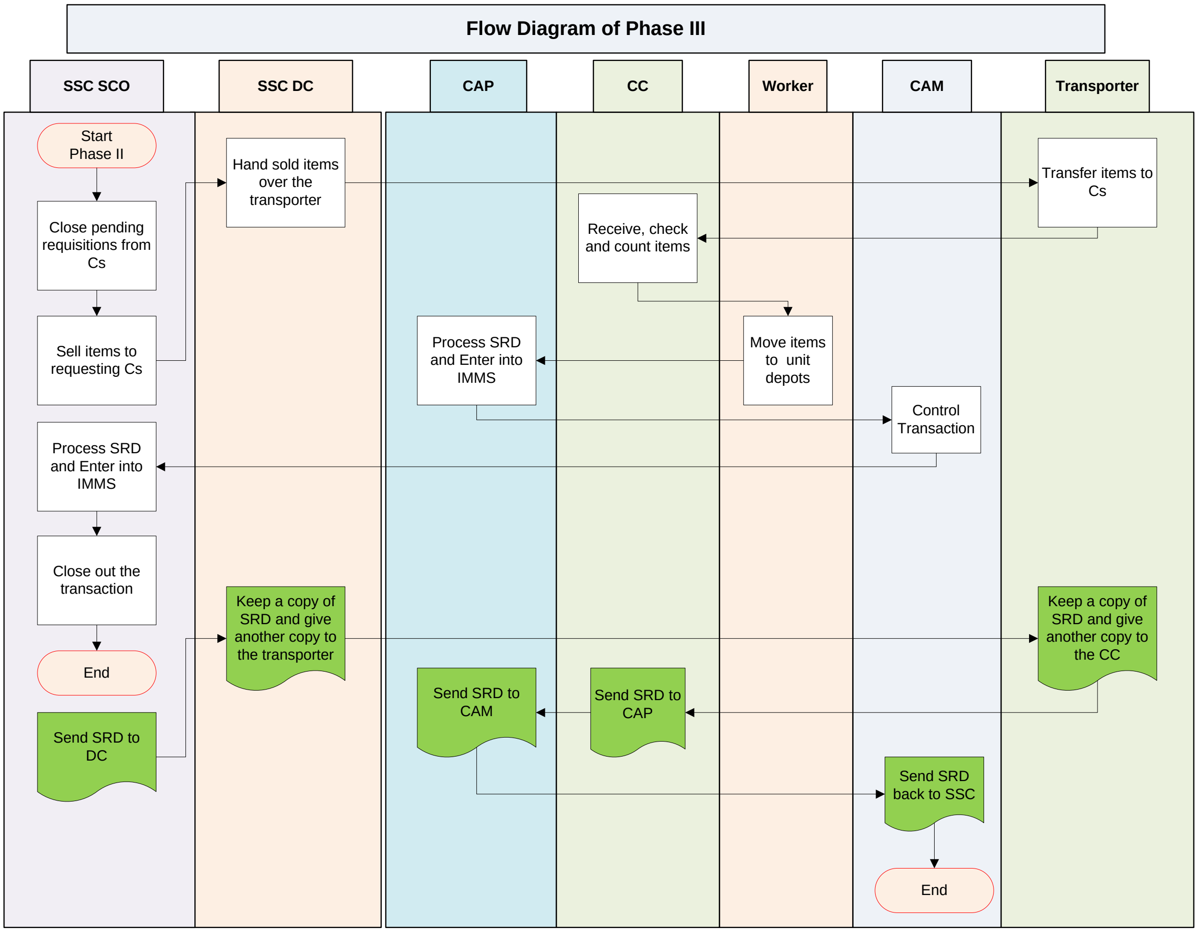

Figure 11. The Third Phase Flow Diagram

2. Key Documents and Processes

The TNLS uses the integrated material management system (IMMS), which has been a core supply management tool to manage all assets in the supply chain management (SCM) for over a decade. The IMMS provides various solutions to different stakeholders such as inventory managers and decision makers at headquarters. Stakeholders ask for information that is reliable, accurate, and up-to-date to make correct and timely decisions. Therefore, the IMMS should be able to offer quality information to meet stakeholder’s needs. Quality information can be obtained by increasing real-time visibility, traceability, and accurate identification of assets. However, the current manually driven and partially barcode-driven processes of SCM fail to meet these characteristics sufficiently.

It is crucial to state some key documents and activities necessary in the current TNLS supply chain in order to understand the current supply chain better.

A send and receive document (SRD) is a printed document that is generally used to determine the ownership of materiel as it is delivered from one custodian to another custodian or a transporter. In other words, it determines the actual ownership of items in transit. In addition, a SRD provides some important information about the transaction such as materiel name, stock identification number (SIN), quantity, seller supply command ID, as well as buyer supply command or unit ID. Furthermore, a SRD is printed by the MSC SCO for the first phase transaction and by the SSC SCO for the second phase transaction. A SRD is an order document for the WC/DC to deliver sold items to the transporter. Whenever a materiel’s custody changes, a new custodian or transporter controls and signs a SRD and leaves a copy of the SRD to the previous custodian and keeps a copy for himself. Once the SSC SCO/CAP processes the SRD and gives the TN from his IMMS, he or she sends the SRD back to the issuing SCO. Eventually, the SCO simply enters the TN written on the SRD into his IMMS and closes the transaction.

At the end of the year, the inventory control center (ICC) collects all data from the MSC and SSCs and other components, then cross-matches transactions among supply commands. The product of the process is the non-conformance list (NL) that shows mismatching transactions with the detailed grounds. Each component gets this list and tries to fix these transactions before the current fiscal year’s transaction permission expires. Generally, non-conformance is the result of simple human mistakes. The most common mistake is to enter quantity, stock number, or component ID code inaccurately to the integrated material management system. Conversely, it takes a considerable amount of time and effort to correct these simple mistakes. In case of a dispute over transactions, inspectors from the Ministry of Defense (MOD) involve themselves in the dispute in order to resolve it.

After this broad description of the current MLS, next chapter clarifies how the current system will change with the integration of the RFID. Moreover, both the current and RFID integrated systems will be analyzed based on the cost categories.

IV. ANALYSIS

Based on the information provided in the previous chapter, the current TNLS and the new proposed logistics system integrated with RFID technology will be analyzed. As an investment decision model, the authors will develop a cost of ownership (COO) model for the analysis.

A METHODOLOGY

Based on the literature review, the authors decided to use a COO model as an investment decision method. The authors also conducted phone interviews with the personnel working in the Inventory Control Center (ICC). The primary focus of the interviews with the personnel was to gain an appreciation for the processes of the TNLS. The authors' main knowledge about the TNLS was based on one of the author's working experience. As a result of these interviews, the authors were able to identify the processes of the TNLS, categorize them, and determine the parameters related to the COO of the TNLS. Some of the data related to the TNLS logistics operations were collected from the TNLS itself. For the sake of easiness in the calculations, some assumptions were made. The data related to the initial infrastructure construction cost of RFID was collected from internet searches. Moreover, the authors strove to provide current average costs related to the cost element of RFID technology. After collecting the data, the authors used Easy Fit software (MathWave Technologies, 2005) to determine which distribution model best fit to the data. Some of cost element calculations required simulation to project future possibilities. Thus, the authors wrote code in Visual Basic and incorporated them into macros. Finally, the authors developed the COO model in MS Excel 2007.

B. CATEGORIZATION OF THE COST ELEMENTS

The proposed COO model includes infrastructure construction cost, logistics operation cost, and miscellaneous cost categories. Each cost category consists of cost elements that represent different cost components of a logistics system.

1. Infrastructure Construction Cost

The authors subcategorized the infrastructure construction cost as program management office (PMO) cost, integration cost, equipment cost, and test cost.

PMO cost defines the labor and stationary costs required to plan, program, and execute the acquisition of RFID technology. Integration cost is the cost that is incurred to incorporate RFID technology into the existing system, such as the middleware cost. Equipment cost embraces the purchasing of the equipment required for construction of the RFID-integrated logistics system. It consists of door and hand-held readers, antennas, label printers, integrator server, and local server costs. The last cost element, namely the test cost, is the cost required to figure out how well- a constructed RFID-integrated logistics system performs and whether it needs further improvements.

Among all of these cost elements, infrastructure construction cost is incurred mostly at the beginning phase of the construction of the RFID-integrated logistics system.

2. Logistics Operating Cost

Logistics operating cost is the cost that is incurred to order, receive, store, process, and distribute the supplies using the RFID-integrated logistics system. This cost is comprised of the RFID tag purchase cost, maintenance cost, inventory cost, and labor cost.

The RFID tag purchase cost is the cost that defines the cost of buying RFID tags that are used on cases of supplies. This model requires disposable tags. In other words, once the RFID tag is applied on cases, it cannot be used again. Therefore, the annual demand of the RFID tags equals to the total number of cases of supplies purchased. Maintenance cost involves the sustainment cost of all the components of the RFID system. It includes both corrective and preventive maintenance costs. Inventory cost defines the conversion of physical inventory levels into dollar values. This conversion includes the ordering cost, purchase cost, and handling cost. Ordering cost includes all costs endured during preparing and sending the orders to suppliers and receiving them. Purchase cost is the total cost spent on acquiring supplies. Purchasing cost is ignored in the calculations because it has to be incurred for both scenarios. Holding cost is the total amount paid for conserving supplies such as the facilities used, electricity, and security. Labor cost is the amount of money paid to the personnel that are assigned to work in the logistics system. Labor cost embraces the salaries paid to custodians, accountants, managers, the inspection team, stock controllers, workers, and check and count teams.

3. Miscellaneous Costs

Miscellaneous costs are incurred due to the loss or misidentification of supplies. Loss cost is incurred as a result of any lost or stolen items throughout the supply chain. Misidentification cost emerges when an item is not classified correctly and treated as another item. Misidentified items will remain on the shelves or move between supply commands. Thus, disutility cost of these items will consist of the holding cost and purchasing cost.

C. SCENARIOS

In order to get an appreciation for the effects of RFID technology on the COO of the TNLS, the authors will go over the following two different Scenarios:

- "As-is" scenario: the current manually driven logistics system
- "To-be" scenario: the proposed logistics system integrated with RFID technology

The authors will perform a COO analysis for each scenario to compare total ownership costs of both scenarios, and will perform a sensitivity analysis to evaluate the effects of the parameters on the overall ownership cost.

1. "As-is" Scenario

This scenario is based on the current, manually driven logistics system as described in the previous chapter and illustrated in Figures 9 through 11.

2. "To-be" Scenario

This scenario uses the "as-is" scenario and integrates it with RFID technology. According to this scenario, RFID technology integration will be completed within four years. It is required to implement RFID into the MSC in the first year. The reason for this requirement is that the MSC is the key component of the supply chain. Moreover, the

MSC is the trigger point for almost all of the supply chain activities. All the SSCs will be equipped with RFID in due course according to the decision of management. RFID readers will be mounted at the gates of warehouses and depots.

The supply chain phases will be modified due to improvements or process flow changes to make the phases more efficient and leaner. The modified first phase begins with the MSC SCO sending purchase orders to the PO. The PO contracts out with numerous suppliers for materiel. After getting contracts, the MSC SCO sends orders to suppliers in order to inform them to ship materiel to the MSC. Once materiel arrives to the MSC, the IC receives shipment. Afterwards, he or she makes workers carry the materiel into the inspection depot without counting. In the meantime, as materiel pass through the RFID reader, the RFID system will automatically identify, count the items, and insert the relevant information into the database of the IMMS. Moreover, the system will update the status of the items as “waiting for inspection” in the IMMS. Authorized users will be able to access real-time information about the items such as the type and quantity of the item, delivery date, and the status of the inspection process. Then, the IMMS will automatically prepare and send the IAD to the IT. Therefore, the Inventory Acceptance Manager (IAM) and stock control personnel for the inspection process are no longer needed. Later, the IT inspects materiel according to the terms stated in the contract, and then updates the status of the items in the database of the IMMS according to the inspection results. If the ICM agrees with the results, he or she prepares the AD and sends it to the WC. An authorized WC makes workers transfer items into his or her responsible warehouse. Meanwhile, the RFID system will automatically identify the items delivered, count and record them into the database of the IMMS as they pass through the RFID readers mounted at warehouse gates. In the meantime, the system recognizes the changes in status of transferred items and simultaneously sends necessary payment documents to the PO. Finally, the first phase ends when the PO disburses to the supplier. The flow chart of the first phase is displayed in Figure 12.

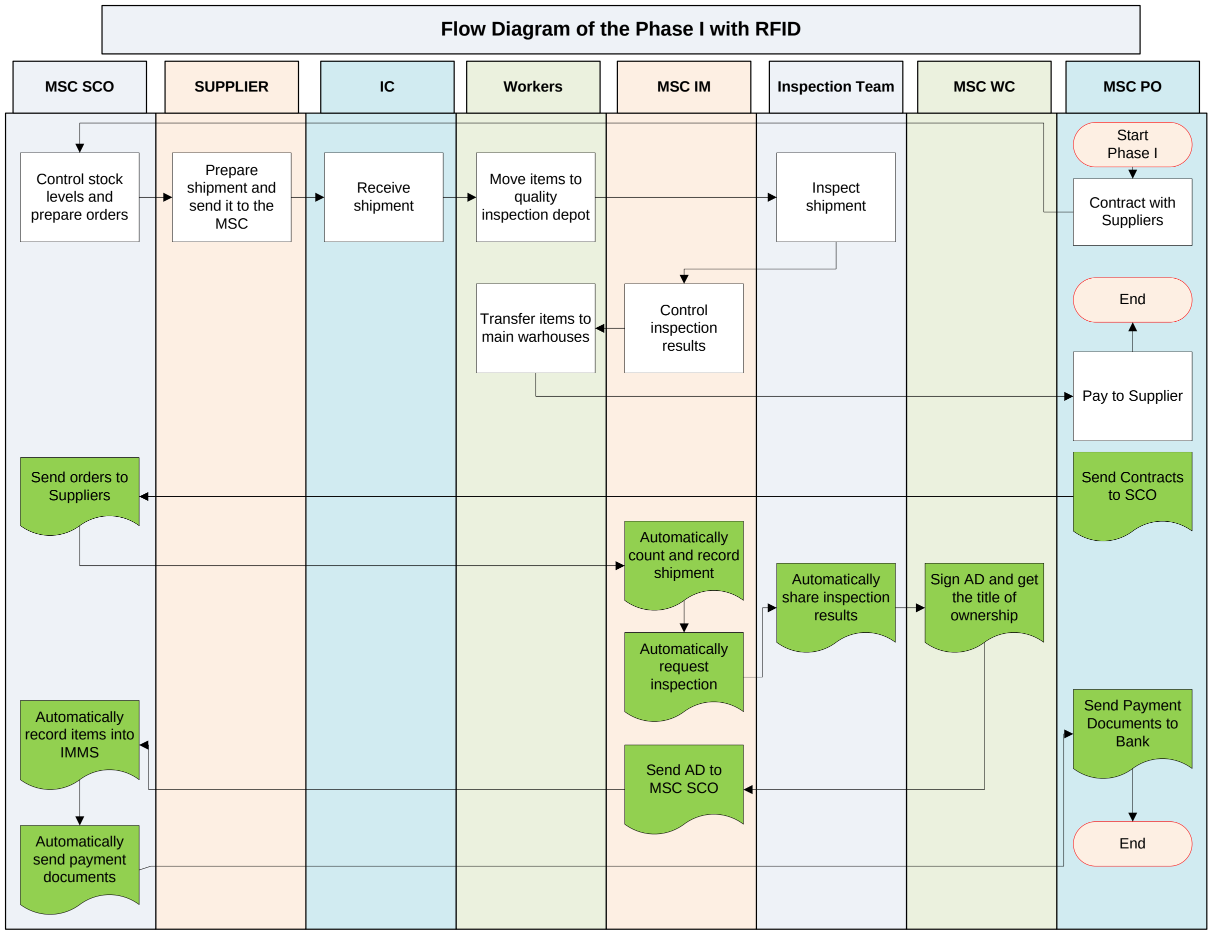

Figure 12. The Modified First Phase Flow Diagram

The modified second phase of the supply chain process takes place between the MSC and SSC or among SSCs. The authors will only explain the process between the MSC and SSC since the same process applies to the transaction among the SSCs. This phase is initiated when the RFID-integrated IMMS closes pending requisitions from the SSCs by selling the materiel to the SSCs. Following this, the system automatically sends authorization to the WC to check out sold items. When the WC sees this authorization on his or her computer, he or she finds the materiel in the warehouse and prepares it for hauling. Once ready, workers load materiel into vehicles and the transporter gets the responsibility of the items by signing the shipping bill. When the vehicle arrives to the SSC, the DC receives the transferred items and workers unload and carry shipped materiel from the vehicle to the depots. Meanwhile, the RFID system will automatically identify items delivered, count and record them into the database of the IMMS as they pass through the RFID readers mounted at warehouse gates. In the meantime, the system recognizes the changes in the status of transferred items and simultaneously sends the information to the MSC and matches, compares, and closes the transaction. The flow chart of the second phase is displayed in Figure 13.

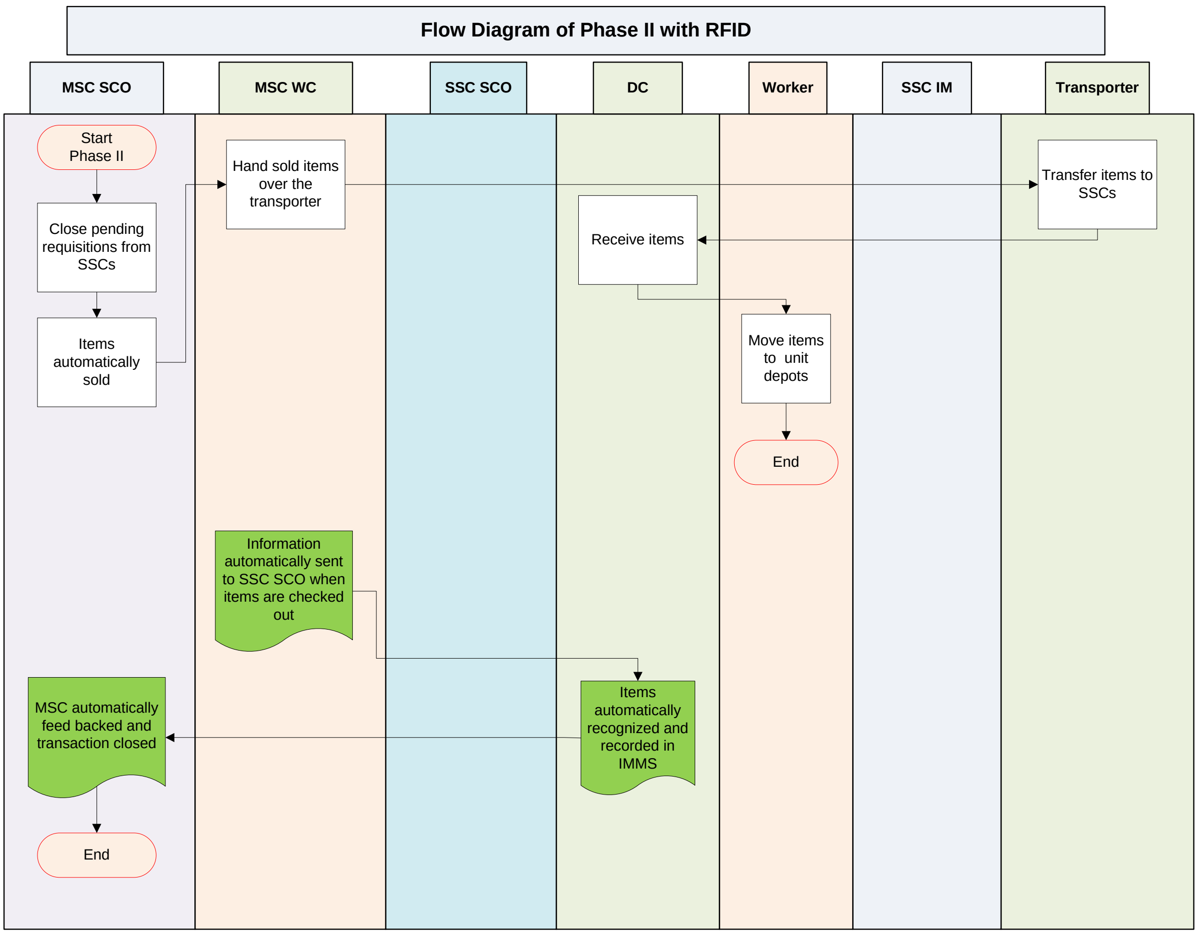

Figure 13. The Modified Second Phase Flow Diagram

The modified third phase of the supply chain process takes place between the SSC and ultimate customers (i.e., the end user). This phase is initiated when the RFID-integrated IMMS closes pending requisitions from the Cs by selling the materiel to the Cs. Following this, the system automatically sends authorization to the DC to check out sold items. When the DC sees this authorization on his or her computer, he or she finds the materiel in the warehouse, prepares it for hauling and then prints the SRD. Once ready, the shipment is controlled and counted by the transporter. If the transporter agrees that the items match with the SRD, then workers load the materiel into the vehicles. When the vehicles arrive to the Cs, the CC checks and counts each materiel and compares them to each SRD. If the CC agrees that each materiel matches with the SRD, then the workers unload and carry the shipped materiel from the vehicles to the customer storage area. In the meantime, the CC signs the SRD and hands it over to Customer Asset Management Personnel (CAMP). CAMP process the SRD by entering the materiel's SIN, seller SSC IDN, and the quantity of the materiel delivered into the C's IMMS. Then, CAMP control and approve the transaction and send the SRD back to the SSC. After the SSC SCO gets the SRD back, the TN given by the C is entered into the SSC's IMMS and the transaction is closed. Eventually, the third phase, as well as all supply chain events, ends at this point as displayed in Figure 14.

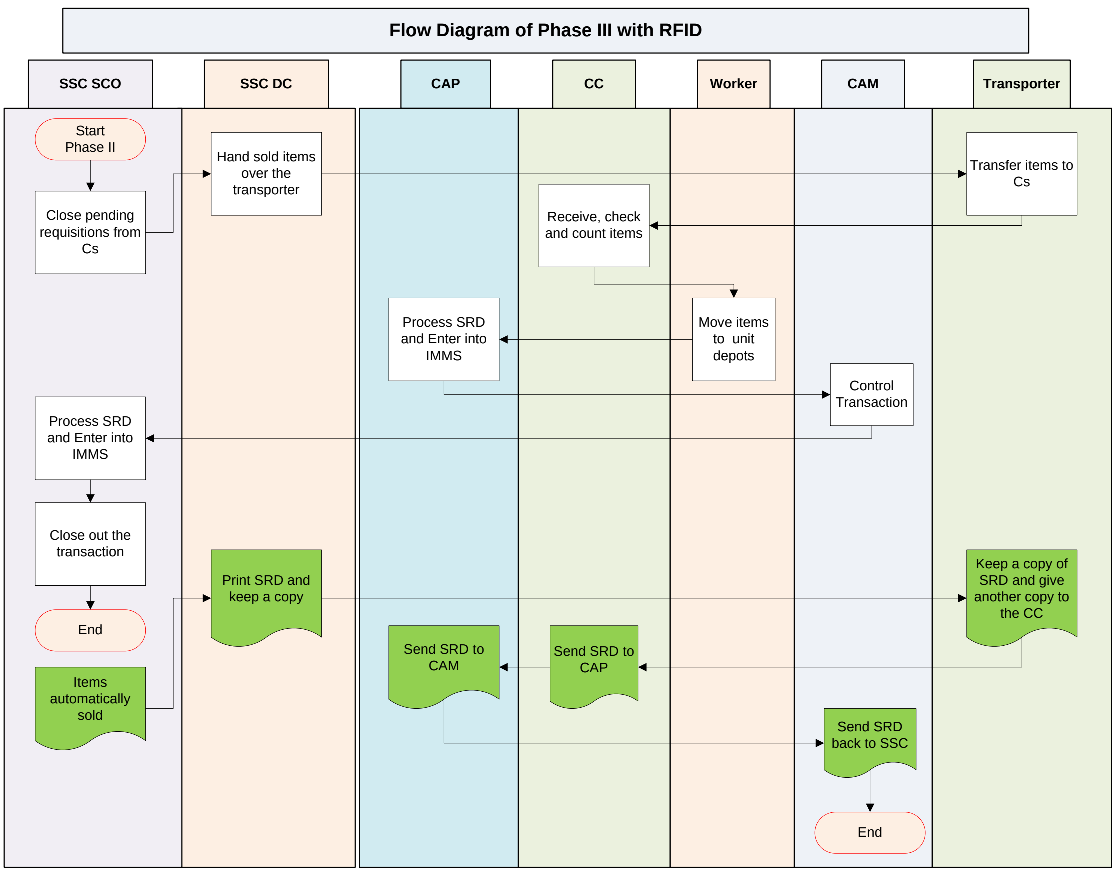

Figure 14. The Modified Third Phase Flow Diagram

D. ASSUMPTIONS

The model developed required the authors to make some assumptions based on their experience, literature review, and interviews. Due to difficulty obtaining the exact data, and the fact that the supply process has many complex components, the authors simplified the supply chain processes and input parameters.

The authors divided the assumptions into three categories including environmental assumptions, supply-chain specific assumptions, and process-related assumptions.

The first environmental assumption is that the supply chain in the model is available at any time and no shortage of resources exists such as equipment, personnel, software, etc. The second environmental assumption is that the system is up during its lifetime without any significant component failure. The third environmental assumption is that it is a mandatory requirement to construct the new RFID-integrated supply chain within four years and the MSCs must be the first places to adopt it in the first year.

The first assumption specific to supply chains is that the Navy is expected to mandate its suppliers to be compliant with RFID technology at most in ten years. Thus, all RFID tags are anticipated to be purchased by the MSCs during this time. After the ten-year period, the cost of RFID tags should be incurred by the suppliers. Moreover, the tag prices are estimated to reduce gradually due to the improvements in RFID technology and the increase in the number of tags to be purchased. The second assumption specific to supply chains is that the SSCs do not purchase any items by themselves and have to acquire the items by means of the MSCs. The third assumption specific to supply chains is that all the supply items have the same priority designators. This means that no item has precedence over other items, and each item has to run through the same processes. The fourth assumption is that the transportation cost and time of the items are neglected throughout the TNLS. Furthermore, no delays exist due to the lack of transportation.

The first process-related assumption is that the inventory cost does not include the purchasing cost of the items. The second process-related assumption is that supply items delivered to supply commands will be in cases. The third process-related assumption is that demand size represents the quantity of cases and not the number of items. The fourth assumption is that the standard deviations of the daily demand for all cost categories are the same. The last process- related assumption is that the needed database infrastructure has already been established and has enough capacity to meet the overload of data.

E. INPUT PARAMETERS

The authors developed the model using MS Excel 2007. The model contains twelve worksheets. The *data & consolidated results* worksheet includes all the input parameters and historical data as well as consolidated results as displayed in Appendix A.

The authors divided the input parameters into ten categories in the *data & consolidated results* worksheet. All the pink colored cells depict variable parameters that are subject to change by the user. Remaining white colored cells are either constant or calculated parameters.

The Salary and Manpower input parameters are named according to job titles and grouped by both the type of supply command and the processes they work in. The variable parameters include salaries and the number of personnel working under this title. In the MSC receiving process, the number of accountants and managers for the “to-be” scenario is zero, as a result of the automation in the receiving process. In the MSC inspection process, the number of leaders and quality controllers for the “to-be” scenario are the same as those for the “as-is” scenario due to the law restrictions (TAF, 2006). In the MSC and SSC storing processes, the number of custodians for the “as-is” scenario is the same as the number of warehouses/depots. All the remaining number of personnel parameters for the “to-be” scenario is multiplied by the reduction rate related to the pertinent job title. The number of personnel working in the checking and counting (CC) process is eliminated in the “to-be” scenario as a consequence of visibility improvement This process also requires duration and frequency parameters for the “as-is” scenario.

The general parameters are comprised of the discount rate; inflation rate; the number of MSC, SSC, and warehouses per MSC; depots per SSC; door readers per warehouse/depot; hand readers per warehouse/depot; door-reader antennas per reader; local servers per SSC; integration server; and label printers per MSC/SSC. Construction time is assumed to be constant at four years. Finally, system lifetime value will be retrieved from the user by means of an input box that will appear when the user pushes the “RUN” button.

Reduction goal parameters define the reduction goals in terms of personnel titles as well as misidentification and loss rates.

Construction cost parameters are related to all the costs incurred prior to and during the construction of the system. PMO labor cost reflects the total amount of salary of all acquisition personnel. Test cost per warehouse depot, integration cost to the current system per command and the purchase of a door reader, hand reader, antenna, labor printer, and an integrator server are variable parameters in this category.

Supply command construction plan parameters show when and how many supply commands should be integrated with the RFID technology. The construction has to be finished in four years and the MSCs must be the first places to be integrated with RFID in the first year. These are variable parameters. All these parameters inserted by the user are controlled by the macro developed in Visual Basic (VB). Therefore, the model does not allow the user to make logical errors. The written code in the macro can be found in Appendix B.

Expected tag price parameter contains the probable purchase price of a tag. The prices are expected to reduce gradually due to technological improvements and the size of the batch purchased.

Lead-time parameters refer to the time required to transport the supplies between to points. Specifically, the lead time for the first phase reflects time spent to acquire items from a supplier to the MSCs. The second phase lead time is the time consumed to transfer an item from the MSCs to the SSCs. The third phase lead time is the final process time that takes place between the SSCs and customers.

Inventory parameters are grouped by the unit costs to simplify the calculations. Each unit cost between intervals is fixed to the upper limit of the interval. Misidentification and loss probabilities, namely expected annual demands for the SSCs, are variable parameters. Expected annual demand for the MSC and standard deviations of the daily demands of the SSCs as well as the MSCs are obtained through calculations embedded in the model.

Historical misidentified and lost item data parameters are retrieved from IMMS historical data.

Operating cost parameters are made up of the ordering cost, holding cost rate, system maintenance cost per command, the review interval, inventory on hand, confidence level, and rate of standard deviation parameters. The rate of standard deviation is used in the calculation of the safety stock and represents the percentage of the daily demand.

In addition to all of these input parameters, the *data & consolidated results* worksheet includes a breakdown of the consolidated results of the cost elements. Moreover, as displayed in Figure 15. , a “RUN” button is put on the worksheet to run the model. After entering all the input parameters, the user has to press this button to see the results. Whenever the user presses the “RUN” button, an input box will appear asking to enter the lifetime of the system as displayed in Figure 16.

CONSOLIDATED RESULTS OF THE COST ELEMENTS

Cost Elements		As-Is	To-Be	Change Rate
Infrastructure Construction Cost		$ -	$ 20,394,127	
Logistics Operating Cost		$ 144,444,232	$ 118,861,046	17.7%
	Tag Purchase Cost	$ -	$ 6,259,478	
	Maintenance cost	$ -	$ 10,969,725	
	Inventory Cost	$ 59,854,632	$ 39,656,810	33.7%
	Labor Cost	$ 84,589,600	$ 61,975,033	26.7%
Miscellaneous Cost		$ 7,667,055	$ 1,533,411	80.0%
	Misidentification Cost	$ 3,265,586	$ 653,117	80.0%
	Loss Cost	$ 4,401,469	$ 880,294	80.0%

TOTAL LCC	
CURRENT (As-Is)	$ 152,111,287
RFID INTEGRATED (To-Be)	$ 140,788,584
DIFFERENCE	$ 11,322,703
CHANGE RATE	7%

RUN

Figure 15. Consolidated results of the cost elements

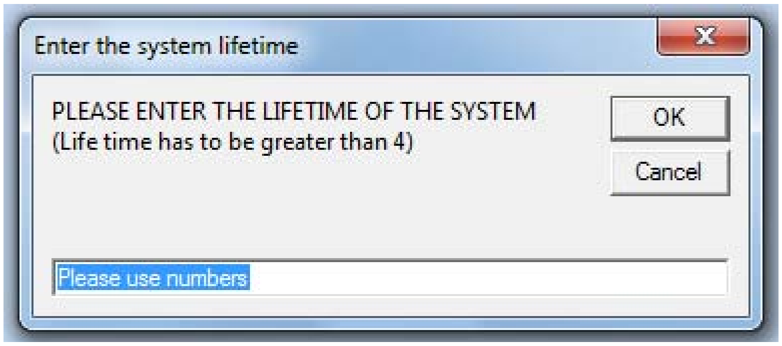

Figure 16. Input Box to Obtain the Lifetime of the System

F. MODEL

The authors developed equations for each cost elements. Then, the total cost of each category obtained by adding the costs of these related cost elements. Formulas used to get the cost elements are displayed in Table 2.

Cost Category	Cost Element	Formula
Construction Cost	Labor (PMO)	Monthly labor cost of PMO x 12
	Integration Cost to Current System	Integration cost x Number of SSCs and MSCs constructed in the corresponding year
	Door Reader Cost	Door reader cost x Number of door readers required
	Hand Reader Cost	Hand reader cost x Number of hand readers required
	Antenna cost	Antenna cost x Number of antennas required
	Label Printer Cost	Label printer cost x Number of label printers required
	Integrator Server Cost	Integrator server cost x Number of integrator server required by the MSCs
	Local Server Cost	Local server cost x Number of local server required by the SSCs
	Test Cost	Test cost x Number of warehouses/depots integrated with RFID

Cost Category	Cost Element	Formula
Operating Cost	Tag Purchase Cost	Tag cost for the corresponding year x Annual demand
Operating Cost	Maintenance Cost	Annual Maintenance Cost x Number of MSCs and SSCs integrated with RFID
Operating Cost	Inventory Cost	As explained below
Operating Cost	Labor Cost	Monthly salary of each personnel x Number of personnel x 12
Miscellaneous Cost	Misidentification cost	As explained below
Miscellaneous Cost	Loss Cost	As explained below

Table 2. Formulas Used in the Model

Inventory costs for both scenarios are obtained by incorporating the multi-period inventory systems. The authors used a “fixed time period with safety stock model” for the “as-is” scenario because it is the preferred model for the current system. However, for the “to-be” scenario, the authors decided to use a “fixed order quantity model” due to the increased real-time visibility and traceability resulting from the integration with RFID technology. This is one of the significant benefits of RFID technology implementation in a supply chain.

The “fixed time period with safety stock model” is based on fixed time intervals to order supplies. In other words, orders are placed at the time of review. The model consists of two components. The first component is safety stock and the latter is required inventory for the fixed review period. The safety stock level is:

$$SS = z\sigma_{T+L} \quad (1)$$

where

SS = safety stock level

z = the number of standard deviations for a specified service probability

T = the number of days between reviews

L = lead time

σ_{T+L} = standard deviation of demand over the review and lead time

After the safety stock level is calculated, the order quantity will be:

$$Q = d(T + L) + SS + I \quad (2)$$

where

Q = quantity to be ordered

d = average daily demand

I = inventory on hand

After all of these calculations, the level of inventory and total annual inventory cost for the "as-is" scenario will be:

$$Average\ Inventory = SS + \frac{Q}{2} \quad (3)$$

$$Total\ Inventory\ Cost = \frac{D}{Q}S + \left(SS + \frac{Q}{2}\right)H \quad (4)$$

where

D = annual demand

S= ordering Cost

H = holding Cost

On the other hand, the "fixed order quantity model with safety stock" attempts to determine the reorder point as well as the order quantity. The following formulas are used in the calculations:

$$SS = z\sigma_L \quad (5)$$

$$R = dL \quad (6)$$

$$Q = \sqrt{\frac{2DS}{H}} \quad (7)$$

where

σ_L = standard deviation of demand over the lead time

R = reorder point

After all of these calculations, the level of inventory and total annual inventory cost for the "as-is" scenario will be:

$$Average\ Inventory = SS + \frac{Q}{2} \quad (8)$$

$$TC = \frac{D}{Q}S + (SS + \frac{Q}{2})H \quad (9)$$

The authors obtained historical data regarding misidentified items in previous years and calculated the mean and the standard deviation, then estimated a misidentification probability distribution based on experience as displayed in Table 3.

Misidentified Item Avg. Unit Cost	**Probability**
$ 10,000.00	0.010
$ 8,000.00	0.015
$ 6,000.00	0.020
$ 4,000.00	0.025
$ 2,000.00	0.030
$ 1,000.00	0.120
$ 500.00	0.220
$ 250.00	0.260
$ 100.00	0.300

Table 3. Misidentification Probability Distribution

The authors created a simulation model to calculate the misidentification cost throughout the lifecycle of the system. The number of misidentified items is randomly created by the simulation for each year using the mean and standard deviation of the historical data. The average unit cost of the misidentified items for each year is generated by the simulation as well. For every misidentified item, the simulation generates a random number between zero and one. This number is looked up in the table and the corresponding unit cost is found. This process is iterated as many times as the generated misidentified item numbers for each year. The average unit cost for all these misidentified items is calculated by averaging these generated unit costs. Eventually, the total misidentification cost is equated to the sum of the total value of misidentified inventory and holding cost of these items.

The authors used exactly the same simulation architecture in their loss cost calculations. Similar to the misidentification cost calculation, the authors estimated a historical loss data, the associated mean and standard deviation and the loss probability distribution table, which is displayed in Table 4.

Lost Item Avg. Unit Cost	**Probability**
$ 10,000.00	0.005
$ 8,000.00	0.008
$ 6,000.00	0.010
$ 4,000.00	0.020
$ 2,000.00	0.030
$ 1,000.00	0.090
$ 500.00	0.220
$ 250.00	0.280
$ 100.00	0.337

Table 4. Loss Probability Distribution

The number of lost items for a specific year is randomly created by the simulation using the mean and standard deviation of the historical data. The average unit cost of the lost items for each year is calculated by the simulation as well. For every lost item, the simulation generates a random number between zero and one. This generated number is looked up in the table and the corresponding unit cost is found. This process is iterated as many times as the generated lost item numbers for each year. The average unit cost for all of the lost items is calculated by averaging these generated unit costs. Finally, the total loss cost is calculated by multiplying the generated number of lost items with the average unit cost of these items.

The authors calculated all the cost elements for each year within the lifecycle as constant dollars. First, constant dollar values are adjusted for inflation using the following formula:

$$(IAV)_t = (CV)_t\,(1 + i)^t \qquad (10)$$

where

IAV = inflation-adjusted value

CV = constant dollar value

i = inflation rate

t = time

Then, these inflation-adjusted values are discounted to current dollars using the formula:

$$(PV)_t = (IAV)_t \,/\, (1 + i + r)^t \qquad (11)$$

where

PV = present value

r = discount rate

In addition, the total cost of each cost element is calculated as adding all the annual present values together.

$$PV = \sum_{t=1}^{n} (PV)_t \tag{12}$$

where

n = lifetime

Finally, the present values of all the cost elements are added up to obtain the total ownership cost of the system.

$$COO = LCC = (PV)_{construction} + (PV)_{operating} + (PV)_{miscellaneous} \tag{13}$$

The authors elucidated in this chapter how they developed the model, in the next chapter the results of the analysis will be evaluated.

V. RESULTS

A. COST OF OWNERSHIP

The model developed by the authors encompasses all cost elements incurred during the lifetime of the system. Lifetime can be determined by the user before running the model. The results are obtained for a 20-year lifetime. Misidentification and loss costs are obtained by means of a simulation embedded in the worksheet. Every time the user runs the model, the simulation replicates itself 100 times to ensure the confidence intervals around the estimates are sufficiently small. Moreover, a year consists of 250 days.

1. As-is Scenario: Current Manually Driven Logistics System

The results of this scenario represent the COO of the current manually driven logistics system as explained in Chapter III.

The COO of keeping the current system in operation is $152.4M. This cost is the sum of $144.5M in logistics operating costs and $7.9M in miscellaneous costs. Under the "fixed time period with safety stock inventory control" model, inventory cost represents 39.29% of the COO. Labor cost, which constitutes 55.53% of the COO, is the largest cost element for the current system. Furthermore, miscellaneous cost, which consists of misidentification and loss costs, accounts for $7.9M of the COO, which represents 5.18% of the total cost. Table 5. depicts the summary of the cost elements.

Cost Elements	As-Is Scenario	Distribution
Infrastructure Construction Cost	**$ -**	**0.0%**
Logistics Operating Cost	**$ 144,444,232**	**94.8%**
- *Tag Purchase Cost*	*$ -*	*0.0%*
- *Maintenance Cost*	*$ -*	*0.0%*
- *Inventory Cost*	*$ 59,854,632*	*39.3%*
- *Labor Cost*	*$ 84,589,600*	*55.5%*
Miscellaneous Cost	**$ 7,890,178**	**5.2%**
- *Misidentification Cost*	*$ 3,383,450*	*2.2%*
- *Loss Cost*	*$ 4,506,729*	*3.0%*

Table 5. COO of As-is Scenario

2. To-be Scenario: Proposed Logistics System Integrated with RFID Technology

The results of this scenario represent the COO of the proposed logistics system integrated with RFID technology as explained in Chapter IV.

The COO of constructing and operating the new RFID-integrated system is $140.9M. This cost is the sum of $20.4M in infrastructure construction costs, $118.9M in logistics operating costs, and $1.6M in miscellaneous costs. Under the “fixed quantity with safety stock inventory control” model, inventory cost represents 28.16% of the COO. Labor cost constitutes 44% of the COO for the proposed system. Furthermore, miscellaneous cost, which consists of misidentification and loss costs, accounts for $1.58M of the COO. This cost represents 1.12 % of the total cost. Table 6. depicts the summary of the cost elements.

Cost Elements	To-Be Scenario	Distribution
Infrastructure Construction Cost	**$ 20,394,127**	**14.5%**
Logistics Operating Cost	**$ 118,861,046**	**84.4%**
- *Tag Purchase Cost*	*$ 6,259,478*	*4.4%*
- *Maintenance Cost*	*$ 10,969,725*	*7.8%*
- *Inventory Cost*	*$ 39,656,810*	*28.2%*
- *Labor Cost*	*$ 61,975,033*	*44.0%*
Miscellaneous Cost	**$ 1,578,036**	**1.1%**
- *Misidentification Cost*	*$ 676,690*	*0.5%*
- *Loss Cost*	*$ 901,346*	*0.6%*

Table 6. COO of To-be Scenario

Given these results, with the integration of RFID technology the COO of the system reduces from $152.4M to $140.9M. Within the proposed lifetime of 20 years, there is an approximate reduction of $12M, which accounts for an 8% reduction in the COO of the current system. The detailed results of COO are displayed in Appendix C.

3. Payback Period

One of the biggest concerns related to RFID technology is its initial construction cost. From this point of view, it is crucial to determine the payback period. The payback period is the period of time required for the return on investment to repay the sum of the original investment. For the model developed by the authors, the payback period refers to the length of time where the COO of the proposed system is equal to that of the current system and begins being less than that of the current system. After the payback period the benefits gained from the proposed system is greater than the initial construction cost of the system. Briefly, the payback period is the point where COOs of the two scenarios are equal.

To calculate the payback period the authors changed the lifetime parameter and held all the other variables constant. Since the initial construction is assumed to finish at the end of the fourth year, the authors run the model for the lifetime range of 5 years to thirty years. Figure 17. displays the graph of the COOs of both the proposed and current system. The results indicate that beginning from the eleventh year the COO of the proposed system is less than that of the current system.

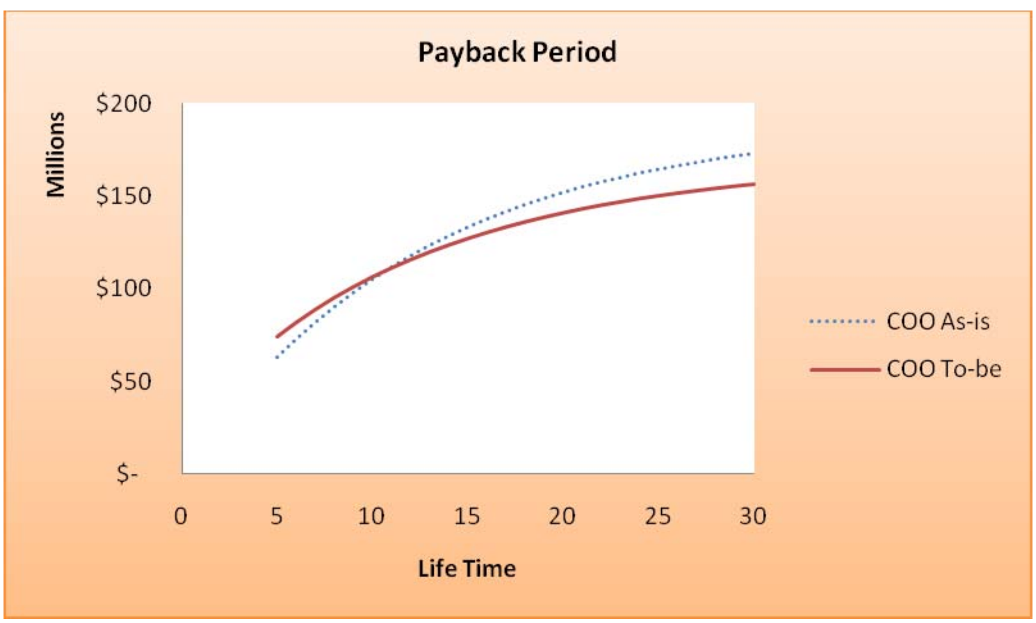

Figure 17. Payback Period

As a result of this analysis, the payback period is eleven years. At first glance, a payback period of eleven years may seem to be too high for a decision maker to justify the investment in the RFID technology. However, this technology is still immature and with further improvements in the RFID technology and in turn, with the reductions in the initial construction cost, the payback period may reduce gradually in the future.

B. SENSITIVITY ANALYSIS

The purpose of this part of the study is to determine how the independent variables used in the model will affect the COO of the system, and which of these variables are the most significant. The authors kept a parameter as variable and the remaining parameters as constant for the sensitivity analysis. All sensitivity analyses should be taken into account within the borders and parameter values described in the model developed by the authors. The detailed results of each cost element are displayed in Appendix D.

1. Discount Rate

Discount rate has a significant effect on the total COO. When the discount rate is 17.5%, the total COO of the "to-be" scenario equals that of the "as-is" scenario. The COO of the "as-is" scenario is lower than that of the "to-be" scenario for discount rates greater than 17.5%. On the other hand, the COO of the "to-be" scenario has lower values when discount rates are less than 17.5%, as displayed in Figure 18. In the current conditions, a discount rate of 17.5% is extremely high and may be almost impossible but, when the discount rate is higher than 17.5 %, it is better not to implement RFID technology since its total cost will be higher. In other words, operating the current logistics system is less costly than the proposed system for discount rates greater than 17.5%.

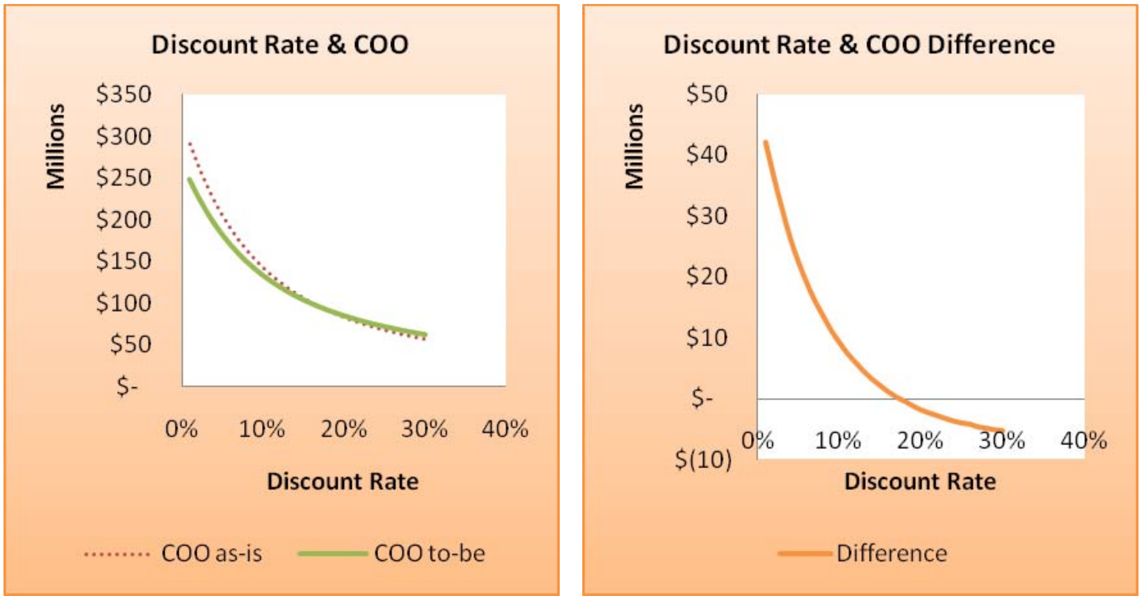

Figure 18. The Effect of Discount Rate

2. Inflation Rate

The inflation rate is another economic parameter that has a slight effect on the total cost. As displayed in Figure 19. , as the inflation rate increases, the difference of the total cost between the "as-is" and "to-be" scenarios slightly increases. There is a linear relationship between inflation rate and COO differences. The slope of this line indicates that every 1% increase in inflation rate causes an increase of $180.313 in the difference of the total cost between the two systems.

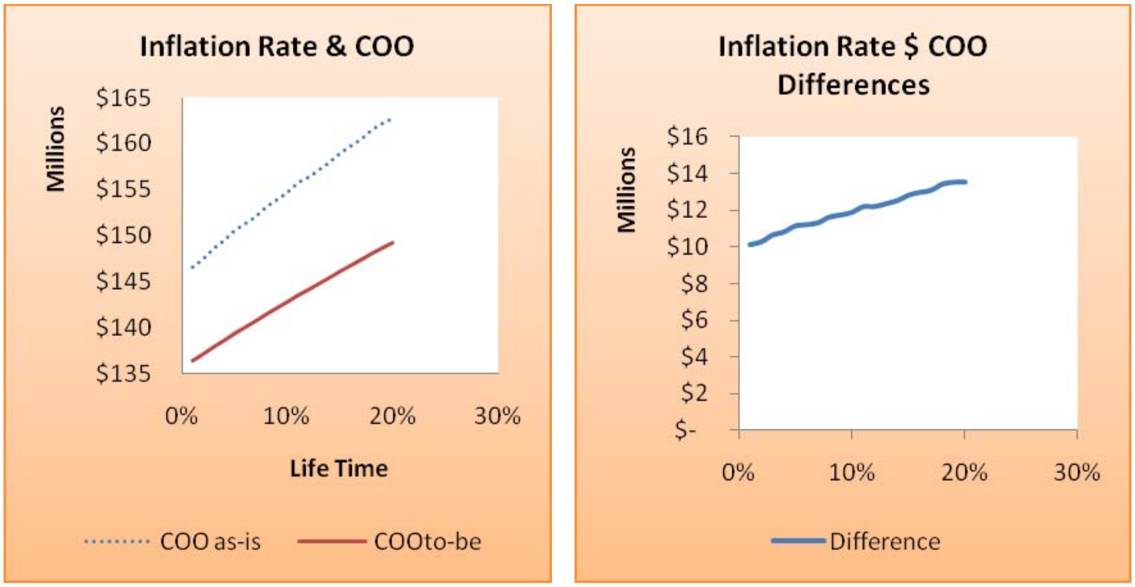

Figure 19. The Effect of Inflation Rate

3. Holding Cost

Holding cost that is related to inventory cost is a crucial parameter of the model. Holding cost is the result of having inventory to meet demand. The easiest way to meet demand is to keep as much inventory as possible. However, there should be a balance between inventory level and customer demand. The objective is to find the optimum inventory level in order to refrain from stocking out as well as paying higher holding costs for the sake of increased responsiveness whenever large variability exists in demand. The holding cost rate has a tremendous effect on ownership cost. In the model developed by the authors, when the holding cost rate is 6.5%, the COOs of both scenarios are equal. As the holding cost rate increases, the COO of the 'to-be' scenario decreases, as displayed in Figure 20. The primary reason is that increased visibility and traceability enables the application of the "fixed quantity" model to inventory calculations. This model results in a lower amount of inventory, and in turn lower total COO. On the other hand, the holding cost of inventory for the "as-is" scenario increases proportionally with the holding cost rates. The reason is that the application of the "fixed time period" model to this scenario due to low visibility and traceability of inventory. Therefore, inventory on hand at any time is greater in the "as-is" scenario than the "to-be" scenario.

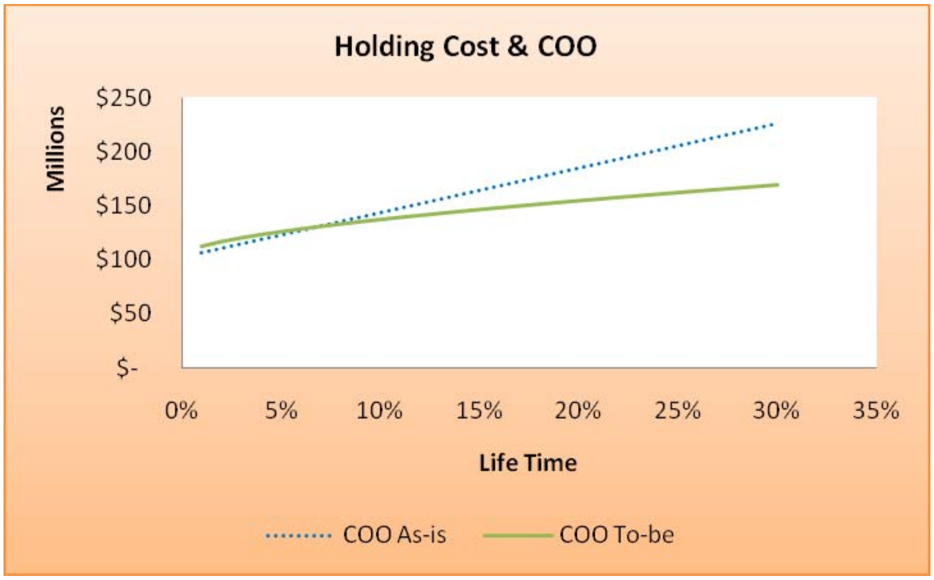

Figure 20. The Effect of Holding Cost

4. Total Monetary Value of Annual Demand

The amount of demand is an important parameter in determining the reorder point, quantity of order and inventory level, and consequently has an important effect on COO. When the total monetary value of annual demand is $280M, the COOs of the scenarios are the same as displayed in Figure 21. The COO of the "to-be" scenario apparently has a lower value than that of the "as-is" scenario when the total monetary value of annual demand is greater than $280M. Both scenarios have almost the same amount of COO when the total monetary value of annual demand is under $280M. Hence, it can be concluded that as the total monetary value of annual demand rises, the "to-be" scenario will cost less than the "as-is" scenario.

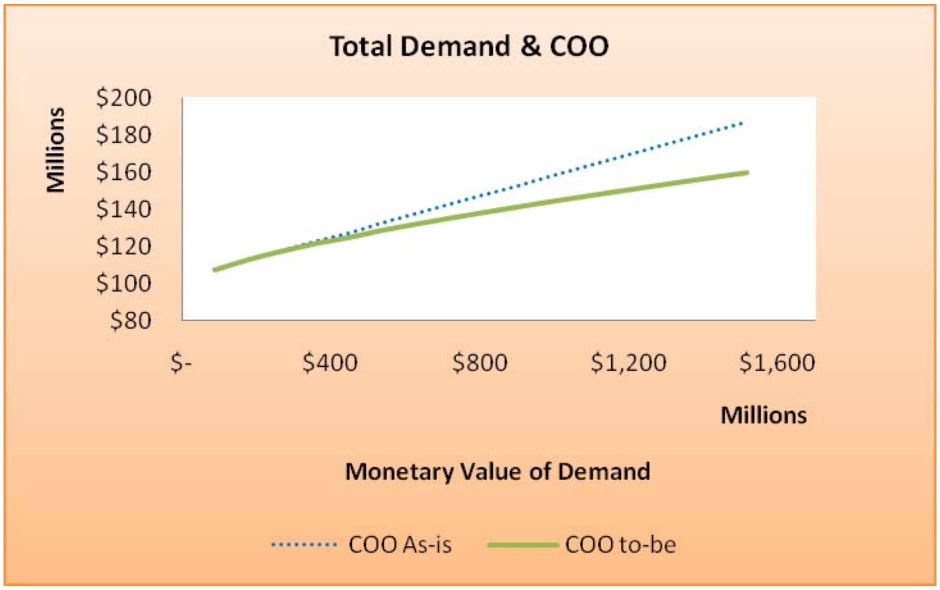

Figure 21. The Effect of Monetary Value of Demand

5. Ordering Cost

Ordering cost is an important part of the inventory cost. Ordering cost and COO have a linear relationship for the "as-is" scenario. It can be explained by the periodic review used in the inventory calculation for this scenario. Ordering cost has nothing to do with the quantity to be ordered. Thus, the inventory cost and COO increases in direct proportion to the ordering cost for the "as-is" scenario. The situation is not the same for the "to-be" scenario because of the continuous review model. This model attempts to optimize the order quantity for each different ordering cost by taking the holding cost into account. While the cost per order increases, its effect on the COO decreases gradually. As a result of the EOQ equation used in the model, an increase in the cost per order results in an increase in the quantity to be ordered; therefore, the number of annual orders decreases. Briefly, the slight concave curve in the graph is a consequence of the inverse trend between the cost per order and EOQ. On the other hand, while the cost per order increases, the COO curves of both scenarios converge, as seen in the Figure 22. This trend can be explained by the increase in the holding cost. Consequently, while the cost per order increases, both the EOQ and total holding cost also increase.

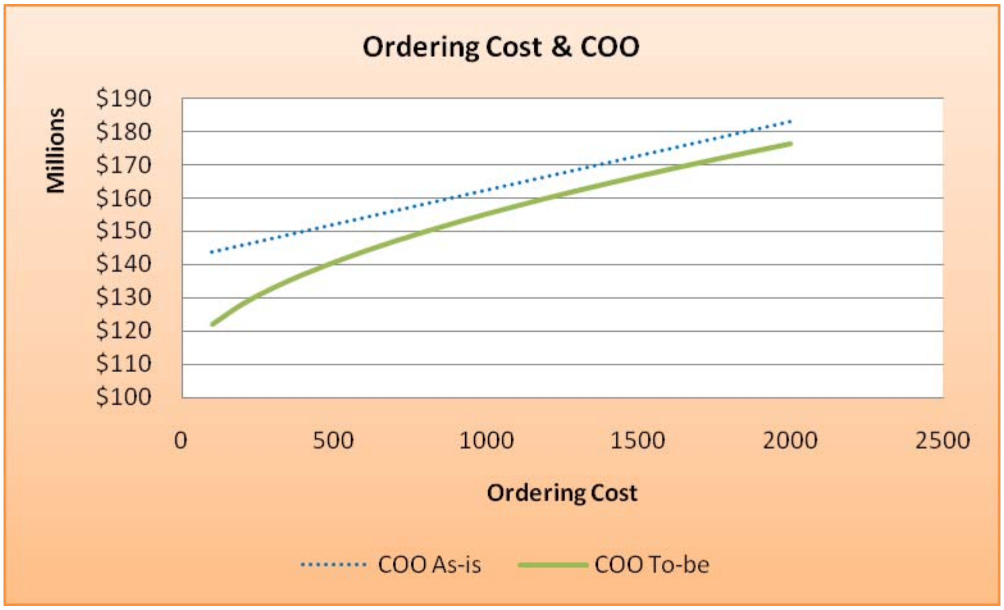

Figure 22. The Effect of Ordering Cost

6. Standard Deviation of Daily Demand

The standard deviation of daily demand is calculated as a product of the standard deviation rate and daily demand. Standard deviation plays a significant role in safety stock levels and in turn, inventory cost. As seen in Figure 23. the gap between COOs increases as the standard deviation of daily demand increases. The "as-is" scenario requires standard deviation of demand over the review and lead time. On the other hand, the "to-be" scenario requires only standard deviation of demand over lead time. The former uses the square root of lead time whereas the latter uses the square root of lead time and a review period as the following equations explain:

$$\sigma_L = \sigma_d \sqrt{L} \tag{14}$$

$$\sigma_{L+T} = \sigma_d \sqrt{L+T} \tag{15}$$

Therefore, greater variations in daily demand can be tackled through increased visibility and a flexible inventory policy, which is the result of RFID technology implementation.

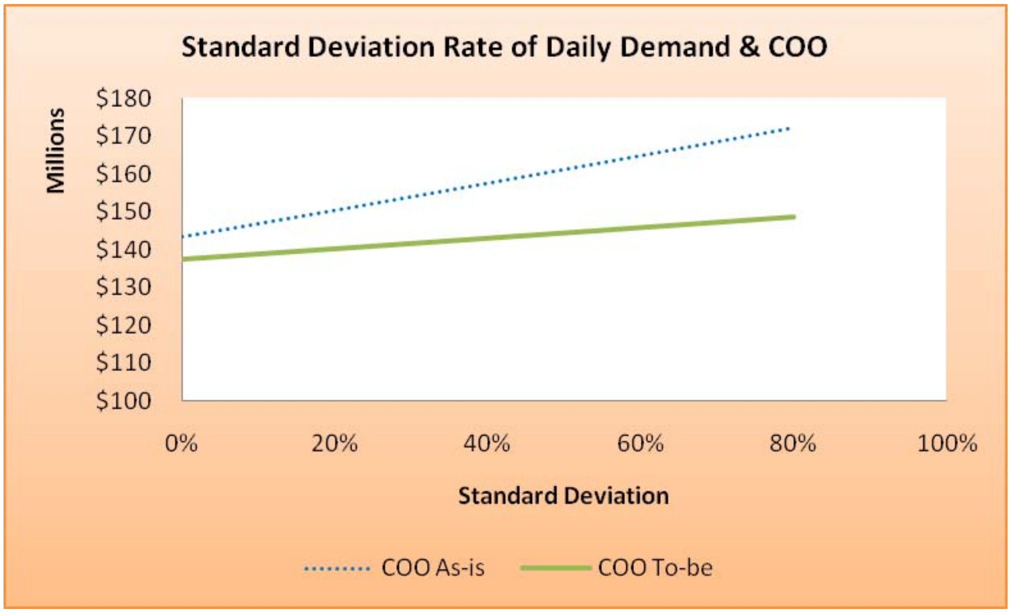

Figure 23. The Effect of Standard Deviation of Daily Demand

7. Labor Reduction Rate

Labor reduction is one of the most important benefits gained by the integration with RFID technology in terms of COO. The authors perceive reduction in three occupations including workers, stock controllers, and custodians. However, reduction goals of each occupation vary from one another. Out of these three, the reduction in the number of workers is anticipated to be dominant, followed by custodians, and then stock controllers. Each reduction in these occupations has different effects on the COO, which is displayed in Figure 24.

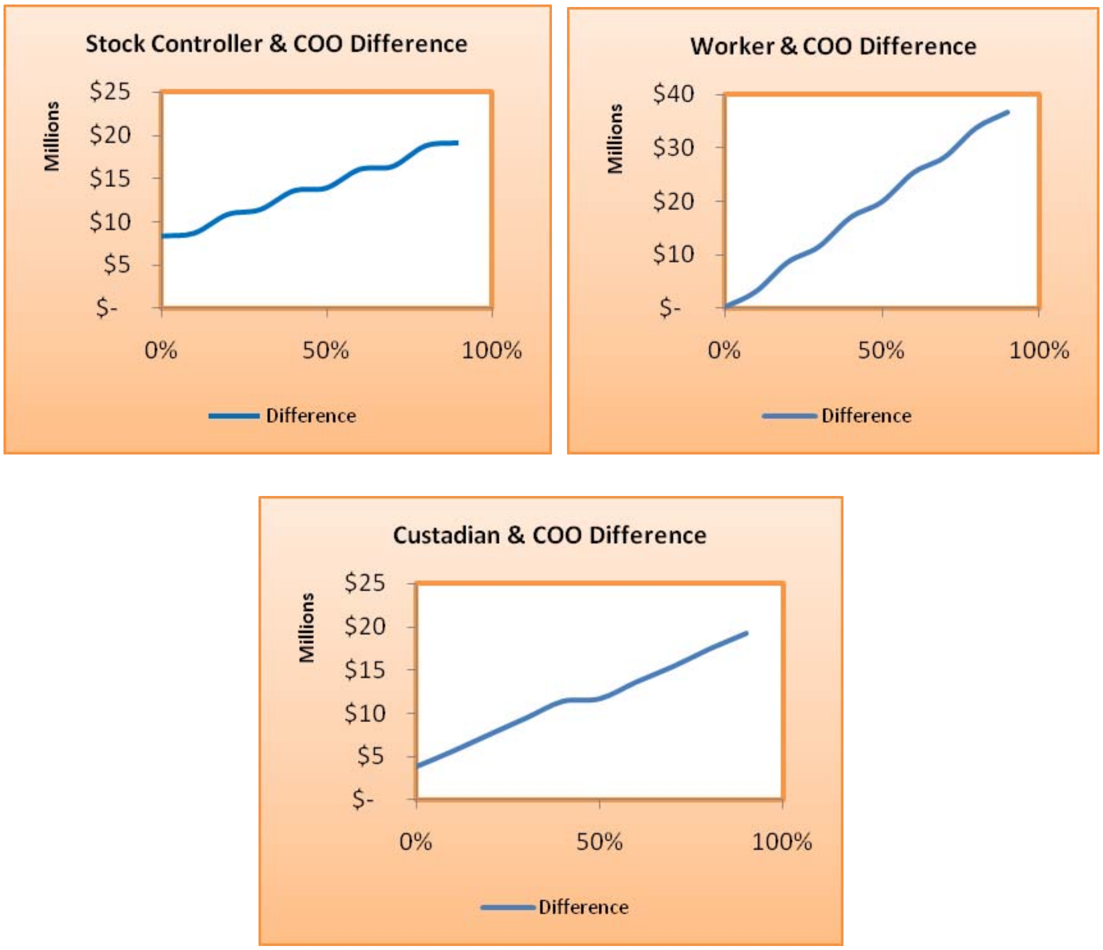

Figure 24. The Effect of Labor Reduction

THIS PAGE INTENTIONALLY LEFT BLANK

VI. CONCLUSIONS

A. SUMMARY

Having better and accurate information about inventory provides decision makers numerous benefits. Sweeney II (2005) points out basic benefits gained from RFID applications in a supply chain. First, every item gets its own unique identification number, which results in serialized data. Serialized data results in better inventory control and decreased carrying cost. Secondly, human intervention can be reduced through performing counting and scanning barcode processes automatically. Less human intervention leads to less errors, which in turn produces decreased costs, faster checkouts, decreased damage, and reduced returns. Moreover, the automation enables many items to be counted simultaneously. Thirdly, real-time information flow can be obtained, which allows decision makers to track and update information about an item. Lastly, items can be transported inside confined places from the manufacturing place to the final destination without having long delays born of counting and identification issues.

This study examined the cost of ownership of a RFID-integrated military logistics system. The study primarily focused on the question of whether the cost of integrating and operating the TNLS with RFID was worth the investment. To answer this question, the authors developed a COO model. The main result of the study revealed that the cost of ownership of the RFID-integrated logistics system cost less than that of the current logistics system despite the huge initial integration cost.

Moreover, this study identified the key cost parameters that have significant impact on the cost of ownership. The study indicated that lifetime of the system, discount rate, inflation rate, holding cost, ordering cost, quantity of demand, and labor reduction rates are delicate parameters that should be considered in decision making.

Finally, the results of the study indicated that the Turkish Navy should incorporate its logistics system with RFID technology. Hence, the Turkish Navy will reduce the total expenditure it needs to have to operate its logistics system, as well as enjoy the immeasurable benefits from RFID technology. Moreover, the model developed in this study can be used as a basis to evaluate investment in RFID technology integration in other business processes.

B. RECOMMENDATIONS

The research supports the following recommendations to implement RFID technology in the Turkish Naval Logistics System.

First, the authors recommend that the Turkish Navy integrate its supply chain with RFID technology. The Turkish Navy should recognize that the total cost of implementing and operating the RFID-integrated logistics system will be less than that of operating the current logistics system in the long run.

Secondly, the Turkish Navy should incorporate the “fixed quantity with safety stock” model instead of the ”fixed time period with safety stock” model to determine the reorder point and economic order quantity. Increased visibility, traceability, and real-time information flow as a consequence of RFID integration enable inventory mangers to utilize the “fixed quantity with safety stock” model in order to meet customer demands with lower inventory levels. In turn, lower inventory levels will result in greater savings of inventory holding costs.

The third recommendation for the Turkish Navy is to develop a policy that mandates its suppliers to attach RFID tags onto their products. In addition, this policy should include, but not be limited to, the level of tagging, tag cost share ratio and tagging compliance criteria for items.

Finally, the authors developed this model for a military logistics system, but it could also be used as a basis for any other supply chain. The decision makers can adopt this model to their own supply chain processes with small changes. Thus, they can determine the total cost of integrating their supply chain with RFID technology. Furthermore, they can decide on the worthiness of the investment by comparing the difference between COOs of their current and RFID-integrated systems.

C. FUTURE RESEARCH

One of the future research opportunities would be to determine the relationship between tagging cost and item cost. This study proved that it is obvious to gain a significant reduction in COO with the integration of RFID technology. However, as a consequence of this integration, the manufacturers have to bear an additional tagging cost and it is clear that the tagging cost will increase the cost of an item. Thus, the question of how to determine the relationship between the tagging cost and item cost should be studied. That is to say, what should be the minimum level of an item cost to be worth tagging?

Another future research opportunity could be to determine which other processes could be a candidate for the integration to a RFID-implemented supply chain and the COO of these RFID-integrated processes. For instance, is it worth integrating the transportation system with RFID in the supply chain, and what is the COO of this RFID-integrated transportation system?

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX A- INPUT PARAMETERS

This appendix includes input parameters, salary and manpower parameters, historical data, and inventory input parameters.

Salary & Manpower			
MSC			
Receving Process	Salary	As-Is #	To-Be #
Custodian	$ 1,000	2	1
Accountant	$ 1,500	1	0
Manager	$ 2,000	1	0
Inspection Process	Salary	As-Is #	To-Be #
Leader	$ 2,200	1	1
Quality Controller	$ 1,700	2	2
Storing Process	Salary	As-Is #	To-Be #
Custodian	$ 1,250	25	15
Stock Control	$ 1,500	20	14
Manager	$ 2,100	2	1
Worker	$ 1,900	35	26
SSC			
SSC Storing Process	Salary	As-Is #	To-Be #
Custodian	$ 1,250	9	5
Stock Control	$ 1,500	5	4
Manager	$ 2,100	1	1
Worker	$ 1,900	15	11
Checking & Counting Team			
CC Process	Salary	As-Is #	To-Be #
Leader	$ 2,100	1	0
C & C Person	$ 1,750	4	0
Counting			
Duration of Counting (weeks)	2		

Table 7. Salary & Manpower Input Parameters

General Parameters	
# of MSC	1
# of SSC	12
# of Warehouses per MSC	25
# of Depots per SSC	9
# of Door Readers per Warehouse/Depot	2
# of Hand Readers per Warehouse/Depot	2
# of Door Readers Antennas per reader	4
System Life Time (Year)	20
Discount Rate	9.0%
Inflation Rate	7.0%
Construction Time (Year)	4
# of Local Servers per SSC	1
# of Integrator Servers	1
# of label printer per MSC	2
# of label printer per SSC	0

Reduction Goals	
Stock Controller	30.0%
Worker	25.0%
Custodian	40.0%
Misidentification	80.0%
Loss	80.0%

Construction Cost		
PMO Labor Cost (Monthly)	$	6,500
Test Cost per warehouse/depot	$	6,000
Integration Cost to Current System (per Command)	$	600,000
Door Reader Cost	$	50,000
Hand Reader Cost	$	1,000
Antenna	$	1,500
Label Printer	$	2,000
Local Server	$	5,000
Integrator Server	$	10,000

Supply Command Construction Plan		
	SSC	MSC
Year 1	3	1
Year 2	4	0
Year 3	3	0
Year 4	2	0

Expected Tag Prices		
Year 1	$	0.70
Year 2	$	0.60
Year 3	$	0.50
Year 4	$	0.40
Year 5	$	0.35
Year 6	$	0.30
Year 7	$	0.25
Year 8	$	0.20
Year 9	$	0.10
Year10	$	0.05

Operating Cost		
Ordering Cost (per order)	$	500
Holding Cost Rate		12%
System Maintenance per year per command	$	100,000
Review Interval (Days)		5
Inventory on Hand		0
Confidence Level		99%
Rate of Standard Deviation		25%

Lead Time			
Phase	Current System	RFID Integrated Sy	Change Rate
First Phase	4	2	50%
Second Phase	6	2	67%
Third Phase	4	1	75%
Total	14	5	64%

Table 8. Input Parameters

Historical Inventory Data		
Year	**The number of misidentified items**	**The number of lost items**
1979	163	760
1980	254	659
1981	351	636
1982	369	869
1983	354	852
1984	299	648
1985	194	622
1986	320	559
1987	278	865
1988	192	636
1989	154	650
1990	255	771
1991	300	796
1992	326	912
1993	197	829
1994	364	842
1995	560	698
1996	235	708
1997	301	754
1998	408	846
1999	184	803
2000	454	678
2001	290	821
2002	458	797
2003	332	749
2004	259	733
2005	218	820
2006	429	778
2007	485	754
2008	178	667

Table 9. Historical Data

Inventory Info						
Item Av Unit Cost	Misidentification Probability	Loss Probability	Expected Annual Demand		Standard Deviation of daily demand	
			MSC	SSC	MSC	SSC
$ 10,000	0.01	0.005	1,440	120	0.28	0.08
$ 8,000	0.015	0.008	2,880	240	0.57	0.16
$ 6,000	0.02	0.01	3,900	325	0.77	0.22
$ 4,000	0.025	0.02	5,400	450	1.07	0.31
$ 2,000	0.03	0.03	84,000	7000	16.61	4.79
$ 1,000	0.12	0.09	180,000	15000	35.59	10.27
$ 500	0.22	0.22	396,000	33000	78.30	22.60
$ 250	0.26	0.28	576,000	48000	113.89	32.88
$ 100	0.3	0.337	1,182,000	98500	233.71	67.47

Table 10. Inventory Inputs

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX B- VISUAL BASIC CODES USED IN THE MODEL

The authors wrote the following code in the Visual Basic Programming Language and incorporated them into the model they developed by means of a macro in Microsoft Excel. This macro is the crucial element that runs the COO model.

```
Sub simulation()
  '-----------------------------------------------------------------------------------------------------------------------------------------------------------
  'CONTROL THE SSCs AND SOLVE THE CONFLICTS IF EXIST
  year1 = Sheets("DATA&Consilated Results").Range("k5")
  year2 = Sheets("DATA&Consilated Results").Range("k6")
  year3 = Sheets("DATA&Consilated Results").Range("k7")
  year4 = Sheets("DATA&Consilated Results").Range("k8")
  number_ssc = Sheets("DATA&Consilated Results").Range("h5")
  '-----------------------------------------------------------------------------------------------------------------------------------------------------------
  'SOLVE THE CONFLICTS
  If year1 >= number_ssc Then
    Sheets("DATA&Consilated Results").Range("k5") = number_ssc
    year1 = number_ssc
    Sheets("DATA&Consilated Results").Range("k6") = 0
    Sheets("DATA&Consilated Results").Range("k7") = 0
    Sheets("DATA&Consilated Results").Range("k8") = 0
    ElseIf year1 + year2 >= number_ssc Then
      Sheets("DATA&Consilated Results").Range("k6") = number_ssc - year1
      Sheets("DATA&Consilated Results").Range("k7") = 0
      Sheets("DATA&Consilated Results").Range("k8") = 0
      ElseIf year1 + year2 + year3 >= number_ssc Then
        Sheets("DATA&Consilated Results").Range("k7") = number_ssc - year1 - year2
        Sheets("DATA&Consilated Results").Range("k8") = 0
        ElseIf year1 + year2 + year3 + year4 >= number_ssc Then
          Sheets("DATA&Consilated Results").Range("k8") = number_ssc - year1 - year2 - year3
        Else: Sheets("DATA&Consilated Results").Range("k8") = number_ssc - year1 - year2 - year3
  End If
  '-----------------------------------------------------------------------------------------------------------------------------------------------------------
  'DEFINE THE VARIABLES THAT WILL BE USED IN THE MACRO
  lifetime = 0
  Iteration = 10
  '-------------------------------------------------------------------------------------------------------------------
  'GET THE LIFETIME FROM THE USER BY MEANS OF AN INPUT BOX
  str1 = "PLEASE ENTER THE LIFETIME OF THE SYSTEM"
  str2 = "(Life time has to be greater than 4)"
  lifetime = InputBox(str1 & vbCrLf & str2, "Enter the system lifetime", "Please use numbers")
  Sheets("DATA&Consilated Results").Range("h11") = lifetime
  '-------------------------------------------------------------------------------------------------------------------
  'CONTROL THE LIFETIME ENTERED BY THE USER (IF IT IS LESS THAN 4, DO NOTHING
  If lifetime <= 4 Then
    MsgBox "Lifetime has to be greater than 4"
  Else:
  'IF LIFETIME IS GREATER THAN 4 DO THE FOLLOWINGS
  'CLEAR CELLS THAT ARE TO BE RECALCULATED
```

```
Sheets("Totals").Range("G2", "xfd200").ClearContents
Sheets("Totals").Range("G2", "xfd200").Borders.LineStyle = xlNone
Sheets("Totals").Range("G2", "xfd200").Interior.ColorIndex = xlNone
Sheets("Maintenance_RFID").Range("G2", "xfd200").ClearContents
Sheets("Maintenance_RFID").Range("G2", "xfd200").Borders.LineStyle = xlNone
Sheets("Maintenance_RFID").Range("G2", "xfd200").Interior.ColorIndex = xlNone
Sheets("Tag Purchase Cost").Range("G1", "xfd12").ClearContents
Sheets("Tag Purchase Cost").Range("G1", "xfd12").Borders.LineStyle = xlNone
Sheets("Tag Purchase Cost").Range("G1", "xfd12").Interior.ColorIndex = xlNone
Sheets("Inventory_Current").Range("G27", "xfd200").ClearContents
Sheets("Inventory_Current").Range("G27", "xfd200").Borders.LineStyle = xlNone
Sheets("Inventory_Current").Range("G27", "xfd200").Interior.ColorIndex = xlNone
Sheets("Inventory_RFID").Range("G27", "xfd200").ClearContents
Sheets("Inventory_RFID").Range("G27", "xfd200").Borders.LineStyle = xlNone
Sheets("Inventory_RFID").Range("G27", "xfd200").Interior.ColorIndex = xlNone
Sheets("Misidentification Cost").Range("I6", "xfd500").ClearContents
Sheets("Misidentification Cost").Range("I6", "xfd500").Borders.LineStyle = xlNone
Sheets("Misidentification Cost").Range("I6", "xfd500").Interior.ColorIndex = xlNone
Sheets("Loss Cost").Range("I6", "xfd500").ClearContents
Sheets("Loss Cost").Range("I6", "xfd500").Borders.LineStyle = xlNone
Sheets("Loss Cost").Range("I6", "xfd500").Interior.ColorIndex = xlNone
Sheets("Labor Cost_Current").Range("f32", "xfd200").ClearContents
Sheets("Labor Cost_Current").Range("f32", "xfd200").Borders.LineStyle = xlNone
Sheets("Labor Cost_Current").Range("f32", "xfd200").Interior.ColorIndex = xlNone
Sheets("Labor Cost_RFID").Range("f32", "xfd200").ClearContents
Sheets("Labor Cost_RFID").Range("f32", "xfd200").Borders.LineStyle = xlNone
Sheets("Labor Cost_RFID").Range("f32", "xfd200").Interior.ColorIndex = xlNone
'-----------------------------------------------------------------------------------------------------------------------------------------------------------------------
'WORK ON THE MAINTENANCE_RFID WORKSHEET
related_year = 5
related_date = 2014
Related_column = 7
For i = 5 To lifetime
   Sheets("Maintenance_RFID").Cells(2, Related_column) = related_year
   Sheets("Maintenance_RFID").Cells(2, Related_column).Interior.ColorIndex = 36
   Sheets("Maintenance_RFID").Cells(2, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
   Sheets("Maintenance_RFID").Cells(3, Related_column) = related_date
   Sheets("Maintenance_RFID").Cells(3, Related_column).Interior.ColorIndex = 36
   Sheets("Maintenance_RFID").Cells(3, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
   Sheets("Maintenance_RFID").Cells(5, Related_column).FormulaR1C1 = Sheets("Maintenance_RFID").Cells(5, 6).FormulaR1C1
   Sheets("Maintenance_RFID").Cells(5, Related_column).Interior.ColorIndex = 36
   Sheets("Maintenance_RFID").Cells(5, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
   Sheets("Maintenance_RFID").Cells(6, Related_column).FormulaR1C1 = Sheets("Maintenance_RFID").Cells(6, 6).FormulaR1C1
   Sheets("Maintenance_RFID").Cells(6, Related_column).Interior.ColorIndex = 36
   Sheets("Maintenance_RFID").Cells(6, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
```

```
        Sheets("Maintenance_RFID").Cells(7, Related_column).FormulaR1C1 = Sheets("Maintenance_RFID").Cells(7, 6).FormulaR1C1
        Sheets("Maintenance_RFID").Cells(7, Related_column).Interior.ColorIndex = 36
        Sheets("Maintenance_RFID").Cells(7, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Maintenance_RFID").Cells(10, Related_column).FormulaR1C1 = Sheets("Maintenance_RFID").Cells(10, 6).FormulaR1C1
        Sheets("Maintenance_RFID").Cells(10, Related_column).Interior.ColorIndex = 36
        Sheets("Maintenance_RFID").Cells(10, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Maintenance_RFID").Cells(11, Related_column).FormulaR1C1 = Sheets("Maintenance_RFID").Cells(11, 6).FormulaR1C1
        Sheets("Maintenance_RFID").Cells(11, Related_column).Interior.ColorIndex = 36
        Sheets("Maintenance_RFID").Cells(11, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Maintenance_RFID").Cells(12, Related_column).FormulaR1C1 = Sheets("Maintenance_RFID").Cells(12, 6).FormulaR1C1
        Sheets("Maintenance_RFID").Cells(12, Related_column).Interior.ColorIndex = 36
        Sheets("Maintenance_RFID").Cells(12, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Maintenance_RFID").Cells(13, Related_column).FormulaR1C1 = Sheets("Maintenance_RFID").Cells(13, 6).FormulaR1C1
        Sheets("Maintenance_RFID").Cells(13, Related_column).Interior.ColorIndex = 36
        Sheets("Maintenance_RFID").Cells(13, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Maintenance_RFID").Cells(14, Related_column).FormulaR1C1 = Sheets("Maintenance_RFID").Cells(14, 6).FormulaR1C1
        Sheets("Maintenance_RFID").Cells(14, Related_column).Interior.ColorIndex = 36
        Sheets("Maintenance_RFID").Cells(14, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Maintenance_RFID").Cells(15, Related_column).FormulaR1C1 = Sheets("Maintenance_RFID").Cells(15, 6).FormulaR1C1
        Sheets("Maintenance_RFID").Cells(15, Related_column).Interior.ColorIndex = 36
        Sheets("Maintenance_RFID").Cells(15, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Maintenance_RFID").Cells(16, Related_column).FormulaR1C1 = Sheets("Maintenance_RFID").Cells(16, 6).FormulaR1C1
        Sheets("Maintenance_RFID").Cells(16, Related_column).Interior.ColorIndex = 36
        Sheets("Maintenance_RFID").Cells(16, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Maintenance_RFID").Cells(17, Related_column).FormulaR1C1 = Sheets("Maintenance_RFID").Cells(17, 6).FormulaR1C1
        Sheets("Maintenance_RFID").Cells(17, Related_column).Interior.ColorIndex = 36
        Sheets("Maintenance_RFID").Cells(17, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Maintenance_RFID").Cells(19, Related_column).FormulaR1C1 = Sheets("Maintenance_RFID").Cells(19, 6).FormulaR1C1
        Sheets("Maintenance_RFID").Cells(19, Related_column).Interior.ColorIndex = 36
        Sheets("Maintenance_RFID").Cells(19, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        related_year = related_year + 1
        related_date = related_date + 1
        Related_column = Related_column + 1
    Next i
    Sheets("Maintenance_RFID").Cells(3, Related_column).Value = "TOTAL"
    Sheets("Maintenance_RFID").Cells(3, Related_column).Interior.ColorIndex = 36
    Sheets("Maintenance_RFID").Cells(3, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    '-----------------------------------------------------------------------------------------------------------------------------------------------------------
    'WORK ON THE TAG PURCHASE COST WOKRSHEET
    related_year = 5
    related_date = 2014
    Related_column = 7
    If lifetime <= 10 Then
        For i = 5 To lifetime
            Formula2 = "=Cost_Tag_Year_" & i & "*SUM('DATA&Consilated Results'!$R$5:$R$13)*Number_MSC"
```

```
        Sheets("Tag Purchase Cost").Cells(2, Related_column) = related_year
        Sheets("Tag Purchase Cost").Cells(2, Related_column).Interior.ColorIndex = 36
        Sheets("Tag Purchase Cost").Cells(2, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Tag Purchase Cost").Cells(3, Related_column) = related_date
        Sheets("Tag Purchase Cost").Cells(3, Related_column).Interior.ColorIndex = 36
        Sheets("Tag Purchase Cost").Cells(3, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Tag Purchase Cost").Cells(5, Related_column).Formula = Formula2
        Sheets("Tag Purchase Cost").Cells(5, Related_column).Interior.ColorIndex = 36
        Sheets("Tag Purchase Cost").Cells(5, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Tag Purchase Cost").Cells(6, Related_column).FormulaR1C1 = Sheets("Tag Purchase Cost").Cells(6, 6).FormulaR1C1
        Sheets("Tag Purchase Cost").Cells(6, Related_column).Interior.ColorIndex = 36
        Sheets("Tag Purchase Cost").Cells(6, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Tag Purchase Cost").Cells(7, Related_column).FormulaR1C1 = Sheets("Tag Purchase Cost").Cells(7, 6).FormulaR1C1
        Sheets("Tag Purchase Cost").Cells(7, Related_column).Interior.ColorIndex = 36
        Sheets("Tag Purchase Cost").Cells(7, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        related_year = related_year + 1
        related_date = related_date + 1
        Related_column = Related_column + 1
    Next i
 Else:
    For i = 5 To 10
        Formula2 = "=Cost_Tag_Year_" & i & "*SUM('DATA&Consilated Results'!$R$5:$R$13)*Number_MSC"
        Sheets("Tag Purchase Cost").Cells(2, Related_column) = related_year
        Sheets("Tag Purchase Cost").Cells(2, Related_column).Interior.ColorIndex = 36
        Sheets("Tag Purchase Cost").Cells(2, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Tag Purchase Cost").Cells(3, Related_column) = related_date
        Sheets("Tag Purchase Cost").Cells(3, Related_column).Interior.ColorIndex = 36
        Sheets("Tag Purchase Cost").Cells(3, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Tag Purchase Cost").Cells(5, Related_column).Formula = Formula2
        Sheets("Tag Purchase Cost").Cells(5, Related_column).Interior.ColorIndex = 36
        Sheets("Tag Purchase Cost").Cells(5, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Tag Purchase Cost").Cells(6, Related_column).FormulaR1C1 = Sheets("Tag Purchase Cost").Cells(6, 6).FormulaR1C1
        Sheets("Tag Purchase Cost").Cells(6, Related_column).Interior.ColorIndex = 36
        Sheets("Tag Purchase Cost").Cells(6, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Tag Purchase Cost").Cells(7, Related_column).FormulaR1C1 = Sheets("Tag Purchase Cost").Cells(7, 6).FormulaR1C1
        Sheets("Tag Purchase Cost").Cells(7, Related_column).Interior.ColorIndex = 36
        Sheets("Tag Purchase Cost").Cells(7, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        related_year = related_year + 1
        related_date = related_date + 1
        Related_column = Related_column + 1
    Next i
End If
Sheets("Maintenance_RFID").Cells(3, Related_column).Value = "TOTAL"
Sheets("Maintenance_RFID").Cells(3, Related_column).Interior.ColorIndex = 36
Sheets("Maintenance_RFID").Cells(3, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
```

```
'------------------------------------------------------------------------------------------------------------------------------------------------------------------------
'WORK ON INVENTORY_CURRENT WORKSHEET
related_year = 5
related_date = 2014
Related_column = 7
For i = 5 To lifetime
    Sheets("Inventory_Current").Cells(27, Related_column) = related_year
    Sheets("Inventory_Current").Cells(27, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_Current").Cells(27, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_Current").Cells(28, Related_column) = related_date
    Sheets("Inventory_Current").Cells(28, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_Current").Cells(28, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_Current").Cells(30, Related_column).FormulaR1C1 = Sheets("Inventory_Current").Cells(30, 6).FormulaR1C1
    Sheets("Inventory_Current").Cells(30, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_Current").Cells(30, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_Current").Cells(31, Related_column).FormulaR1C1 = Sheets("Inventory_Current").Cells(31, 6).FormulaR1C1
    Sheets("Inventory_Current").Cells(31, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_Current").Cells(31, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_Current").Cells(32, Related_column).FormulaR1C1 = Sheets("Inventory_Current").Cells(32, 6).FormulaR1C1
    Sheets("Inventory_Current").Cells(32, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_Current").Cells(32, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_Current").Cells(35, Related_column).FormulaR1C1 = Sheets("Inventory_Current").Cells(35, 6).FormulaR1C1
    Sheets("Inventory_Current").Cells(35, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_Current").Cells(35, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_Current").Cells(36, Related_column).FormulaR1C1 = Sheets("Inventory_Current").Cells(36, 6).FormulaR1C1
    Sheets("Inventory_Current").Cells(36, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_Current").Cells(36, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_Current").Cells(37, Related_column).FormulaR1C1 = Sheets("Inventory_Current").Cells(37, 6).FormulaR1C1
    Sheets("Inventory_Current").Cells(37, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_Current").Cells(37, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_Current").Cells(38, Related_column).FormulaR1C1 = Sheets("Inventory_Current").Cells(38, 6).FormulaR1C1
    Sheets("Inventory_Current").Cells(38, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_Current").Cells(38, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_Current").Cells(40, Related_column).FormulaR1C1 = Sheets("Inventory_Current").Cells(40, 6).FormulaR1C1
    Sheets("Inventory_Current").Cells(40, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_Current").Cells(40, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    related_year = related_year + 1
    related_date = related_date + 1
    Related_column = Related_column + 1
Next i
'------------------------------------------------------------------------------------------------------------------------------------------------------------------------
'WORK ON THE INVENTORY_RFID WORKSHEET
related_year = 5
related_date = 2014
Related_column = 7
```

```
For i = 5 To lifetime
    Sheets("Inventory_RFID").Cells(27, Related_column) = related_year
    Sheets("Inventory_RFID").Cells(27, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_RFID").Cells(27, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_RFID").Cells(28, Related_column) = related_date
    Sheets("Inventory_RFID").Cells(28, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_RFID").Cells(28, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_RFID").Cells(30, Related_column).FormulaR1C1 = Sheets("Inventory_RFID").Cells(30, 6).FormulaR1C1
    Sheets("Inventory_RFID").Cells(30, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_RFID").Cells(30, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_RFID").Cells(31, Related_column).FormulaR1C1 = Sheets("Inventory_RFID").Cells(31, 6).FormulaR1C1
    Sheets("Inventory_RFID").Cells(31, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_RFID").Cells(31, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_RFID").Cells(32, Related_column).FormulaR1C1 = Sheets("Inventory_RFID").Cells(32, 6).FormulaR1C1
    Sheets("Inventory_RFID").Cells(32, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_RFID").Cells(32, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_RFID").Cells(35, Related_column).FormulaR1C1 = Sheets("Inventory_RFID").Cells(35, 6).FormulaR1C1
    Sheets("Inventory_RFID").Cells(35, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_RFID").Cells(35, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_RFID").Cells(36, Related_column).FormulaR1C1 = Sheets("Inventory_RFID").Cells(36, 6).FormulaR1C1
    Sheets("Inventory_RFID").Cells(36, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_RFID").Cells(36, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_RFID").Cells(37, Related_column).FormulaR1C1 = Sheets("Inventory_RFID").Cells(37, 6).FormulaR1C1
    Sheets("Inventory_RFID").Cells(37, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_RFID").Cells(37, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_RFID").Cells(38, Related_column).FormulaR1C1 = Sheets("Inventory_RFID").Cells(38, 6).FormulaR1C1
    Sheets("Inventory_RFID").Cells(38, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_RFID").Cells(38, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_RFID").Cells(39, Related_column).FormulaR1C1 = Sheets("Inventory_RFID").Cells(39, 6).FormulaR1C1
    Sheets("Inventory_RFID").Cells(39, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_RFID").Cells(39, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_RFID").Cells(40, Related_column).FormulaR1C1 = Sheets("Inventory_RFID").Cells(40, 6).FormulaR1C1
    Sheets("Inventory_RFID").Cells(40, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_RFID").Cells(40, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_RFID").Cells(41, Related_column).FormulaR1C1 = Sheets("Inventory_RFID").Cells(41, 6).FormulaR1C1
    Sheets("Inventory_RFID").Cells(41, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_RFID").Cells(41, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_RFID").Cells(42, Related_column).FormulaR1C1 = Sheets("Inventory_RFID").Cells(42, 6).FormulaR1C1
    Sheets("Inventory_RFID").Cells(42, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_RFID").Cells(42, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Inventory_RFID").Cells(44, Related_column).FormulaR1C1 = Sheets("Inventory_RFID").Cells(44, 6).FormulaR1C1
    Sheets("Inventory_RFID").Cells(44, Related_column).Interior.ColorIndex = 36
    Sheets("Inventory_RFID").Cells(44, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    related_year = related_year + 1
    related_date = related_date + 1
```

```
        Related_column = Related_column + 1
    Next i
    '---------------------------------------------------------------------------------------------------------------------------------------------------------------------
    'WORK ON MISIDENTIFICATION COST WORKSHEET
    Sheets("Misidentification Cost").Range("r2", "r33").ClearContents
    Sheets("Misidentification Cost").Range("r2", "r33").Borders.LineStyle = xlNone
    Sheets("Misidentification Cost").Range("s1", "xfd33").ClearContents
    Sheets("Misidentification Cost").Range("s1", "xfd33").Borders.LineStyle = xlNone
    Sheets("Misidentification Cost").Range("i6", "q500").ClearContents
    related_year = 5
    related_date = 2014
    Related_column = 9
    related_row = 6
    For i = 5 To lifetime
        Sheets("Misidentification Cost").Cells(related_row, Related_column) = related_year
        Sheets("Misidentification Cost").Cells(related_row, Related_column).Interior.ColorIndex = 36
        Sheets("Misidentification Cost").Cells(related_row, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        related_row = related_row + 1
        related_year = related_year + 1
    Next i
    Related_column = 10
    related_row = 6
    For i = 5 To lifetime
        Sheets("Misidentification Cost").Cells(related_row, Related_column) = related_date
        Sheets("Misidentification Cost").Cells(related_row, Related_column).Interior.ColorIndex = 36
        Sheets("Misidentification Cost").Cells(related_row, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        related_row = related_row + 1
        related_date = related_date + 1
    Next i
    related_row = 6
    Related_column = 13
    For i = 5 To lifetime
        Sheets("Misidentification Cost").Cells(related_row, Related_column).FormulaR1C1 = Sheets("Misidentification Cost").Cells(5, Related_column).FormulaR1C1
        Sheets("Misidentification Cost").Cells(related_row, Related_column).Interior.ColorIndex = 36
        Sheets("Misidentification Cost").Cells(related_row, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Misidentification Cost").Cells(related_row, Related_column + 1).FormulaR1C1 = Sheets("Misidentification Cost").Cells(5, Related_column + 1).FormulaR1C1
        Sheets("Misidentification Cost").Cells(related_row, Related_column + 1).Interior.ColorIndex = 36
        Sheets("Misidentification Cost").Cells(related_row, Related_column + 1).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Misidentification Cost").Cells(related_row, Related_column + 2).FormulaR1C1 = Sheets("Misidentification Cost").Cells(5, Related_column + 2).FormulaR1C1
        Sheets("Misidentification Cost").Cells(related_row, Related_column + 2).Interior.ColorIndex = 36
        Sheets("Misidentification Cost").Cells(related_row, Related_column + 2).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Misidentification Cost").Cells(related_row, Related_column + 3).FormulaR1C1 = Sheets("Misidentification Cost").Cells(5, Related_column + 3).FormulaR1C1
        Sheets("Misidentification Cost").Cells(related_row, Related_column + 3).Interior.ColorIndex = 36
```

```
            Sheets("Misidentification Cost").Cells(related_row, Related_column + 3).BorderAround ColorIndex:=1, Weight:=xlThin
            Sheets("Misidentification Cost").Cells(related_row, Related_column + 4).FormulaR1C1 = Sheets("Misidentification Cost").Cells(5, Related_column + 4).FormulaR1C1
            Sheets("Misidentification Cost").Cells(related_row, Related_column + 4).Interior.ColorIndex = 36
            Sheets("Misidentification Cost").Cells(related_row, Related_column + 4).BorderAround ColorIndex:=1, Weight:=xlThin
            related_row = related_row + 1
        Next i
        Related_column = 18
        sira = 1
        For Count = 1 To Iteration
            Related_column = Related_column + 1
            Sheets("Misidentification Cost").Cells(sira, Related_column) = Count & ". iteration"
            Sheets("Misidentification Cost").Cells(sira, Related_column).BorderAround ColorIndex:=3, Weight:=xlThick
            For related_row = 2 To lifetime + 1
                Sheets("Misidentification Cost").Range("K" & related_row) = Application.WorksheetFunction.Max (Application.WorksheetFunction.NormInv (Rnd, Sheets("Misidentification Cost").Range("e15"), Sheets("Misidentification Cost").Range("e16")))
                Sheets("Misidentification Cost").Range("K" & related_row).Interior.ColorIndex = 36
                Sheets("Misidentification Cost").Range("K" & related_row).BorderAround ColorIndex:=1, Weight:=xlThin
            Next related_row
            For related_row = 2 To lifetime + 1
                misidentified = Sheets("Misidentification Cost").Range("k" & related_row)
                fiyat_toplam = 0
                    For dongu = 1 To misidentified
                        fiyat = Application.WorksheetFunction.Lookup(Rnd, Sheets("Misidentification Cost").Range("F3:F11"), Sheets ("Misidentification Cost").Range("D3:D11"))
                        fiyat_toplam = fiyat_toplam + fiyat
                    Next dongu
                fiyat_average = fiyat_toplam / misidentified
                Sheets("Misidentification Cost").Range("L" & related_row) = fiyat_average
                Sheets("Misidentification Cost").Range("L" & related_row).Interior.ColorIndex = 36
                Sheets("Misidentification Cost").Range("L" & related_row).BorderAround ColorIndex:=1, Weight:=xlThin
                Sheets("Misidentification Cost").Cells(related_row, Related_column) = Sheets("Misidentification Cost").Range("q" & related_row)
                Sheets("Misidentification Cost").Cells(related_row, Related_column).BorderAround ColorIndex:=3, Weight:=xlThick
            Next related_row
        Next Count
        Related_column = 18
        For related_row = 2 To lifetime + 1
            Sheets("Misidentification Cost").Cells(related_row, Related_column) = Application.WorksheetFunction.Sum(Sheets("Misidentification Cost").Range("S" & related_row, "xfd" & related_row)) / Iteration
            Sheets("Misidentification Cost").Cells(related_row, Related_column).BorderAround ColorIndex:=3, Weight:=xlThick
        Next related_row
        '--------------------------------------------------------------------------------------------------------------------------------------------------------------------
        ' WORK ON LOSS COST WORKSHEET
        Sheets("Loss Cost").Range("p2", "p33").ClearContents
        Sheets("Loss Cost").Range("p2", "p33").Borders.LineStyle = xlNone
        Sheets("Loss Cost").Range("q1", "xfd33").ClearContents
        Sheets("Loss Cost").Range("q1", "xfd33").Borders.LineStyle = xlNone
```

```
        Sheets("Loss Cost").Range("i6", "o500").ClearContents
        related_year = 5
        related_date = 2014
        Related_column = 9
        related_row = 6
        For i = 5 To lifetime
            Sheets("Loss Cost").Cells(related_row, Related_column) = related_year
            Sheets("Loss Cost").Cells(related_row, Related_column).Interior.ColorIndex = 36
            Sheets("Loss Cost").Cells(related_row, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
            related_row = related_row + 1
            related_year = related_year + 1
        Next i
        Related_column = 10
        related_row = 6
        For i = 5 To lifetime
            Sheets("Loss Cost").Cells(related_row, Related_column) = related_date
            Sheets("Loss Cost").Cells(related_row, Related_column).Interior.ColorIndex = 36
            Sheets("Loss Cost").Cells(related_row, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
            related_row = related_row + 1
            related_date = related_date + 1
        Next i
        related_row = 6
        Related_column = 13
        For i = 5 To lifetime
            Sheets("Loss Cost").Cells(related_row, Related_column).FormulaR1C1 = Sheets("Loss Cost").Cells(5, Related_column).FormulaR1C1
            Sheets("Loss Cost").Cells(related_row, Related_column).Interior.ColorIndex = 36
            Sheets("Loss Cost").Cells(related_row, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
            Sheets("Loss Cost").Cells(related_row, Related_column + 1).FormulaR1C1 = Sheets("Loss Cost").Cells(5, Related_column + 1).FormulaR1C1
            Sheets("Loss Cost").Cells(related_row, Related_column + 1).Interior.ColorIndex = 36
            Sheets("Loss Cost").Cells(related_row, Related_column + 1).BorderAround ColorIndex:=1, Weight:=xlThin
            Sheets("Loss Cost").Cells(related_row, Related_column + 2).FormulaR1C1 = Sheets("Loss Cost").Cells(5, Related_column + 2).FormulaR1C1
            Sheets("Loss Cost").Cells(related_row, Related_column + 2).Interior.ColorIndex = 36
            Sheets("Loss Cost").Cells(related_row, Related_column + 2).BorderAround ColorIndex:=1, Weight:=xlThin
            related_row = related_row + 1
        Next i
        Related_column = 16
        sira = 1
        For Count = 1 To Iteration
            Related_column = Related_column + 1
            Sheets("Loss Cost").Cells(sira, Related_column) = Count & ". iteration"
            Sheets("Loss Cost").Cells(sira, Related_column).BorderAround ColorIndex:=3, Weight:=xlThick
            For related_row = 2 To lifetime + 1
                Sheets("Loss Cost").Range("K" & related_row) = Application.WorksheetFunction.Max(Application.WorksheetFunction.NormInv(Rnd, Sheets("Loss Cost").Range("e15"), Sheets("Loss Cost").Range("e16")))
```

```
          Sheets("Loss Cost").Range("K" & related_row).Interior.ColorIndex = 36
          Sheets("Loss Cost").Range("K" & related_row).BorderAround ColorIndex:=1, Weight:=xlThin
        Next related_row
        For related_row = 2 To lifetime + 1
          misidentified = Sheets("Loss Cost").Range("k" & related_row)
          fiyat_toplam = 0
            For dongu = 1 To misidentified
              fiyat = Application.WorksheetFunction.Lookup(Rnd, Sheets("Loss Cost").Range("F3:F11"), Sheets("Loss Cost").Range("D3:D11"))
              fiyat_toplam = fiyat_toplam + fiyat
            Next dongu
          fiyat_average = fiyat_toplam / misidentified
          Sheets("Loss Cost").Range("L" & related_row) = fiyat_average
          Sheets("Loss Cost").Range("L" & related_row).Interior.ColorIndex = 36
          Sheets("Loss Cost").Range("L" & related_row).BorderAround ColorIndex:=1, Weight:=xlThin
          Sheets("Loss Cost").Cells(related_row, Related_column) = Sheets("Loss Cost").Range("o" & related_row)
          Sheets("Loss Cost").Cells(related_row, Related_column).BorderAround ColorIndex:=3, Weight:=xlThick
        Next related_row
      Next Count
      Related_column = 16
      For related_row = 2 To lifetime + 1
        Sheets("Loss Cost").Cells(related_row, Related_column) = Application.WorksheetFunction.Sum(Sheets("Loss Cost").Range("q" & related_row, "xfd" & related_row)) / Iteration
        Sheets("Loss Cost").Cells(related_row, Related_column).BorderAround ColorIndex:=3, Weight:=xlThick
      Next related_row
      '--------------------------------------------------------------------------------------------------------------------------------------------------------------
      'WORK ON LABOR COST_CURRENT WORKSHEET
      related_year = 5
      related_date = 2014
      Related_column = 6
      For i = 5 To lifetime
        Sheets("Labor Cost_Current").Cells(32, Related_column) = related_year
        Sheets("Labor Cost_Current").Cells(32, Related_column).Interior.ColorIndex = 36
        Sheets("Labor Cost_Current").Cells(32, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Labor Cost_Current").Cells(33, Related_column) = related_date
        Sheets("Labor Cost_Current").Cells(33, Related_column).Interior.ColorIndex = 36
        Sheets("Labor Cost_Current").Cells(33, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Labor Cost_Current").Cells(35, Related_column).FormulaR1C1 = Sheets("Labor Cost_Current").Cells(35, 5).FormulaR1C1
        Sheets("Labor Cost_Current").Cells(35, Related_column).Interior.ColorIndex = 36
        Sheets("Labor Cost_Current").Cells(35, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Labor Cost_Current").Cells(36, Related_column).FormulaR1C1 = Sheets("Labor Cost_Current").Cells(36, 5).FormulaR1C1
        Sheets("Labor Cost_Current").Cells(36, Related_column).Interior.ColorIndex = 36
        Sheets("Labor Cost_Current").Cells(36, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Labor Cost_Current").Cells(37, Related_column).FormulaR1C1 = Sheets("Labor Cost_Current").Cells(37, 5).FormulaR1C1
        Sheets("Labor Cost_Current").Cells(37, Related_column).Interior.ColorIndex = 36
        Sheets("Labor Cost_Current").Cells(37, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
```

```
    Sheets("Labor Cost_Current").Cells(40, Related_column).FormulaR1C1 = Sheets("Labor Cost_Current").Cells(40, 5).FormulaR1C1
    Sheets("Labor Cost_Current").Cells(40, Related_column).Interior.ColorIndex = 36
    Sheets("Labor Cost_Current").Cells(40, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Labor Cost_Current").Cells(41, Related_column).FormulaR1C1 = Sheets("Labor Cost_Current").Cells(41, 5).FormulaR1C1
    Sheets("Labor Cost_Current").Cells(41, Related_column).Interior.ColorIndex = 36
    Sheets("Labor Cost_Current").Cells(41, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Labor Cost_Current").Cells(42, Related_column).FormulaR1C1 = Sheets("Labor Cost_Current").Cells(42, 5).FormulaR1C1
    Sheets("Labor Cost_Current").Cells(42, Related_column).Interior.ColorIndex = 36
    Sheets("Labor Cost_Current").Cells(42, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Labor Cost_Current").Cells(43, Related_column).FormulaR1C1 = Sheets("Labor Cost_Current").Cells(43, 5).FormulaR1C1
    Sheets("Labor Cost_Current").Cells(43, Related_column).Interior.ColorIndex = 36
    Sheets("Labor Cost_Current").Cells(43, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Labor Cost_Current").Cells(45, Related_column).FormulaR1C1 = Sheets("Labor Cost_Current").Cells(45, 5).FormulaR1C1
    Sheets("Labor Cost_Current").Cells(45, Related_column).Interior.ColorIndex = 36
    Sheets("Labor Cost_Current").Cells(45, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    related_year = related_year + 1
    related_date = related_date + 1
    Related_column = Related_column + 1
Next i
'--------------------------------------------------------------------------------------------------------------------------------------------------------------------------
'WORK ON LABOR COST_RFID WORKSHEET
related_year = 5
related_date = 2014
Related_column = 6
For i = 5 To lifetime
    Sheets("Labor Cost_RFID").Cells(32, Related_column) = related_year
    Sheets("Labor Cost_RFID").Cells(32, Related_column).Interior.ColorIndex = 36
    Sheets("Labor Cost_RFID").Cells(32, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Labor Cost_RFID").Cells(33, Related_column) = related_date
    Sheets("Labor Cost_RFID").Cells(33, Related_column).Interior.ColorIndex = 36
    Sheets("Labor Cost_RFID").Cells(33, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Labor Cost_RFID").Cells(35, Related_column).FormulaR1C1 = Sheets("Labor Cost_RFID").Cells(35, 5).FormulaR1C1
    Sheets("Labor Cost_RFID").Cells(35, Related_column).Interior.ColorIndex = 36
    Sheets("Labor Cost_RFID").Cells(35, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Labor Cost_RFID").Cells(36, Related_column).FormulaR1C1 = Sheets("Labor Cost_RFID").Cells(36, 5).FormulaR1C1
    Sheets("Labor Cost_RFID").Cells(36, Related_column).Interior.ColorIndex = 36
    Sheets("Labor Cost_RFID").Cells(36, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Labor Cost_RFID").Cells(37, Related_column).FormulaR1C1 = Sheets("Labor Cost_RFID").Cells(37, 5).FormulaR1C1
    Sheets("Labor Cost_RFID").Cells(37, Related_column).Interior.ColorIndex = 36
    Sheets("Labor Cost_RFID").Cells(37, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Labor Cost_RFID").Cells(40, Related_column).FormulaR1C1 = Sheets("Labor Cost_RFID").Cells(40, 5).FormulaR1C1
    Sheets("Labor Cost_RFID").Cells(40, Related_column).Interior.ColorIndex = 36
    Sheets("Labor Cost_RFID").Cells(40, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Labor Cost_RFID").Cells(41, Related_column).FormulaR1C1 = Sheets("Labor Cost_RFID").Cells(41, 5).FormulaR1C1
    Sheets("Labor Cost_RFID").Cells(41, Related_column).Interior.ColorIndex = 36
```

```
    Sheets("Labor Cost_RFID").Cells(41, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Labor Cost_RFID").Cells(42, Related_column).FormulaR1C1 = Sheets("Labor Cost_RFID").Cells(42, 5).FormulaR1C1
    Sheets("Labor Cost_RFID").Cells(42, Related_column).Interior.ColorIndex = 36
    Sheets("Labor Cost_RFID").Cells(42, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Labor Cost_RFID").Cells(43, Related_column).FormulaR1C1 = Sheets("Labor Cost_RFID").Cells(43, 5).FormulaR1C1
    Sheets("Labor Cost_RFID").Cells(43, Related_column).Interior.ColorIndex = 36
    Sheets("Labor Cost_RFID").Cells(43, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Labor Cost_RFID").Cells(44, Related_column).FormulaR1C1 = Sheets("Labor Cost_RFID").Cells(44, 5).FormulaR1C1
    Sheets("Labor Cost_RFID").Cells(44, Related_column).Interior.ColorIndex = 36
    Sheets("Labor Cost_RFID").Cells(44, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Labor Cost_RFID").Cells(45, Related_column).FormulaR1C1 = Sheets("Labor Cost_RFID").Cells(45, 5).FormulaR1C1
    Sheets("Labor Cost_RFID").Cells(45, Related_column).Interior.ColorIndex = 36
    Sheets("Labor Cost_RFID").Cells(45, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Labor Cost_RFID").Cells(46, Related_column).FormulaR1C1 = Sheets("Labor Cost_RFID").Cells(46, 5).FormulaR1C1
    Sheets("Labor Cost_RFID").Cells(46, Related_column).Interior.ColorIndex = 36
    Sheets("Labor Cost_RFID").Cells(46, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Labor Cost_RFID").Cells(47, Related_column).FormulaR1C1 = Sheets("Labor Cost_RFID").Cells(47, 5).FormulaR1C1
    Sheets("Labor Cost_RFID").Cells(47, Related_column).Interior.ColorIndex = 36
    Sheets("Labor Cost_RFID").Cells(47, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Labor Cost_RFID").Cells(49, Related_column).FormulaR1C1 = Sheets("Labor Cost_RFID").Cells(49, 5).FormulaR1C1
    Sheets("Labor Cost_RFID").Cells(49, Related_column).Interior.ColorIndex = 36
    Sheets("Labor Cost_RFID").Cells(49, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    related_year = related_year + 1
    related_date = related_date + 1
    Related_column = Related_column + 1
Next i
'-----------------------------------------------------------------------------------------------------------------------------------------------------------
'WORK ON TOTALS WORKSHEET
related_year = 5
related_date = 2014
Related_column = 7
For i = 5 To lifetime
    Sheets("Totals").Cells(2, Related_column) = related_year
    Sheets("Totals").Cells(2, Related_column).Interior.ColorIndex = 36
    Sheets("Totals").Cells(2, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Totals").Cells(3, Related_column) = related_date
    Sheets("Totals").Cells(3, Related_column).Interior.ColorIndex = 36
    Sheets("Totals").Cells(3, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Totals").Cells(4, Related_column).FormulaR1C1 = Sheets("Totals").Cells(4, 6).FormulaR1C1
    Sheets("Totals").Cells(4, Related_column).Interior.ColorIndex = 36
    Sheets("Totals").Cells(4, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Totals").Cells(5, Related_column).FormulaR1C1 = Sheets("Totals").Cells(5, 6).FormulaR1C1
    Sheets("Totals").Cells(5, Related_column).Interior.ColorIndex = 36
    Sheets("Totals").Cells(5, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
    Sheets("Totals").Cells(6, Related_column).FormulaR1C1 = Sheets("Totals").Cells(6, 6).FormulaR1C1
```

```
Sheets("Totals").Cells(6, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(6, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(7, Related_column).FormulaR1C1 = Sheets("Totals").Cells(7, 6).FormulaR1C1
Sheets("Totals").Cells(7, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(7, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(8, Related_column).FormulaR1C1 = Sheets("Totals").Cells(8, 6).FormulaR1C1
Sheets("Totals").Cells(8, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(8, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(9, Related_column).FormulaR1C1 = Sheets("Totals").Cells(9, 6).FormulaR1C1
Sheets("Totals").Cells(9, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(9, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(10, Related_column).FormulaR1C1 = Sheets("Totals").Cells(10, 6).FormulaR1C1
Sheets("Totals").Cells(10, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(10, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Formula1 = "='Misidentification Cost'!R" & i + 1
Sheets("Totals").Cells(11, Related_column).Formula = Formula1
Sheets("Totals").Cells(11, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(11, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Formula2 = "='Loss Cost'!P" & i + 1
Sheets("Totals").Cells(12, Related_column).Formula = Formula2
Sheets("Totals").Cells(12, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(12, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(13, Related_column).FormulaR1C1 = Sheets("Totals").Cells(13, 6).FormulaR1C1
Sheets("Totals").Cells(13, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(13, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(18, Related_column) = related_year
Sheets("Totals").Cells(18, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(18, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(19, Related_column) = related_date
Sheets("Totals").Cells(19, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(19, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(20, Related_column).FormulaR1C1 = 0
Sheets("Totals").Cells(20, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(20, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(21, Related_column).FormulaR1C1 = Sheets("Totals").Cells(21, 6).FormulaR1C1
Sheets("Totals").Cells(21, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(21, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(22, Related_column).FormulaR1C1 = Sheets("Totals").Cells(22, 6).FormulaR1C1
Sheets("Totals").Cells(22, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(22, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(23, Related_column).FormulaR1C1 = Sheets("Totals").Cells(23, 6).FormulaR1C1
Sheets("Totals").Cells(23, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(23, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(24, Related_column).FormulaR1C1 = Sheets("Totals").Cells(24, 6).FormulaR1C1
Sheets("Totals").Cells(24, Related_column).Interior.ColorIndex = 36
```

```
Sheets("Totals").Cells(24, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(25, Related_column).FormulaR1C1 = Sheets("Totals").Cells(25, 6).FormulaR1C1
Sheets("Totals").Cells(25, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(25, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(26, Related_column).FormulaR1C1 = Sheets("Totals").Cells(26, 6).FormulaR1C1
Sheets("Totals").Cells(26, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(26, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(27, Related_column).FormulaR1C1 = Sheets("Totals").Cells(27, 6).FormulaR1C1
Sheets("Totals").Cells(27, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(27, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(28, Related_column).FormulaR1C1 = Sheets("Totals").Cells(28, 6).FormulaR1C1
Sheets("Totals").Cells(28, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(28, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(29, Related_column).FormulaR1C1 = Sheets("Totals").Cells(29, 6).FormulaR1C1
Sheets("Totals").Cells(29, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(29, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(34, Related_column) = related_year
Sheets("Totals").Cells(34, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(34, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(35, Related_column) = related_date
Sheets("Totals").Cells(35, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(35, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(36, Related_column).FormulaR1C1 = Sheets("Totals").Cells(36, 6).FormulaR1C1
Sheets("Totals").Cells(36, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(36, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(37, Related_column).FormulaR1C1 = Sheets("Totals").Cells(37, 6).FormulaR1C1
Sheets("Totals").Cells(37, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(37, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(38, Related_column).FormulaR1C1 = Sheets("Totals").Cells(38, 6).FormulaR1C1
Sheets("Totals").Cells(38, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(38, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(39, Related_column).FormulaR1C1 = Sheets("Totals").Cells(39, 6).FormulaR1C1
Sheets("Totals").Cells(39, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(39, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(40, Related_column).FormulaR1C1 = Sheets("Totals").Cells(40, 6).FormulaR1C1
Sheets("Totals").Cells(40, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(40, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(41, Related_column).FormulaR1C1 = Sheets("Totals").Cells(41, 6).FormulaR1C1
Sheets("Totals").Cells(41, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(41, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(42, Related_column).FormulaR1C1 = Sheets("Totals").Cells(42, 6).FormulaR1C1
Sheets("Totals").Cells(42, Related_column).Interior.ColorIndex = 36
Sheets("Totals").Cells(42, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
Sheets("Totals").Cells(43, Related_column).FormulaR1C1 = Sheets("Totals").Cells(43, 6).FormulaR1C1
Sheets("Totals").Cells(43, Related_column).Interior.ColorIndex = 36
```

```
        Sheets("Totals").Cells(43, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Totals").Cells(44, Related_column).FormulaR1C1 = Sheets("Totals").Cells(44, 6).FormulaR1C1
        Sheets("Totals").Cells(44, Related_column).Interior.ColorIndex = 36
        Sheets("Totals").Cells(44, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        Sheets("Totals").Cells(45, Related_column).FormulaR1C1 = Sheets("Totals").Cells(45, 6).FormulaR1C1
        Sheets("Totals").Cells(45, Related_column).Interior.ColorIndex = 36
        Sheets("Totals").Cells(45, Related_column).BorderAround ColorIndex:=1, Weight:=xlThin
        related_year = related_year + 1
        related_date = related_date + 1
        Related_column = Related_column + 1
    Next i
    End If
'-----------------------------------------------------------------------------------------------------------------------------------------------------------------------
End Sub
```

APPENDIX C- CONSOLIDATED TOTAL RESULTS

The following tables provide consolidated cost of ownership results and potential savings for utilizing TNLS with RFID technology.

AS-IS	1	2	3	4	5	6	7	8	9	10
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Infrastructure Construction Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Logistics Operating Cost	$ 13,988,413	$ 12,903,105	$ 11,902,002	$ 10,978,571	$ 10,126,785	$ 9,341,086	$ 8,616,347	$ 7,947,837	$ 7,331,195	$ 6,762,395
Tag Purchase Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Maintenance Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Inventory Cost	$ 5,796,502	$ 5,346,774	$ 4,931,938	$ 4,549,287	$ 4,196,325	$ 3,870,749	$ 3,570,432	$ 3,293,416	$ 3,037,892	$ 2,802,193
Labor Cost	$ 8,191,911	$ 7,556,331	$ 6,970,064	$ 6,429,284	$ 5,930,460	$ 5,470,338	$ 5,045,915	$ 4,654,422	$ 4,293,303	$ 3,960,202
Miscellaneous Cost	$ 716,509	$ 764,727	$ 646,008	$ 664,446	$ 550,980	$ 507,257	$ 508,215	$ 413,797	$ 419,552	$ 395,981
Misidentification Cost	$ 286,480	$ 335,581	$ 292,711	$ 321,407	$ 241,237	$ 214,656	$ 215,978	$ 168,258	$ 181,328	$ 181,493
Loss Cost	$ 430,029	$ 429,146	$ 353,297	$ 343,039	$ 309,743	$ 292,601	$ 292,237	$ 245,539	$ 238,224	$ 214,488
Total	$ 14,704,922	$ 13,667,832	$ 12,548,010	$ 11,643,017	$ 10,677,766	$ 9,848,343	$ 9,124,562	$ 8,361,635	$ 7,750,747	$ 7,158,377

	11	12	13	14	15	16	17	18	19	20
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	$ 6,237,727	$ 5,753,765	$ 5,307,352	$ 4,895,575	$ 4,515,746	$ 4,165,386	$ 3,842,210	$ 3,544,107	$ 3,269,133	$ 3,015,494
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	$ 2,584,782	$ 2,384,238	$ 2,199,254	$ 2,028,623	$ 1,871,229	$ 1,726,048	$ 1,592,130	$ 1,468,603	$ 1,354,660	$ 1,249,557
	$ 3,652,945	$ 3,369,527	$ 3,108,098	$ 2,866,952	$ 2,644,516	$ 2,439,338	$ 2,250,079	$ 2,075,504	$ 1,914,474	$ 1,765,937
	$ 320,111	$ 279,030	$ 286,268	$ 260,307	$ 228,744	$ 224,848	$ 187,366	$ 185,179	$ 170,358	$ 160,496
	$ 132,239	$ 106,554	$ 125,235	$ 107,329	$ 85,028	$ 95,427	$ 71,693	$ 78,184	$ 81,522	$ 61,111
	$ 187,872	$ 172,476	$ 161,033	$ 152,978	$ 143,716	$ 129,421	$ 115,673	$ 106,995	$ 88,836	$ 99,385
	$ 6,557,838	$ 6,032,795	$ 5,593,620	$ 5,155,882	$ 4,744,490	$ 4,390,234	$ 4,029,575	$ 3,729,286	$ 3,439,491	$ 3,175,989
Total LCC		$ 152,334,410								

Table 11. The COO of the "as-is" Scenario

TO-BE	1	2	3	4	5	6	7	8	9	10
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Infrastructure Construction Cost	$ 8,068,353	$ 5,801,076	$ 4,028,549	$ 2,496,148	$ -	$ -	$ -	$ -	$ -	$ -
Logistics Operating Cost	$ 13,534,175	$ 11,757,202	$ 10,294,413	$ 9,098,447	$ 8,311,345	$ 7,591,610	$ 6,933,526	$ 6,331,861	$ 5,723,044	$ 5,224,800
Tag Purchase Cost	$ 1,570,072	$ 1,241,362	$ 954,208	$ 704,140	$ 568,320	$ 449,336	$ 345,395	$ 254,878	$ 117,551	$ 54,216
Maintenance Cost	$ 368,966	$ 680,678	$ 863,317	$ 941,123	$ 868,105	$ 800,752	$ 738,625	$ 681,318	$ 628,457	$ 579,697
Inventory Cost	$ 4,388,549	$ 3,779,044	$ 3,299,736	$ 2,929,277	$ 2,702,006	$ 2,492,367	$ 2,298,994	$ 2,120,624	$ 1,956,093	$ 1,804,327
Labor Cost	$ 7,206,588	$ 6,056,118	$ 5,177,152	$ 4,523,907	$ 4,172,914	$ 3,849,154	$ 3,550,512	$ 3,275,042	$ 3,020,944	$ 2,786,560
Miscellaneous Cost	$ 143,302	$ 152,945	$ 129,202	$ 132,889	$ 110,196	$ 101,451	$ 101,643	$ 82,759	$ 83,910	$ 79,196
Misidentification Cost	$ 57,296	$ 67,116	$ 58,542	$ 64,281	$ 48,247	$ 42,931	$ 43,196	$ 33,652	$ 36,266	$ 36,299
Loss Cost	$ 86,006	$ 85,829	$ 70,659	$ 68,608	$ 61,949	$ 58,520	$ 58,447	$ 49,108	$ 47,645	$ 42,898
Total	$ 21,745,830	$ 17,711,224	$ 14,452,163	$ 11,727,485	$ 8,421,541	$ 7,693,061	$ 7,035,169	$ 6,414,620	$ 5,806,955	$ 5,303,996

	11	12	13	14	15	16	17	18	19	20
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Infrastructure Construction Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Logistics Operating Cost	$ 4,769,418	$ 4,399,377	$ 4,058,046	$ 3,743,198	$ 3,452,777	$ 3,184,889	$ 2,937,786	$ 2,709,854	$ 2,499,607	$ 2,305,672
Tag Purchase Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Maintenance Cost	$ 534,721	$ 493,234	$ 454,966	$ 419,667	$ 387,106	$ 357,072	$ 329,368	$ 303,814	$ 280,242	$ 258,499
Inventory Cost	$ 1,664,336	$ 1,535,206	$ 1,416,096	$ 1,306,226	$ 1,204,881	$ 1,111,399	$ 1,025,170	$ 945,631	$ 872,263	$ 804,587
Labor Cost	$ 2,570,361	$ 2,370,937	$ 2,186,985	$ 2,017,305	$ 1,860,790	$ 1,716,418	$ 1,583,248	$ 1,460,410	$ 1,347,102	$ 1,242,586
Miscellaneous Cost	$ 64,022	$ 55,806	$ 57,254	$ 52,061	$ 45,749	$ 44,970	$ 37,473	$ 37,036	$ 34,072	$ 32,099
Misidentification Cost	$ 26,448	$ 21,311	$ 25,047	$ 21,466	$ 17,006	$ 19,085	$ 14,339	$ 15,637	$ 16,304	$ 12,222
Loss Cost	$ 37,574	$ 34,495	$ 32,207	$ 30,596	$ 28,743	$ 25,884	$ 23,135	$ 21,399	$ 17,767	$ 19,877
Total	$ 4,833,440	$ 4,455,183	$ 4,115,300	$ 3,795,259	$ 3,498,526	$ 3,229,859	$ 2,975,259	$ 2,746,890	$ 2,533,678	$ 2,337,771
Total LCC		$ 140,833,209								

Table 12. The COO of the "to-be" Scenario

DIFFERENCE	1 2010	2 2011	3 2012	4 2013	5 2014	6 2015	7 2016	8 2017	9 2018	10 2019
Infrastructure Construction Cost	$ (8,068,353)	$ (5,801,076)	$ (4,028,549)	$ (2,496,148)	$ -	$ -	$ -	$ -	$ -	$ -
Logistics Operating Cost	$ 454,238	$ 1,145,903	$ 1,607,589	$ 1,880,124	$ 1,815,441	$ 1,749,477	$ 1,682,821	$ 1,615,976	$ 1,608,150	$ 1,537,596
Tag Purchase Cost	$ (1,570,072)	$ (1,241,362)	$ (954,208)	$ (704,140)	$ (568,320)	$ (449,336)	$ (345,395)	$ (254,878)	$ (117,551)	$ (54,216)
Maintenance Cost	$ (368,966)	$ (680,678)	$ (863,317)	$ (941,123)	$ (868,105)	$ (800,752)	$ (738,625)	$ (681,318)	$ (628,457)	$ (579,697)
Inventory Cost	$ 1,407,953	$ 1,567,729	$ 1,632,202	$ 1,620,010	$ 1,494,320	$ 1,378,381	$ 1,271,438	$ 1,172,792	$ 1,081,799	$ 997,867
Labor Cost	$ 985,322	$ 1,500,214	$ 1,792,912	$ 1,905,376	$ 1,757,545	$ 1,621,184	$ 1,495,403	$ 1,379,380	$ 1,272,359	$ 1,173,642
Miscellaneous Cost	$ 573,207	$ 611,782	$ 516,806	$ 531,557	$ 440,784	$ 405,805	$ 406,572	$ 331,038	$ 335,642	$ 316,785
Misidentification Cost	$ 229,184	$ 268,465	$ 234,169	$ 257,125	$ 192,990	$ 171,725	$ 172,783	$ 134,607	$ 145,063	$ 145,195
Loss Cost	$ 344,023	$ 343,317	$ 282,637	$ 274,432	$ 247,795	$ 234,081	$ 233,790	$ 196,431	$ 190,579	$ 171,590
Total	$ (7,040,908)	$ (4,043,392)	$ (1,904,153)	$ (84,468)	$ 2,256,225	$ 2,155,282	$ 2,089,393	$ 1,947,014	$ 1,943,792	$ 1,854,381

	11 2020	12 2021	13 2022	14 2023	15 2024	16 2025	17 2026	18 2027	19 2028	20 2029
Infrastructure Construction Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Logistics Operating Cost	$ 1,468,309	$ 1,354,388	$ 1,249,306	$ 1,152,377	$ 1,062,969	$ 980,497	$ 904,424	$ 834,253	$ 769,527	$ 709,822
Tag Purchase Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Maintenance Cost	$ (534,721)	$ (493,234)	$ (454,966)	$ (419,667)	$ (387,106)	$ (357,072)	$ (329,368)	$ (303,814)	$ (280,242)	$ (258,499)
Inventory Cost	$ 920,446	$ 849,032	$ 783,159	$ 722,397	$ 666,349	$ 614,649	$ 566,961	$ 522,972	$ 482,397	$ 444,970
Labor Cost	$ 1,082,583	$ 998,590	$ 921,113	$ 849,647	$ 783,726	$ 722,920	$ 666,831	$ 615,094	$ 567,372	$ 523,351
Miscellaneous Cost	$ 256,089	$ 223,224	$ 229,014	$ 208,246	$ 182,995	$ 179,878	$ 149,893	$ 148,143	$ 136,286	$ 128,397
Misidentification Cost	$ 105,791	$ 85,243	$ 100,188	$ 85,863	$ 68,022	$ 76,342	$ 57,354	$ 62,547	$ 65,218	$ 48,889
Loss Cost	$ 150,298	$ 137,981	$ 128,827	$ 122,383	$ 114,973	$ 103,537	$ 92,538	$ 85,596	$ 71,069	$ 79,508
Total	$ 1,724,397	$ 1,577,612	$ 1,478,320	$ 1,360,623	$ 1,245,964	$ 1,160,375	$ 1,054,316	$ 982,396	$ 905,813	$ 838,219
Total Difference		$ 11,501,202								

Table 13. The Difference Between COO of Two Scenarios

APPENDIX D- COST ELEMENTS

The following tables provide results of cost breakdown for both scenarios.

Year	1	2	3	4	
	2010	2011	2012	2013	
Labor (PMO)	$ 78,000	$ 78,000	$ 78,000	$ 78,000	
Integration Cost to Current SYS	$ 2,400,000	$ 2,400,000	$ 1,800,000	$ 1,200,000	
Door Reader Cost	$ 5,200,000	$ 3,600,000	$ 2,700,000	$ 1,800,000	
Hand Reader Cost	$ 104,000	$ 72,000	$ 54,000	$ 36,000	
Antenna Cost	$ 624,000	$ 432,000	$ 324,000	$ 216,000	
Label Printer Cost	$ 4,000	$ -	$ -	$ -	
Integrator Server Cost	$ 10,000	-	-	-	
Local Server Cost	$ 15,000	$ 20,000	$ 15,000	$ 10,000	
Test Cost	$ 312,000	$ 216,000	$ 162,000	$ 108,000	**Total**
Total Construction Cost (Current Year)	$ 8,747,000	$ 6,818,000	$ 5,133,000	$ 3,448,000	$ 24,146,000
Total Construction Cost (Inc Inflation)	$ 9,359,290	$ 7,805,928	$ 6,288,146	$ 4,519,625	$ 27,972,989
PV (2009)	$ 8,068,353	$ 5,801,076	$ 4,028,549	$ 2,496,148	$ 20,394,127

Table 14. Construction Cost for the “to-be” Scenario

Year	1	2	3	4	5	6	7	8	9	10
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
MSC										
Total Annual Maintenance Cost (Current Year)	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000
Total Annual Maintenance Cost(Inc Inflation)	$ 107,000	$ 114,490	$ 122,504	$ 131,080	$ 140,255	$ 150,073	$ 160,578	$ 171,819	$ 183,846	$ 196,715
Total Annual Maintenance Cost PV (2009)	$ 92,241	$ 85,085	$ 78,483	$ 72,394	$ 66,777	$ 61,596	$ 56,817	$ 52,409	$ 48,343	$ 44,592
SSC										
SSCs with RFID	3	7	10	12	12	12	12	12	12	12
SSCs without RFID	9	5	2	0	0	0	0	0	0	0
Total Annual Maintenance Cost (Current Year)	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000
Total Annual Maintenance Cost (Inc Inflation)	$ 107,000	$ 114,490	$ 122,504	$ 131,080	$ 140,255	$ 150,073	$ 160,578	$ 171,819	$ 183,846	$ 196,715
Total Annual Maintenance Cost PV (2009)	$ 92,241	$ 85,085	$ 78,483	$ 72,394	$ 66,777	$ 61,596	$ 56,817	$ 52,409	$ 48,343	$ 44,592
Total SSCs Annual Maintenance Cost with RFID	$ 276,724	$ 595,593	$ 784,833	$ 868,729	$ 801,328	$ 739,156	$ 681,807	$ 628,909	$ 580,114	$ 535,105
Total SSCs Annual Maintenance Cost without RFID	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total SSCs Annual Maintenance Cost	$ 276,724	$ 595,593	$ 784,833	$ 868,729	$ 801,328	$ 739,156	$ 681,807	$ 628,909	$ 580,114	$ 535,105
Total Annual Maintenance Cost (MSC+SSCs)	$ 368,966	$ 680,678	$ 863,317	$ 941,123	$ 868,105	$ 800,752	$ 738,625	$ 681,318	$ 628,457	$ 579,697

Year	11	12	13	14	15	16	17	18	19	20	TOTAL
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	
MSC											
Total Annual Maintenance Cost (Current Year)	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	
Total Annual Maintenance Cost(Inc Inflation)	$ 210,485	$ 225,219	$ 240,985	$ 257,853	$ 275,903	$ 295,216	$ 315,882	$ 337,993	$ 361,653	$ 386,968	
Total Annual Maintenance Cost PV (2009)	$ 41,132	$ 37,941	$ 34,997	$ 32,282	$ 29,777	$ 27,467	$ 25,336	$ 23,370	$ 21,557	$ 19,885	
SSC											
SSCs with RFID	12	12	12	12	12	12	12	12	12	12	
SSCs without RFID	0	0	0	0	0	0	0	0	0	0	
Total Annual Maintenance Cost (Current Year)	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	
Total Annual Maintenance Cost (Inc Inflation)	$ 210,485	$ 225,219	$ 240,985	$ 257,853	$ 275,903	$ 295,216	$ 315,882	$ 337,993	$ 361,653	$ 386,968	$ 4,386,518
Total Annual Maintenance Cost PV (2009)	$ 41,132	$ 37,941	$ 34,997	$ 32,282	$ 29,777	$ 27,467	$ 25,336	$ 23,370	$ 21,557	$ 19,885	$ 952,484
Total SSCs Annual Maintenance Cost with RFID	$ 493,588	$ 455,293	$ 419,968	$ 387,385	$ 357,329	$ 329,605	$ 304,032	$ 280,444	$ 258,685	$ 238,615	$ 10,017,242
Total SSCs Annual Maintenance Cost without RFID	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total SSCs Annual Maintenance Cost	$ 493,588	$ 455,293	$ 419,968	$ 387,385	$ 357,329	$ 329,605	$ 304,032	$ 280,444	$ 258,685	$ 238,615	$ 10,017,242
Total Annual Maintenance Cost (MSC+SSCs)	$ 534,721	$ 493,234	$ 454,966	$ 419,667	$ 387,106	$ 357,072	$ 329,368	$ 303,814	$ 280,242	$ 258,499	$ 10,969,725

Table 15. Maintenance Cost for the “to-be” Scenario

Error! Not a valid link.

Year	1	2	3	4	5	6	7	8	9	10
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
MSC										
Total Annual Tag Purchase Cost (Current Year)	$1,702,134	$1,458,972	$1,215,810	$ 972,648	$ 851,067	$ 729,486	$607,905	$486,324	$243,162	$121,581
Total Annual Tag Purchase Cost(Inc Inflation)	$1,821,283	$1,670,377	$1,489,420	$1,274,943	$1,193,665	$1,094,762	$976,163	$835,595	$447,043	$239,168
Total Annual Tag Purchase Cost PV (2009)	$1,570,072	$1,241,362	$ 954,208	$ 704,140	$ 568,320	$ 449,336	$345,395	$254,878	$117,551	$ 54,216
TOTAL INVENTORY COST (2009)	**$ 6,259,478**									

Table 16. Tag Purchase Cost for the “to-be” Scenario

Actions	MSC							
$ value of item	$ 100	$ 250	$ 500	$ 1,000	$ 2,000	$ 4,000	$ 8,000	$ 10,000
Annual Demand	1,182,000	576,000	396,000	180,000	84,000	5,400	2,880	1,440
Daily Demand	4,728.00	2,304.00	1,584.00	720.00	336.00	21.60	11.52	5.76
Holding Cost Percentage per item cost	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Holding Cost per item	$ 12	$ 30	$ 60	$ 120	$ 240	$ 480	$ 960	$ 1,200
Ordering Cost	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500
# of days between reviews	5	5	5	5	5	5	5	5
Lead Time	4	4	4	4	4	4	4	4
Inventory on hand	0	0	0	0	0	0	0	0
Standard Deviation	233.71	113.89	78.30	35.59	16.61	1.07	0.57	0.28
Standard Deviation during Lead Time	701.12	341.66	234.89	106.77	49.83	3.20	1.71	0.85
Desired Probability of not stocking out	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Z value	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33
SS Level without RFID	1,631.06	794.83	546.45	248.38	115.91	7.45	3.97	1.99
EOQ without RFID	44,183.06	21,530.83	14,802.45	6,728.38	3,139.91	201.85	107.65	53.83
Average inventory	23,722.59	11,560.25	7,947.67	3,612.58	1,685.87	108.38	57.80	28.90
Annual number of orders	26.75	26.75	26.75	26.75	26.75	26.75	26.75	26.75
Annual Purchasing Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Annual Ordering Cost	$ 13,376	$ 13,376	$ 13,376	$ 13,376	$ 13,376	$ 13,376	$ 13,376	$ 13,376
Annual Holding Cost	$ 284,671	$ 346,807	$ 476,860	$ 433,509	$ 404,609	$ 52,021	$ 55,489	$ 34,681
Annual Total Cost	$ 298,047	$ 360,184	$ 490,236	$ 446,885	$ 417,985	$ 65,397	$ 68,865	$ 48,057

Table 17. Inventory Calculations of a MSC for the “as-is” Scenario

Actions	SSC							
$ value of item	$ 100	$ 250	$ 500	$ 1,000	$ 2,000	$ 4,000	$ 8,000	$ 10,000
Annual Demand	98,500	48,000	33,000	15,000	7,000	450	240	120
Daily Demand	394.00	192.00	132.00	60.00	28.00	1.80	0.96	0.48
Holding Cost Percentage per item cost	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Holding Cost per item	$ 12	$ 30	$ 60	$ 120	$ 240	$ 480	$ 960	$ 1,200
Ordering Cost	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500
# of days between reviews	5	5	5	5	5	5	5	5
Lead Time	6	6	6	6	6	6	6	6
Inventory on hand	0	0	0	0	0	0	0	0
Standard Deviation	67.47	32.88	22.60	10.27	4.79	0.31	0.16	0.08
Standard Deviation during Lead Time	223.76	109.04	74.96	34.07	15.90	1.02	0.55	0.27
Desired Probability of not stocking out	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Z value	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33
SS Level without RFID	520.54	253.66	174.39	79.27	36.99	2.38	1.27	0.63
EOQ without RFID	4,854.54	2,365.66	1,626.39	739.27	344.99	22.18	11.83	5.91
Average inventory	2,947.81	1,436.50	987.59	448.91	209.49	13.47	7.18	3.59
Annual number of orders	20.29	20.29	20.29	20.29	20.29	20.29	20.29	20.29
Annual Purchasing Cost	-	-	-	-	-	-	-	-
Annual Ordering Cost	10,145.14	10,145.14	10,145.14	10,145.14	10,145.14	10,145.14	10,145.14	10,145.14
Annual Holding Cost	$ 35,374	$ 43,095	$ 59,255	$ 53,869	$ 50,277	$ 6,464	$ 6,895	$ 4,309
Annual Total Cost	$ 45,519	$ 53,240	$ 69,401	$ 64,014	$ 60,423	$ 16,609	$ 17,040	$ 14,455

Table 18. Inventory Calculations of a SSC for the “as-is” Scenario

Year	1	2	3	4	5	6	7	8	9	10
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
MSC										
Total Annual Inventory Cost (Current Year)	$ 2,195,657	$ 2,195,657	$ 2,195,657	$ 2,195,657	$ 2,195,657	$ 2,195,657	$ 2,195,657	$ 2,195,657	$ 2,195,657	$ 2,195,657
Total Annual Inventory Cost(Inc Inflation)	$ 2,349,353	$ 2,513,808	$ 2,689,774	$ 2,878,058	$ 3,079,522	$ 3,295,089	$ 3,525,745	$ 3,772,547	$ 4,036,626	$ 4,319,190
Total Annual Inventory Cost PV (2009)	$ 2,025,304	$ 1,868,169	$ 1,723,224	$ 1,589,526	$ 1,466,201	$ 1,352,444	$ 1,247,513	$ 1,150,723	$ 1,061,443	$ 979,089
SSC										
Total Annual Inventory Cost (Current Year)	$ 340,700	$ 340,700	$ 340,700	$ 340,700	$ 340,700	$ 340,700	$ 340,700	$ 340,700	$ 340,700	$ 340,700
Total Annual Inventory Cost (Inc Inflation)	$ 364,549	$ 390,068	$ 417,372	$ 446,588	$ 477,850	$ 511,299	$ 547,090	$ 585,386	$ 626,363	$ 670,209
Total Annual Inventory Cost PV (2009)	$ 314,267	$ 289,884	$ 267,393	$ 246,647	$ 227,510	$ 209,859	$ 193,577	$ 178,558	$ 164,704	$ 151,925
Total SSCs Annual Inventory Cost	$ 3,771,198	$ 3,478,605	$ 3,208,713	$ 2,959,761	$ 2,730,125	$ 2,518,305	$ 2,322,919	$ 2,142,693	$ 1,976,449	$ 1,823,104
Total Annual Inventory Cost (MSC+SSCs)	$ 5,796,502	$ 5,346,774	$ 4,931,938	$ 4,549,287	$ 4,196,325	$ 3,870,749	$ 3,570,432	$ 3,293,416	$ 3,037,892	$ 2,802,193

Year	11	12	13	14	15	16	17	18	19	20	
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	
MSC											
Total Annual Inventory Cost (Current Year)	$ 2,195,657	$ 2,195,657	$ 2,195,657	$ 2,195,657	$ 2,195,657	$ 2,195,657	$ 2,195,657	$ 2,195,657	$ 2,195,657	$ 2,195,657	Total
Total Annual Inventory Cost(Inc Inflation)	$ 4,621,533	$ 4,945,040	$ 5,291,193	$ 5,661,576	$ 6,057,887	$ 6,481,939	$ 6,935,675	$ 7,421,172	$ 7,940,654	$ 8,496,500	$ 96,312,880
Total Annual Inventory Cost PV (2009)	$ 903,126	$ 833,056	$ 768,422	$ 708,803	$ 653,810	$ 603,083	$ 556,292	$ 513,132	$ 473,320	$ 436,597	$ 20,913,274
SSC											
Total Annual Inventory Cost (Current Year)	$ 340,700	$ 340,700	$ 340,700	$ 340,700	$ 340,700	$ 340,700	$ 340,700	$ 340,700	$ 340,700	$ 340,700	Total
Total Annual Inventory Cost (Inc Inflation)	$ 717,123	$ 767,322	$ 821,035	$ 878,507	$ 940,002	$ 1,005,803	$ 1,076,209	$ 1,151,543	$ 1,232,151	$ 1,318,402	$ 14,944,872
Total Annual Inventory Cost PV (2009)	$ 140,138	$ 129,265	$ 119,236	$ 109,985	$ 101,452	$ 93,580	$ 86,320	$ 79,623	$ 73,445	$ 67,747	$ 3,245,113
Total SSCs Annual Inventory Cost	$ 1,681,656	$ 1,551,183	$ 1,430,833	$ 1,319,820	$ 1,217,420	$ 1,122,965	$ 1,035,838	$ 955,472	$ 881,340	$ 812,960	$ 38,941,358
Total Annual Inventory Cost (MSC+SSCs)	$ 2,584,782	$ 2,384,238	$ 2,199,254	$ 2,028,623	$ 1,871,229	$ 1,726,048	$ 1,592,130	$ 1,468,603	$ 1,354,660	$ 1,249,557	$ 59,854,632

Table 19. Inventory Cost for the “as-is” Scenario

Actions	MSC							
$ value of item	$ 100	$ 250	$ 500	$ 1,000	$ 2,000	$ 4,000	$ 8,000	$ 10,000
Annual Demand	1,182,000	576,000	396,000	180,000	84,000	5,400	2,880	1,440
Daily Demand	4,728.00	2,304.00	1,584.00	720.00	336.00	21.60	11.52	5.76
Holding Cost Percentage per item cost	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Holding Cost per item	$ 12	$ 30	$ 60	$ 120	$ 240	$ 480	$ 960	$ 1,200
Ordering Cost	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500
Lead Time	2	2	2	2	2	2	2	2
Standard Deviation of daily demand	233.7082254	113.8882723	78.29818719	35.59008509	16.60870637	1.067702553	0.569441361	0.284720681
Desired Probability of not stocking out	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Z value	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33
Standard Deviation of usage during Lead Time	330.51	161.06	110.73	50.33	23.49	1.51	0.81	0.40
Safety Stock Level	768.89	374.69	257.60	117.09	54.64	3.51	1.87	0.94
Reorder Point	9,456.00	4,608.00	3,168.00	1,440.00	672.00	43.20	23.04	11.52
EOQ	9,924.72	4,381.78	2,569.05	1,224.74	591.61	106.07	54.77	34.64
Average Inventory	5,731.25	2,565.58	1,542.12	729.46	350.45	56.55	29.26	18.26
Annual number of orders	119.10	131.45	154.14	146.97	141.99	50.91	52.58	41.57
Annual Purchasing Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Annual Ordering Cost	$ 59,548	$ 65,727	$ 77,071	$ 73,485	$ 70,993	$ 25,456	$ 26,291	$ 20,785
Annual Holding Cost	$ 68,775	$ 76,967	$ 92,527	$ 87,535	$ 84,107	$ 27,142	$ 28,089	$ 21,909
Total Annual Cost	$ 128,323	$ 142,694	$ 169,599	$ 161,020	$ 155,100	$ 52,598	$ 54,380	$ 42,693

Table 20. Inventory Calculations of a MSC for the “to-be” Scenario

Actions	SSC							
$ value of item	$ 100	$ 250	$ 500	$ 1,000	$ 2,000	$ 4,000	$ 8,000	$ 10,000
Annual Demand	98,500	48,000	33,000	15,000	7,000	450	240	120
Daily Demand	394.00	192.00	132.00	60.00	28.00	1.80	0.96	0.48
Holding Cost Percentage per item cost	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Holding Cost per item	$ 12	$ 30	$ 60	$ 120	$ 240	$ 480	$ 960	$ 1,200
Ordering Cost	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500
Lead Time	2	2	2	2	2	2	2	2
Standard Deviation of daily demand	67.46575342	32.87671233	22.60273973	10.2739726	4.794520548	0.308219178	0.164383562	0.082191781
Desired Probability of not stocking out	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Z value	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33
Standard Deviation of usage during Lead Time	95.41	46.49	31.97	14.53	6.78	0.44	0.23	0.12
Safety Stock Level	221.96	108.16	74.36	33.80	15.77	1.01	0.54	0.27
Reorder Point	788.00	384.00	264.00	120.00	56.00	3.60	1.92	0.96
EOQ	2,865.02	1,264.91	741.62	353.55	170.78	30.62	15.81	10.00
Average Inventory	1,654.47	740.62	445.17	210.58	101.17	16.32	8.45	5.27
Annual number of orders	34.38	37.95	44.50	42.43	40.99	14.70	15.18	12.00
Annual Purchasing Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Annual Ordering Cost	$ 17,190	$ 18,974	$ 22,249	$ 21,213	$ 20,494	$ 7,348	$ 7,589	$ 6,000
Annual Holding Cost	$ 19,854	$ 22,219	$ 26,710	$ 25,269	$ 24,280	$ 7,835	$ 8,109	$ 6,324
Total Annual Cost	$ 37,044	$ 41,192	$ 48,959	$ 46,483	$ 44,774	$ 15,184	$ 15,698	$ 12,324

Table 21. Inventory Calculations of a SSC for the “to-be” Scenario

Year	1	2	3	4	5	6	7	8	9	10
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
MSC										
Total Annual Inventory Cost (Current Year)	$ 906,407	$ 906,407	$ 906,407	$ 906,407	$ 906,407	$ 906,407	$ 906,407	$ 906,407	$ 906,407	$ 906,407
Total Annual Inventory Cost(Inc Inflation)	$ 969,855	$ 1,037,745	$ 1,110,387	$ 1,188,115	$ 1,271,283	$ 1,360,272	$ 1,455,491	$ 1,557,376	$ 1,666,392	$ 1,783,040
Total Annual Inventory Cost PV (2009)	$ 836,082	$ 771,214	$ 711,378	$ 656,185	$ 605,274	$ 558,313	$ 514,996	$ 475,039	$ 438,183	$ 404,186
SSC										
SSCs with RFID	3	7	10	12	12	12	12	12	12	12
SSCs without RFID	9	5	2	0	0	0	0	0	0	0
Total Annual Inventory Cost (Current Year)	$ 261,657	$ 261,657	$ 261,657	$ 261,657	$ 261,657	$ 261,657	$ 261,657	$ 261,657	$ 261,657	$ 261,657
Total Annual Inventory Cost (Inc Inflation)	$ 279,973	$ 299,571	$ 320,541	$ 342,979	$ 366,988	$ 392,677	$ 420,164	$ 449,576	$ 481,046	$ 514,719
Total Annual Inventory Cost PV (2009)	$ 241,356	$ 222,630	$ 205,357	$ 189,424	$ 174,728	$ 161,171	$ 148,667	$ 137,132	$ 126,492	$ 116,678
Total SSCs Annual Inventory Cost with RFID	$ 724,068	$ 1,558,412	$ 2,053,572	$ 2,273,092	$ 2,096,731	$ 1,934,054	$ 1,783,998	$ 1,645,584	$ 1,517,910	$ 1,400,141
Total SSCs Annual Inventory Cost without RFID	$ 2,828,399	$ 1,449,419	$ 534,786	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total SSCs Annual Inventory Cost	$ 3,552,467	$ 3,007,831	$ 2,588,358	$ 2,273,092	$ 2,096,731	$ 1,934,054	$ 1,783,998	$ 1,645,584	$ 1,517,910	$ 1,400,141
Total Annual Inventory Cost (MSC+SSCs)	$ 4,388,549	$ 3,779,044	$ 3,299,736	$ 2,929,277	$ 2,702,006	$ 2,492,367	$ 2,298,994	$ 2,120,624	$ 1,956,093	$ 1,804,327

Year	11	12	13	14	15	16	17	18	19	20	
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	
MSC											
Total Annual Inventory Cost (Current Year)	$ 906,407	$ 906,407	$ 906,407	$ 906,407	$ 906,407	$ 906,407	$ 906,407	$ 906,407	$ 906,407	$ 906,407	**Total**
Total Annual Inventory Cost(Inc Inflation)	$ 1,907,852	$ 2,041,402	$ 2,184,300	$ 2,337,201	$ 2,500,805	$ 2,675,862	$ 2,863,172	$ 3,063,594	$ 3,278,046	$ 3,507,509	$ 39,759,701
Total Annual Inventory Cost PV (2009)	$ 372,827	$ 343,900	$ 317,218	$ 292,607	$ 269,904	$ 248,964	$ 229,647	$ 211,830	$ 195,395	$ 180,235	$ 8,633,378
SSC											
SSCs with RFID	12	12	12	12	12	12	12	12	12	12	
SSCs without RFID	0	0	0	0	0	0	0	0	0	0	
Total Annual Inventory Cost (Current Year)	$ 261,657	$ 261,657	$ 261,657	$ 261,657	$ 261,657	$ 261,657	$ 261,657	$ 261,657	$ 261,657	$ 261,657	**Total**
Total Annual Inventory Cost (Inc Inflation)	$ 550,750	$ 589,302	$ 630,553	$ 674,692	$ 721,920	$ 772,455	$ 826,527	$ 884,383	$ 946,290	$ 1,012,531	$ 11,477,637
Total Annual Inventory Cost PV (2009)	$ 107,626	$ 99,275	$ 91,573	$ 84,468	$ 77,915	$ 71,870	$ 66,294	$ 61,150	$ 56,406	$ 52,029	$ 2,492,242
Total SSCs Annual Inventory Cost with RFID	$ 1,291,509	$ 1,191,306	$ 1,098,877	$ 1,013,619	$ 934,976	$ 862,435	$ 795,522	$ 733,801	$ 676,868	$ 624,352	$ 26,210,829
Total SSCs Annual Inventory Cost without RFID	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 4,812,603
Total SSCs Annual Inventory Cost	$ 1,291,509	$ 1,191,306	$ 1,098,877	$ 1,013,619	$ 934,976	$ 862,435	$ 795,522	$ 733,801	$ 676,868	$ 624,352	$ 31,023,432
Total Annual Inventory Cost (MSC+SSCs)	$ 1,664,336	$ 1,535,206	$ 1,416,096	$ 1,306,226	$ 1,204,881	$ 1,111,399	$ 1,025,170	$ 945,631	$ 872,263	$ 804,587	$ 39,656,810

Table 22. Inventory Cost for the “to-be” Scenario

Year		Simulated # of misidentified items	Simulated Av.Unit Cost	Value of Misidentified Inventory	Holding Cost	Total Misidentification Cost (Current Year)	Total Misidentification Cost (Inflation)	PV (2009)
1	2010	259	$ 1,097	$ 284,000	$ 34,080	$ 318,080	$ 340,346	$ 293,401
2	2011	301	$ 1,018	$ 307,000	$ 36,840	$ 343,840	$ 393,662	$ 292,555
3	2012	295	$ 1,062	$ 313,000	$ 37,560	$ 350,560	$ 429,451	$ 275,131
4	2013	429	$ 1,142	$ 490,500	$ 58,860	$ 549,360	$ 720,099	$ 397,704
5	2014	307	$ 968	$ 297,500	$ 35,700	$ 333,200	$ 467,330	$ 222,502
6	2015	188	$ 975	$ 183,000	$ 21,960	$ 204,960	$ 307,590	$ 126,248
7	2016	225	$ 975	$ 219,500	$ 26,340	$ 245,840	$ 394,765	$ 139,680
8	2017	383	$ 1,116	$ 428,000	$ 51,360	$ 479,360	$ 823,630	$ 251,228
9	2018	324	$ 920	$ 298,500	$ 35,820	$ 334,320	$ 614,634	$ 161,620
10	2019	533	$ 993	$ 529,000	$ 63,480	$ 592,480	$ 1,165,498	$ 264,199
11	2020	377	$ 921	$ 347,000	$ 41,640	$ 388,640	$ 818,030	$ 159,857
12	2021	180	$ 790	$ 142,500	$ 17,100	$ 159,600	$ 359,450	$ 60,554
13	2022	506	$ 951	$ 481,500	$ 57,780	$ 539,280	$ 1,299,581	$ 188,734
14	2023	378	$ 1,005	$ 380,000	$ 45,600	$ 425,600	$ 1,097,424	$ 137,392
15	2024	380	$ 925	$ 351,500	$ 42,180	$ 393,680	$ 1,086,176	$ 117,228
16	2025	268	$ 928	$ 248,500	$ 29,820	$ 278,320	$ 821,646	$ 76,446
17	2026	351	$ 989	$ 347,000	$ 41,640	$ 388,640	$ 1,227,642	$ 98,466
18	2027	341	$ 1,060	$ 361,000	$ 43,320	$ 404,320	$ 1,366,574	$ 94,491
19	2028	305	$ 911	$ 277,500	$ 33,300	$ 310,800	$ 1,124,017	$ 66,999
20	2029	259	$ 824	$ 213,000	$ 25,560	$ 238,560	$ 923,152	$ 47,437

Table 23. Misidentification Cost Calculations for the “as-is” Scenario

Average	1. iteration	2. iteration	3. iteration	4. iteration	5. iteration	6. iteration	7. iteration	8. iteration	9. iteration	10. iteration
$ 286,480	$ 318,196	$ 209,203	$ 320,262	$ 72,317	$ 257,243	$ 386,381	$ 233,481	$ 419,440	$ 354,871	$ 293,401
$ 335,581	$ 288,267	$ 391,662	$ 269,208	$ 356,403	$ 391,662	$ 314,950	$ 407,862	$ 326,385	$ 316,855	$ 292,555
$ 292,711	$ 210,963	$ 359,077	$ 208,326	$ 167,892	$ 429,837	$ 387,205	$ 249,640	$ 358,198	$ 280,845	$ 275,131
$ 321,407	$ 240,812	$ 420,812	$ 340,947	$ 272,028	$ 190,947	$ 318,650	$ 290,271	$ 341,353	$ 400,542	$ 397,704
$ 241,237	$ 162,670	$ 234,469	$ 302,528	$ 190,342	$ 290,187	$ 277,847	$ 266,255	$ 273,360	$ 192,212	$ 222,502
$ 214,656	$ 365,291	$ 146,599	$ 304,926	$ 215,242	$ 300,442	$ 231,799	$ 218,692	$ 219,381	$ 17,937	$ 126,248
$ 215,978	$ 267,587	$ 220,815	$ 101,498	$ 215,724	$ 223,996	$ 165,770	$ 303,541	$ 269,496	$ 251,678	$ 139,680
$ 168,258	$ 161,713	$ 166,703	$ 232,738	$ 185,486	$ 72,199	$ 133,832	$ 129,136	$ 155,844	$ 193,704	$ 251,228
$ 181,328	$ 300,228	$ 143,482	$ 173,802	$ 230,924	$ 84,465	$ 155,935	$ 181,382	$ 196,813	$ 184,631	$ 161,620
$ 181,493	$ 167,809	$ 180,544	$ 153,325	$ 208,263	$ 86,152	$ 254,710	$ 201,021	$ 170,806	$ 128,104	$ 264,199
$ 132,239	$ 175,290	$ 108,491	$ 114,710	$ 139,126	$ 85,226	$ 112,637	$ 198,784	$ 153,868	$ 74,400	$ 159,857
$ 106,554	$ 174,013	$ 82,226	$ 112,609	$ 66,716	$ 136,831	$ 82,438	$ 154,466	$ 119,196	$ 76,489	$ 60,554
$ 125,235	$ 50,760	$ 85,842	$ 195,593	$ 165,020	$ 106,616	$ 84,862	$ 132,682	$ 168,939	$ 73,298	$ 188,734
$ 107,329	$ 148,962	$ 121,484	$ 207,535	$ 76,470	$ 91,113	$ 98,886	$ 95,632	$ 72,312	$ 23,501	$ 137,392
$ 85,028	$ 38,020	$ 62,866	$ 99,885	$ 35,018	$ 132,903	$ 91,548	$ 77,707	$ 49,526	$ 145,576	$ 117,228
$ 95,427	$ 97,519	$ 143,664	$ 76,293	$ 122,283	$ 149,047	$ 102,595	$ 110,132	$ 57,219	$ 19,073	$ 76,446
$ 71,693	$ 73,637	$ 61,151	$ 72,218	$ 57,462	$ 89,811	$ 65,124	$ 65,407	$ 71,083	$ 62,570	$ 98,466
$ 78,184	$ 83,105	$ 65,829	$ 32,588	$ 71,064	$ 80,749	$ 80,880	$ 122,105	$ 109,672	$ 41,356	$ 94,491
$ 81,522	$ 112,873	$ 78,951	$ 88,850	$ 95,369	$ 65,430	$ 80,761	$ 64,706	$ 95,610	$ 65,671	$ 66,999
$ 61,111	$ 63,360	$ 40,533	$ 28,284	$ 78,727	$ 76,277	$ 47,437	$ 72,714	$ 78,393	$ 77,947	$ 47,437

Table 24. The Simulation Results of Misidentification Cost for the “as-is” Scenario

Year		Randomized # of lost items	Simulated Av.Unit Cost	Lost Cost(Current Year)	Lost Cost (Inflation)	PV (2009)
1	2010	657	$ 726	$ 477,200	$ 510,604	$ 440,176
2	2011	605	$ 604	$ 365,350	$ 418,289	$ 310,857
3	2012	596	$ 590	$ 352,150	$ 431,399	$ 276,379
4	2013	662	$ 630	$ 417,000	$ 546,602	$ 301,883
5	2014	925	$ 588	$ 543,900	$ 762,848	$ 363,202
6	2015	800	$ 610	$ 488,000	$ 732,356	$ 300,590
7	2016	867	$ 644	$ 558,600	$ 896,990	$ 317,381
8	2017	705	$ 700	$ 493,850	$ 848,526	$ 258,822
9	2018	770	$ 635	$ 489,350	$ 899,650	$ 236,566
10	2019	915	$ 611	$ 558,750	$ 1,099,146	$ 249,158
11	2020	637	$ 559	$ 356,150	$ 749,643	$ 146,493
12	2021	610	$ 564	$ 343,700	$ 774,078	$ 130,403
13	2022	761	$ 586	$ 445,750	$ 1,074,188	$ 156,001
14	2023	797	$ 624	$ 497,450	$ 1,282,692	$ 160,587
15	2024	709	$ 695	$ 493,100	$ 1,360,478	$ 146,832
16	2025	733	$ 660	$ 483,550	$ 1,427,519	$ 132,817
17	2026	781	$ 719	$ 561,650	$ 1,774,149	$ 142,300
18	2027	650	$ 590	$ 383,700	$ 1,296,880	$ 89,672
19	2028	671	$ 586	$ 393,350	$ 1,422,561	$ 84,795
20	2029	770	$ 581	$ 447,700	$ 1,732,458	$ 89,023

Table 25. Loss Cost Calculations for the "as-is" Scenario

Average	1. iteration	2. iteration	3. iteration	4. iteration	5. iteration	6. iteration	7. iteration	8. iteration	9. iteration	10. iteration
$ 430,029	$ 461,668	$ 376,575	$ 522,686	$ 372,286	$ 379,712	$ 391,934	$ 439,945	$ 488,649	$ 426,663	$ 440,176
$ 429,146	$ 423,892	$ 433,975	$ 458,054	$ 481,282	$ 411,342	$ 431,039	$ 466,434	$ 448,524	$ 426,062	$ 310,857
$ 353,297	$ 336,066	$ 372,717	$ 405,484	$ 364,594	$ 256,327	$ 357,217	$ 344,503	$ 434,248	$ 385,432	$ 276,379
$ 343,039	$ 342,931	$ 383,218	$ 308,363	$ 367,798	$ 288,309	$ 333,520	$ 358,278	$ 354,261	$ 391,833	$ 301,883
$ 309,743	$ 296,424	$ 341,733	$ 248,712	$ 389,145	$ 310,181	$ 385,172	$ 281,333	$ 241,266	$ 240,265	$ 363,202
$ 292,601	$ 317,098	$ 248,295	$ 216,018	$ 272,194	$ 292,675	$ 282,080	$ 308,228	$ 330,988	$ 357,844	$ 300,590
$ 292,237	$ 252,638	$ 292,524	$ 236,985	$ 309,455	$ 348,262	$ 312,751	$ 302,296	$ 308,461	$ 241,616	$ 317,381
$ 245,539	$ 203,766	$ 254,210	$ 256,569	$ 216,711	$ 221,900	$ 187,808	$ 265,793	$ 286,180	$ 303,632	$ 258,822
$ 238,224	$ 260,133	$ 205,191	$ 264,653	$ 233,085	$ 219,283	$ 225,664	$ 222,981	$ 255,419	$ 259,263	$ 236,566
$ 214,488	$ 182,761	$ 221,288	$ 231,433	$ 208,200	$ 202,671	$ 181,713	$ 248,489	$ 236,360	$ 182,805	$ 249,158
$ 187,872	$ 162,473	$ 179,995	$ 183,368	$ 195,317	$ 179,255	$ 235,092	$ 212,778	$ 201,302	$ 182,648	$ 146,493
$ 172,476	$ 197,388	$ 196,022	$ 175,231	$ 143,626	$ 131,959	$ 186,822	$ 167,377	$ 204,749	$ 191,185	$ 130,403
$ 161,033	$ 179,956	$ 173,447	$ 185,643	$ 145,152	$ 153,761	$ 166,115	$ 118,606	$ 162,895	$ 168,757	$ 156,001
$ 152,978	$ 137,634	$ 162,750	$ 128,773	$ 183,862	$ 139,701	$ 131,194	$ 144,381	$ 182,716	$ 158,182	$ 160,587
$ 143,716	$ 156,823	$ 149,319	$ 139,716	$ 142,396	$ 157,701	$ 120,971	$ 152,788	$ 136,425	$ 134,192	$ 146,832
$ 129,421	$ 117,669	$ 139,478	$ 109,745	$ 137,143	$ 147,787	$ 101,875	$ 143,227	$ 139,052	$ 125,415	$ 132,817
$ 115,673	$ 107,931	$ 142,844	$ 108,286	$ 105,765	$ 115,849	$ 110,199	$ 91,653	$ 120,941	$ 110,959	$ 142,300
$ 106,995	$ 128,840	$ 115,508	$ 137,452	$ 89,625	$ 99,604	$ 90,782	$ 106,837	$ 105,248	$ 106,382	$ 89,672
$ 88,836	$ 78,910	$ 87,834	$ 70,168	$ 115,201	$ 93,428	$ 88,125	$ 96,479	$ 99,335	$ 74,081	$ 84,795
$ 99,385	$ 106,333	$ 99,254	$ 108,599	$ 91,519	$ 88,089	$ 116,126	$ 120,421	$ 68,015	$ 106,472	$ 89,023

Table 26. The Simulation Results of Loss Cost for the “as-is” Scenario

MSC (one year)				
Receving	Inspection	Storing	C&C	Total
$66,000.00	$ 66,000.00	$ 1,583,400.00	$ 4,550.00	$ 1,719,950.00

SSC (one year)		
Storing	C&C	Total
$592,200.00	$ 4,550.00	$596,750.00

Table 27. Labor Cost Calculations for the "as-is" Scenario

MSC (one year)				
Receving	Inspection	Storing	C&C	Total
$ 12,000.00	$ 66,000.00	$ 1,095,000.00	$ -	$ 1,173,000.00

SSC (one year)		
Storing	C&C	Total
$423,000.00	$ -	$423,000.00

Table 28. Labor Cost Calculations for the "to-be" Scenario

Year	1	2	3	4	5	6	7	8	9	10
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
MSC										
Total Annual Labor Cost (Current Year)	$ 1,719,950	$ 1,719,950	$ 1,719,950	$ 1,719,950	$ 1,719,950	$ 1,719,950	$ 1,719,950	$ 1,719,950	$ 1,719,950	$ 1,719,950
Total Annual Labor Cost(Inc Inflation)	$ 1,840,347	$ 1,969,171	$ 2,107,013	$ 2,254,504	$ 2,412,319	$ 2,581,181	$ 2,761,864	$ 2,955,194	$ 3,162,058	$ 3,383,402
Total Annual Labor Cost PV (2009)	$ 1,586,506	$ 1,463,415	$ 1,349,874	$ 1,245,142	$ 1,148,536	$ 1,059,426	$ 977,229	$ 901,409	$ 831,473	$ 766,962
SSC										
Total Annual Labor Cost (Current Year)	$ 596,750	$ 596,750	$ 596,750	$ 596,750	$ 596,750	$ 596,750	$ 596,750	$ 596,750	$ 596,750	$ 596,750
Total Annual Labor Cost (Inc Inflation)	$ 638,523	$ 683,219	$ 731,044	$ 782,218	$ 836,973	$ 895,561	$ 958,250	$ 1,025,328	$ 1,097,101	$ 1,173,898
Total Annual Labor Cost PV (2009)	$ 550,450	$ 507,743	$ 468,349	$ 432,012	$ 398,494	$ 367,576	$ 339,057	$ 312,751	$ 288,486	$ 266,103
Total SSCs Annual Labor Cost	$ 6,605,405	$ 6,092,917	$ 5,620,191	$ 5,184,141	$ 4,781,923	$ 4,410,912	$ 4,068,686	$ 3,753,012	$ 3,461,830	$ 3,193,240
Total Annual Labor Cost (MSC+SSCs)	$ 8,191,911	$ 7,556,331	$ 6,970,064	$ 6,429,284	$ 5,930,460	$ 5,470,338	$ 5,045,915	$ 4,654,422	$ 4,293,303	$ 3,960,202

Year	11	12	13	14	15	16	17	18	19	20	
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	
MSC											
Total Annual Labor Cost (Current Year)	$ 1,719,950	$ 1,719,950	$ 1,719,950	$ 1,719,950	$ 1,719,950	$ 1,719,950	$ 1,719,950	$ 1,719,950	$ 1,719,950	$ 1,719,950	Total
Total Annual Labor Cost(Inc Inflation)	$ 3,620,240	$ 3,873,657	$ 4,144,813	$ 4,434,950	$ 4,745,396	$ 5,077,574	$ 5,433,004	$ 5,813,315	$ 6,220,247	$ 6,655,664	$ 75,445,911
Total Annual Labor Cost PV (2009)	$ 707,456	$ 652,567	$ 601,937	$ 555,235	$ 512,156	$ 472,420	$ 435,767	$ 401,957	$ 370,771	$ 342,004	$ 16,382,243
SSC											
Total Annual Labor Cost (Current Year)	$ 596,750	$ 596,750	$ 596,750	$ 596,750	$ 596,750	$ 596,750	$ 596,750	$ 596,750	$ 596,750	$ 596,750	Total
Total Annual Labor Cost (Inc Inflation)	$ 1,256,070	$ 1,343,995	$ 1,438,075	$ 1,538,740	$ 1,646,452	$ 1,761,704	$ 1,885,023	$ 2,016,975	$ 2,158,163	$ 2,309,234	$ 26,176,544
Total Annual Labor Cost PV (2009)	$ 245,457	$ 226,413	$ 208,847	$ 192,643	$ 177,697	$ 163,910	$ 151,193	$ 139,462	$ 128,642	$ 118,661	$ 5,683,946
Total SSCs Annual Labor Cost	$ 2,945,489	$ 2,716,959	$ 2,506,161	$ 2,311,717	$ 2,132,360	$ 1,966,918	$ 1,814,312	$ 1,673,547	$ 1,543,703	$ 1,423,933	$ 68,207,356
Total Annual Labor Cost (MSC+SSCs)	$ 3,652,945	$ 3,369,527	$ 3,108,098	$ 2,866,952	$ 2,644,516	$ 2,439,338	$ 2,250,079	$ 2,075,504	$ 1,914,474	$ 1,765,937	$ 84,589,600

Table 29. Labor Cost for the “as-is” Scenario

Year	1	2	3	4	5	6	7	8	9	10
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
MSC										
Total Annual Labor Cost (Current Year)	$ 1,173,000	$ 1,173,000	$ 1,173,000	$ 1,173,000	$ 1,173,000	$ 1,173,000	$ 1,173,000	$ 1,173,000	$ 1,173,000	$ 1,173,000
Total Annual Labor Cost(Inc Inflation)	$ 1,255,110	$ 1,342,968	$ 1,436,975	$ 1,537,564	$ 1,645,193	$ 1,760,357	$ 1,883,582	$ 2,015,432	$ 2,156,513	$ 2,307,469
Total Annual Labor Cost PV (2009)	$ 1,081,991	$ 998,044	$ 920,609	$ 849,183	$ 783,298	$ 722,525	$ 666,467	$ 614,758	$ 567,061	$ 523,065
SSC										
SSCs with RFID	3	7	10	12	12	12	12	12	12	12
SSCs without RFID	9	5	2	0	0	0	0	0	0	0
Total Annual Labor Cost (Current Year)	$ 423,000	$ 423,000	$ 423,000	$ 423,000	$ 423,000	$ 423,000	$ 423,000	$ 423,000	$ 423,000	$ 423,000
Total Annual Labor Cost (Inc Inflation)	$ 452,610	$ 484,293	$ 518,193	$ 554,467	$ 593,279	$ 634,809	$ 679,246	$ 726,793	$ 777,668	$ 832,105
Total Annual Labor Cost PV (2009)	$ 390,181	$ 359,908	$ 331,984	$ 306,227	$ 282,468	$ 260,552	$ 240,337	$ 221,690	$ 204,490	$ 188,625
Total SSCs Annual Labor Cost with RFID	$ 1,170,543	$ 2,519,359	$ 3,319,844	$ 3,674,724	$ 3,389,616	$ 3,126,629	$ 2,884,046	$ 2,660,284	$ 2,453,882	$ 2,263,495
Total SSCs Annual Labor Cost without RFID	$ 4,954,054	$ 2,538,715	$ 936,698	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total SSCs Annual Labor Cost	$ 6,124,597	$ 5,058,074	$ 4,256,543	$ 3,674,724	$ 3,389,616	$ 3,126,629	$ 2,884,046	$ 2,660,284	$ 2,453,882	$ 2,263,495
Total Annual Labor Cost (MSC+SSCs)	$ 7,206,588	$ 6,056,118	$ 5,177,152	$ 4,523,907	$ 4,172,914	$ 3,849,154	$ 3,550,512	$ 3,275,042	$ 3,020,944	$ 2,786,560

Year	11	12	13	14	15	16	17	18	19	20	
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	
MSC											
Total Annual Labor Cost (Current Year)	$ 1,173,000	$ 1,173,000	$ 1,173,000	$ 1,173,000	$ 1,173,000	$ 1,173,000	$ 1,173,000	$ 1,173,000	$ 1,173,000	$ 1,173,000	Total
Total Annual Labor Cost(Inc Inflation)	$ 2,468,991	$ 2,641,821	$ 2,826,748	$ 3,024,621	$ 3,236,344	$ 3,462,888	$ 3,705,290	$ 3,964,661	$ 4,242,187	$ 4,539,140	$ 51,453,852
Total Annual Labor Cost PV (2009)	$ 482,483	$ 445,049	$ 410,519	$ 378,668	$ 349,289	$ 322,189	$ 297,192	$ 274,134	$ 252,865	$ 233,246	$ 11,172,634
SSC											
SSCs with RFID	12	12	12	12	12	12	12	12	12	12	
SSCs without RFID	0	0	0	0	0	0	0	0	0	0	
Total Annual Labor Cost (Current Year)	$ 423,000	$ 423,000	$ 423,000	$ 423,000	$ 423,000	$ 423,000	$ 423,000	$ 423,000	$ 423,000	$ 423,000	Total
Total Annual Labor Cost (Inc Inflation)	$ 890,352	$ 952,677	$ 1,019,364	$ 1,090,720	$ 1,167,070	$ 1,248,765	$ 1,336,179	$ 1,429,711	$ 1,529,791	$ 1,636,877	$ 18,554,970
Total Annual Labor Cost PV (2009)	$ 173,990	$ 160,491	$ 148,039	$ 136,553	$ 125,958	$ 116,186	$ 107,171	$ 98,856	$ 91,186	$ 84,112	$ 4,029,006
Total SSCs Annual Labor Cost with RFID	$ 2,087,879	$ 1,925,888	$ 1,776,466	$ 1,638,637	$ 1,511,501	$ 1,394,229	$ 1,286,056	$ 1,186,276	$ 1,094,237	$ 1,009,340	$ 42,372,932
Total SSCs Annual Labor Cost without RFID	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 8,429,468
Total SSCs Annual Labor Cost	$ 2,087,879	$ 1,925,888	$ 1,776,466	$ 1,638,637	$ 1,511,501	$ 1,394,229	$ 1,286,056	$ 1,186,276	$ 1,094,237	$ 1,009,340	$ 50,802,399
Total Annual Labor Cost (MSC+SSCs)	$ 2,570,361	$ 2,370,937	$ 2,186,985	$ 2,017,305	$ 1,860,790	$ 1,716,418	$ 1,583,248	$ 1,460,410	$ 1,347,102	$ 1,242,586	$ 61,975,033

Table 30. Labor Cost for the “to-be” Scenario

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF REFERENCES

Bhuptani, M., & Moradpour, S. (2005). RFID Field Guide. New Jersey: Sun Microsystems Press.

Bhuptani, M., & Moradpour, S. (2005). RFID Field Guide Deploying RFID Systems. USA: Prentice Hall.

Brealey, R. A., Myers, S. C., & Allen, F. (2008). Principles of Corporate Finance. New York: McGraw-Hill.

Brown, D. E. (2007). RFID Implementation. The McGraw-Hill Companies.

Chavadi, C. A., & Kokatnur, S. S. (2009). RFID Adoption by Indian Retailers: An Exploratory Study. The Icfai University Journal of Supply Chain Management , 6 (1), 60-77. Retrieved May 7, 2009, from EBSCO database.

Cost Effectiveness Analysis. (2009, July 20). Retrieved July 21, 2009, from Wikipedia: http://en.wikipedia.org/wiki/Cost-effectiveness

Crimean War. (n.d.). Retrieved June 1, 2009, from Wikipedia: http://en.wikipedia.org/wiki/Crimean_War

FKILogistex. (2005). RFID for the Real World. Retrieved October 12, 2008, from RFID Journal: http://www.rfidjournal.com/whitepapers/1/4

Garrison, R. H., Noreen, E. W., & Brewer, P. C. (2008). Managerial Accounting. New York: McGraw-Hill.

Gaukler, G. M., Seifert, R. W., & Warren, H. H. (2007). Item-level RFID in the retail supply chain. Production and Operations Management , 16 (1), 65–76. Retrieved May 4, 2009, from EBSCO database.

Ghiani, G., Laporte, G., & Roberto, M. (2004). Introduction to Logistics Systems Planning and Contol. England: John Wiley & Sons.

Jacobs, F. R., Chase, R. B., & Aquilano, N. J. (2009). Operations & Supply Management. New York: McGraw-Hill/Irwin.

Jaska, P., & Reyes, P. M. (2007). Is RFID right for your organization or application? Management Research News , 30 (8), 570–580. Retrieved May 28, 2009, from EBSCO database.

Jones, E. C., & Chung, C. A. (2007). RFID in Logistics.

Jones, J. (2006). Integrated Logistics Support Handbook. USA: McGraw-Hill Sole Press.

Katina, M., & Luke, M. (2005). The Pros and Cons of RFID in Supply Chain Management. IEEE , 2–3.

Klimczyk, L. (2008, November). The chartered institute of logistics and tranports. Retrieved May 25, 2009, from http://www.ciltuk.org.uk

Lahiri, S. (2005). RFID Sourcebook. New Jersey: IBM Press.

Military Logistics: A Brief History. (n.d.). Retrieved May 26, 2009, from http://www.historyofwar.org/main.html

Myerson, J. M. (2006). RFID in the supply chain: A guide to selection and implementation. Boca Raton, FL, USA: Taylor & Francis Group.

NPV Definition. (n.d.). Retrieved july 22, 2009, from BusinessDictionary: http://www.businessdictionary.com/definition/net-present-value-NPV.html

Office of Aerospace Studies. (2004). AoA Hanbook. Kirtland: Airforce Materiel Command.

OlimpicDataCapture. (2009). What is RFID. Retrieved October 23, 2009, from Olimpic Data Capture: http://www.olympic-data-capture.com/rfid.htm

Openlearn. (2007). Understanding RFID Tags. Retrieved November 25, 2009, from Openlearn Learning Space: http://openlearn.open.ac.uk/mod/resource/view.php?id=182400

Poirier, C., & Duncan, M. (2006). RFID Strategic Implementation and ROI. Fort Lauderdale, FL, USA: J.Ross Publishing.

Randal, G. (2007, July 31). RFID applications: Determining the total cost of ownership. Retrieved May 15, 2009, from articlesbase.com: http://articlesbase.com/print/191136

RFID Journal. (2007). RIFD Components. Retrieved June 2, 2009, from RFID Journal: http://www.rfidjournal.com/article/view/1336/1/129

RFID System Components and Costs. (n.d.). Retrieved June 2, 2009, from RFID Journal: http://www.rfidjournal.com/article/view/1336/1/129

RFID-Journal. (2009). The History of RFID Technology. Retrieved from RFID Journal: http://www.rfidjournal.com/article/view/1338/1/129

SaviTechnology. (2003). Case Study: Operation Enduring Freedom / Operation Iraqi Freedom (OEF/OIF). Retrieved January 8, 2009, from m2mpremier: http://www.m2mpremier.com/UploadFiles/Savi%20Technology3.pdf

Seymour, L. F., Lambert-Porter, E., & Willuweit, L. (2008). Towards a framework for RFID adoption into container supply chain. Journal of Information Science and Technology , 5 (1), 31–46.

Solidsoft. (2006). RFID: An Introduction. RFID Journal , 23–24.

Stokey, E., & Zeckhauser, R. (1978). A primer for policy analysis. New York, New York, USA: Norton&Company.

Sweeney II, P. J. (2005). RFID for Dummies. Hoboken, NJ, USA: Wiley Publishing.

Szmerekovsky, J. G., & Zhang, J. (2008). Coordination and adoption of item-level RFID with vendor managed inventory. International Journal of Production Economics , 114, 388–398. Retrieved May 15, 2009, from ProQuest database.

TAF. (2006). Retrieved January 7, 2010, from Milli Savunma Bakanligi: www.msb.gov.tr/birimler/kalite/doc/msy331_1(B)_mal_alimlari_tamami.pdf

Tedjasaputra, A. (2006). RFID Antenna. Retrieved from RFiD Asia: http://www.rfidconsultation.eu/docs/ficheiros/tedjasaputra_rfid_antenna_design_innovation.pdf

US Logistics Costs Top 10% of GDP. (2008, June 26). Retrieved March 16, 2010, from Logistics Today: http://logisticstoday.com/operations_strategy/us_logistics_costs_0626/

Vance, A. (2003). Get this RFID tag off my fatigues. Retrieved 2009, from The Register: http://www.theregister.co.uk/2003/10/28/get_this_rfid_tag_off/

Vijayan, J. (2003, September 1). Use of RFID raises privacy concern. Retrieved January 10, 2009, from Computerword Security: http://www.computerworld.com/s/article/84515/Use_of_RFID_Raises_Privacy_Concerns

THIS PAGE INTENTIONALLY LEFT BLANK

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Ft. Belvoir, Virginia

2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California

3. Kara Harp Okulu Savunma Bilimleri Enstitusu
   Bakanliklar, Ankara, Turkey

4. Deniz Harp Okulu Deniz Bilimleri Enstitusu
   Tuzla, 34942
   Istanbul, Turkey

5. Geraldo Ferrer
   Naval Postgraduate School
   Monterey, California

6. Keebom Kang
   Naval Postgraduate School
   Monterey, California

7. Genelkurmay Baskanligi Kutuphanesi
   Bakanliklar, 06100
   Ankara, Turkey

8. Kara Kuvvetleri Komutanligi Kutuphanesi
   Bakanliklar, 06100
   Ankara, Turkey

9. Deniz Kuvvetleri Komutanligi Kutuphanesi
   Bakanliklar, 06100
   Ankara, Turkey

10. Hava Kuvvetleri Komutanligi Kutuphanesi
    Bakanliklar, 06100
    Ankara, Turkey

11. Harp Akademileri Komutanligi Kutuphanesi,
    Yenilevent, 34334
    Istanbul, Turkey

12. MSB Savunma Sanayi Mustesarligi
Balgat, 06520
Ankara, Turkey

13. Ahmet Ozdemir
Kara Kuvvetleri Lojistik Komutanligi,
Gumusdere, Ankara, Turkey

14. Mustafa Bayrak
Deniz Kuvvetleri Komutanligi,
Bakanliklar, 06100
Ankara, Turkey