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Feasibility of Radio Frequency Identification (RFID) and Item Unique Identification (IUID) in the Marine Corps Small Arms Weapons Tracking System

04 December 2008

by

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Abstract

The purpose of this MBA project is to determine how effective the use of RFID and IUID can be in Marine Corps armories based on operating procedures, support of key organizations within the Departments of the Navy and the Marine Corps, and current research. This project's first objective is to examine the involvement, progress and procedures of organizations that are involved in supporting and improving the Marine Corps' armory processes. The second objective is to explore the feasibility of implementing RFID and/or UID technology into the current Marine Corps small arms tracking system based on current research. The researchers will determine feasibility and compatibility by examining the existing organizations, current business processes and information technology systems. The third objective is to examine the current research about the use of RFID and UID technology with small arms. The final objective is to provide recommendations for implementation of these technologies in the Marine Corps armory system.

Keywords: RFID, IUID, USMC, USN, implementation

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List of Acronyms

ACOG	Advanced Combat Optical Gun sight (ACOG)
ANAD	Anniston Army Depot
Ao	Operation Availability
AIT	Automatic Information Technology
ASCII	American Standard Code for Information Interchange
ATLASS	Asset Tracking Logistics and Supply System
AUTO ID	Automatic Identification
CAC	Common Access Card
CAGE	Commercial and Government Entity
CBA	Cost Benefit Analysis
CMR	Consolidated Memorandum Receipts
CONUS	Continental United States
C2	Command and Control
DFARS	*Defense Federal Acquisition Regulation Supplement*
DIS	Depot Information System
DoD	Department of Defense
DoN	Department of Navy
DPM	Direct Part Marking
DRMO	Depot Repair Maintenance Organization
DUNS	Data Universal Numbering System
ERP	Enterprise Resource Planning
FEDLOG	Federal Logistics Data
FSD	Fleet Support Department
GABF	General Accounting Balance Files
GCSS-MC	Global Combat Support System—Marine Corps
G/S	Group Separator
HF	High Frequency
HQMC	Headquarters Marine Corps
IC	Integrated Circuits

IEC	International Electrotechnical Commission
IFF	Identify Friend or Foe
ISO	International Standards Organization
IT	Information Technology
ITB	Infantry Training Battalion
IUID	Item Unique Identification
JAMISS	Joint Asset Maintenance Integrated Support System
JSACG	Joint Small Arms Coordinating Group
LF	Low Frequency
LCM	Logistics Chain Management
LOG	Logistics
LOG OA	Logistics Operational Architecture
LOGCOM	Logistics Command
MAGTF	Marine Air Ground Task Force
MAL	Mechanized Allowance List
MC	Mission Capable
MCLB	Marine Corps Logistic Base
MCTB	Marine Combat Training Battalion
MDT	Mean Down Time
MERIT	Marine Corps Equipment Readiness Information Tool
MFS	Mobile Field Service
MIMMS	Maintenance Management System
MMP	Maintenance Management Programs
MOWASP	Mechanization of Warehousing and Shipment Procedures
MTBF	Mean Time between Failure
MTBM	Mean Time between Maintenance
$MTBM_s$	Mean Time between Maintenance (Scheduled)
$MTBM_u$	Mean Time between Maintenance (Unscheduled)
NASA	National Aeronautics and Space Administration
NAVSEA	Naval Sea Systems Command
NIPRNET	Non-secure Internet Protocol Router Network

NSN	National Stock Number
NWSC	Navy Warfare Surface Center
OSD-SCI	Office Under Secretary of Defense—Supply Chain Integration
PEB	Pre-expended Bin
QC	Quality Control
RADAR	Radio Detection and Ranging
RFID	Radio Frequency Identification
RO	Read Only
ROI	Return on Investment
RW	Read/Write
SASSY	Supported Activities Supply System
SAUCD	Small Arms Use Case Demonstration
SAW	Squad Automatic Weapon
SIPRNET	Secure Inter-net Protocol Router Network
SMU	SASSY (Supported Activities Supply System) Management Unit
SNCO	Staff Non-commissioned Officer
SOI	School of Infantry
TAV	Total Asset Visibility
TCN	Transportation Control Number
TMO	Transportation Management Office
UHF	Ultra High Frequency
UID	Unique Identification
UII	Unique Item Identifier
UK	United Kingdom
WORM	Write One/Read Many
WSF	Weapons Serial File
2D	Two-dimensional

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I. Introduction

The current Marine Corps armory inventory system and procedures are manually intensive. Managers at the unit level believe that Radio Frequency Identification (RFID) and Unique Identification (UID) can improve supply chain management and inventory control of armory assets. The Marine Corps needs to adopt better technology to improve issuing, receiving and inventory processing within its armories. UID and RFID technology are possible options that can improve the Marine Corps armory processes. The capabilities of both technologies require analysis to determine feasibility before decision-makers choose either of them. The Department of Defense (DoD) requirements, organizations and military systems affect the success of RFID and UID tag implementation within Marine Corps armories, so these factors require examination.

In 2003, the DoD mandated that RFID tag usage is required from all 43,000 of its suppliers, with the expectation that RFID tags are to be fully implemented by 2008. In the same year, the DoD mandated that UID tags be placed on new equipment, major modifications and reprocurement of equipment/spares. This was done to better track worldwide military assets and their value. UID was designed to improve item lifecycle management, accountability, asset visibility, data quality and interoperability.

Currently, Marine Corps armories suffer from long processing times in the inventory and issue of assets. The accuracy of records and transactions are affected by human error during transcription. The actions enacted on armory assets effects numerous logistic sections throughout the Marine Corps.

RFID or UID tags can be attached to small arms weapons in Marine Corps armories. Once attached, an RFID or UID reader can be used to quickly inventory the weapons. The use of RFID and/or UID tags, along with a reader, can significantly reduce the time required for an inventory. The middleware with which the reader communicates can update current Marine Corps inventory systems as well as the Navy Warfare Surface Center (NWSC) Crane online report system. However, certain conditions may interfere with the functionality of either technology. Therefore, before choosing an RFID or UID system, an organization must identify its needs and analyze various programs and directives.

This study attempts to utilize existing studies, site visits, comparative analysis and a survey in order to determine if and how the use of RFID and UID tags can be used to facilitate the inventory process of small arm assets in Marine Corps armories.

Existing studies consisting of literature reviews, books, magazine articles and military tests were used to secure useful information on the subject matter. The existing studies cover the basic uses and description of RFID and UID technology. Previous tests and evaluations of RFID and UID tags were examined to provide further information about each product's capabilities. In addition, DoD policy and mandates were reviewed regarding implementation of RFID and UID technology. Careful attention was paid to the format of each study in order to verify the legitimacy of its findings and conclusions.

Throughout the thesis, information from existing DoD, Navy and Marine Corps systems and concepts was gathered to compare and analyze the effectiveness of RFID and UID in Marine Corps armories. The Joint Asset Maintenance Integrated Support System (JAMISS) was reviewed as a possible solution to the integration of UID or RFID in Marine Corps armories. The DoD Concept of Operations for UID was studied to compare its vision to the actual implementation of UID in the Marine Corps. Finally, a report from the Government Accounting Office (GAO) and capability information pertaining to the future Marine Corps logistics platform Global Combat Support System Marine Corps (GCSS-MC) was used to review the impact of time on the implementation of UID in the Marine Corps.

Several site visits were conducted at key military installations. These visits were conducted to gain a better understanding of agency procedures and to gather information on the implementation of RFID and UID tags in the Marine Corps. NWSC Crane was visited in order to review the process of the Crane Report and to obtain information on its data-processing system. LOGCOM, Albany, was visited to review the process flow of armory assets from weapon manufactures to the Marine Corps and to gain insight on the usage of UID and/or RFID tags at LOGCOM. Finally, Marine Corps Base Camp Pendleton was visited to issue surveys pertaining to the usage and durability of UID tag markings on small arm assets.

The goal of this thesis is to determine if, with current systems, UID tags are an effective application to improve the inventory and issuing processes of Marine Corps armories. The thesis will also compare RFID and UID tags in order to establish which product is more suitable to improve the processes within Marine Corps armories. Lastly, the thesis team hopes to offer recommendations that will assist in the application of products that will improve the inventory and issuing processes in Marine Corps armories.

The thesis is divided into chapters that develop the examination of RFID and UID technologies and their application within Marine Corps armories. Chapter 2 discusses the Marine Corps armory and provides a technology review, which includes a description of the different inventory processes required of Marine Corps armories. Additionally, the chapter also includes a history of, and describes the components, uses, benefits and challenges of UID and RFID tags. Chapter 3 reviews the organizations, systems and operations of the DoD, Navy and Marine Corps associated with weapon usage and tracking within the Marine Corps. Chapter 4 is a review and analysis of existing studies pertaining to RFID and UID testing. Chapter 5 is an assessment of current Item Unique Identification (IUID) implantation efforts in the DoD and additionally reviews and analyzes the current processes and concepts within the DoD, Marine Corps and Navy. Chapter 6 consists of an analysis of RFID vs. IUID, operation availability and a questionnaire presented to random armories located on Marine Corps Base Camp Pendleton. In Chapter 7, the final chapter, the thesis team presents recommendations for various organizations within the Marine Corps on ways to improve the application of UID and/or RFID.

II. Marine Corps Armory and Technology Review

The small arms armories throughout the Marine Corps have established procedures to maintain accountability of their assets. These procedures have remained the same throughout the years; many of them are transcribed by hand and are labor intensive. For these reasons, the processes require a considerable amount of time to complete. The next sections cover the Marine Corps' small arms inventorying process, reporting procedures, the history of RFID, and a basic introduction to RFID and UID technology.

A. Marine Corps Armory Inventory Processes

The conventional inventory process within Marine Corps armories needs to be updated. The use of RFID and UID technology has the potential to improve this process. RFID is a system of tags and antennas that can be used to track and record location of assets, whereas UID are tags that contain static information about the item that can be used to provide Total Asset Visibility (TAV) and real-time access to information pertaining to current military assets. Organizations within Marine Corps and the Department of the Navy are testing both of these technologies, conducting research, and lobbying for programs to improve inventory procedures. However, the organizations do not appear to be communicating or combining their efforts.

The inventory process for a Marine Corps armory can be broken down into three methods: daily, monthly, and annual inventory processes.

1. Daily Inventory Process

The Marine Corps has many small arm weapons armories that contain weapons of varying types that require inventory on a daily, monthly, and annual basis. A substantial amount of time and manpower is required to inventory these assets. Each day, an armorer counts all the weapons to ensure that all of them are properly accounted for by the armory, no matter where the weapon might be located or to whom it is issued. Any armorer within the armory can perform the daily inventory process. This inventory process is verified against the known on-hand quantity. If there is a discrepancy, it is immediately checked against any weapon-issuing documentation. If an asset cannot be found, the chain of command is notified, and all training is halted to conduct a search for the weapon.

2. Monthly Inventory Process

Each month, a Staff Non-commissioned Officer (SNCO) is selected to conduct an inventory of all the weapons by serial number within the armory. This process is described below and shown in Figure 1. It may take between several hours and several weeks, depending on the number of weapons within the armory. The SNCO is provided with a copy of the Consolidated Memorandum of Receipts (CMR) from the unit’s supply section. The CMR lists each weapon by item description or nomenclature, quantity, and serial number. During the inventory, the SNCO usually selects a junior Marine to assist him or her. The junior Marine goes from weapon to weapon reading the serial number, which the SNCO annotates in the CMR. If there are any changes, the SNCO annotates them on the CMR. Once the SNCO completes the inventory, he or she compiles the results and submits them to the unit’s supply section via the Logistics Officer. The supply section then compares the results of the current inventory to the one conducted during the previous month, to ensure that supply records reflect the inventory results. If the records do not match, a reconciliation is conducted to discover the reason. The supply section then makes the necessary changes to the CMR, and a cover letter annotating the changes is submitted to the Commanding Officer for his signature.

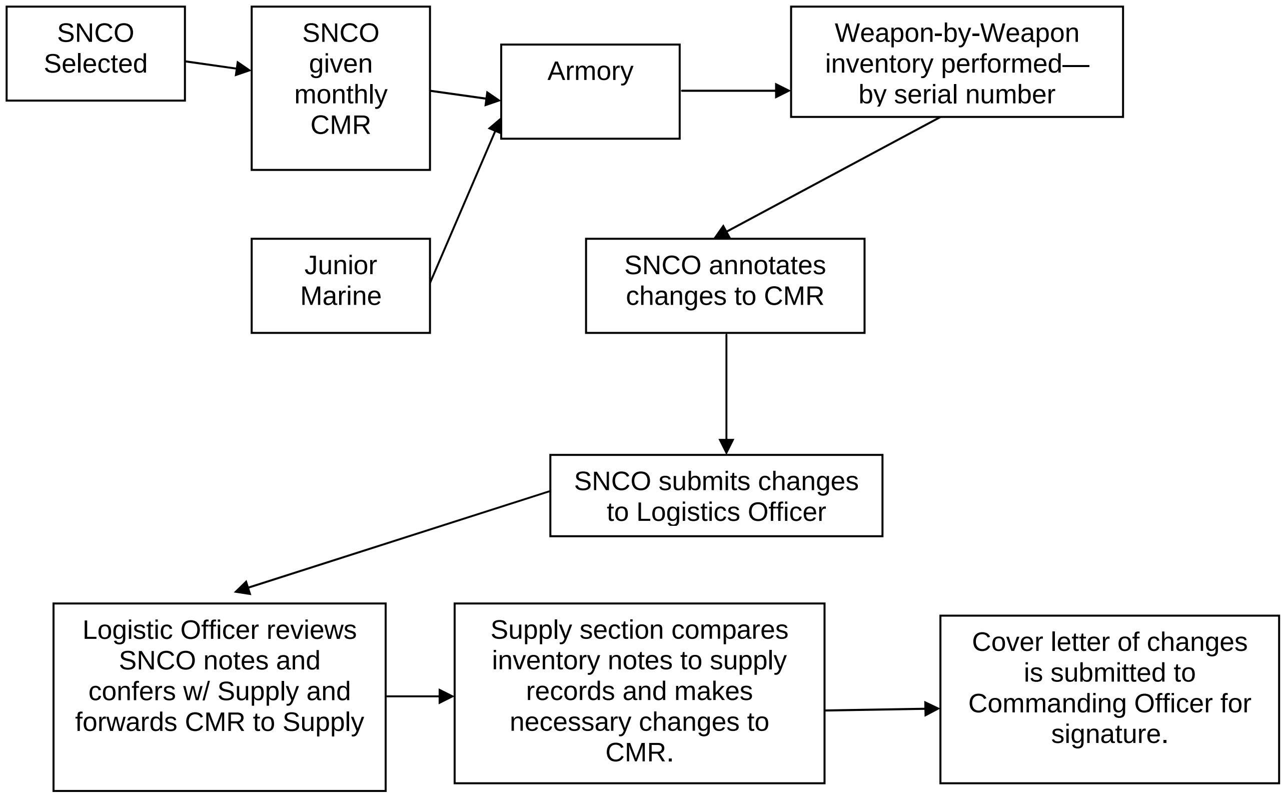

Figure 1. Marine Corps Armory Monthly Inventory Process

This process requires recruiting an SNCO, who has a primary job elsewhere, to step away from that job and conduct the inventory. While that SNCO is away, the capacity of his or her primary section is reduced. The primary section could be an Infantry company, Administrative section, Communication section or any other section (except the Supply section because it would be a conflict of interest). The use of RFID and/or UID tags could reduce the time required to conduct an inventory, and a great portion of that capacity could be returned to the primary section.

3. Annual Inventory Process

On an annual basis, the Supply section receives a consolidated inventory list of weapons that the unit possesses from NWSC Crane, Indiana. This report is called the Crane report. On receipt of this report, the unit must review and reconcile the Crane report against the CMR to ensure accountability. It does not require a physical inventory as is required by the monthly armory inventory. The Crane report needs to be signed by the unit's Commanding Officer, and should be returned to the NWSC Crane within 45 days with any changes and supporting documentation, as seen in Figure 2.

Throughout the year, the unit is required to submit weapons transfers and serial number and quantity changes to NWSC Crane. These changes are submitted via fax or by scanned documentation from each unit that has an armory within the Marine Corps. Once NWSC Crane receives the documentation, it must be manually entered into the database to update the system. Changes submitted to NWSC Crane may not be reflected in its database online for months, which would directly result in the individual units receiving their Crane report with outdated serial numbers and quantities. If the report contains incorrect information, the unit must contact NWSC Crane to verify if the changes were initially received. If they were received, the unit must wait until NWSC Crane processes the changes. If NWSC Crane did not receive the initial changes, the unit must resubmit them. Implementing an automated RFID/UID inventory system at the unit level to automatically update the database could significantly reduce the processing time at NWSC Crane.

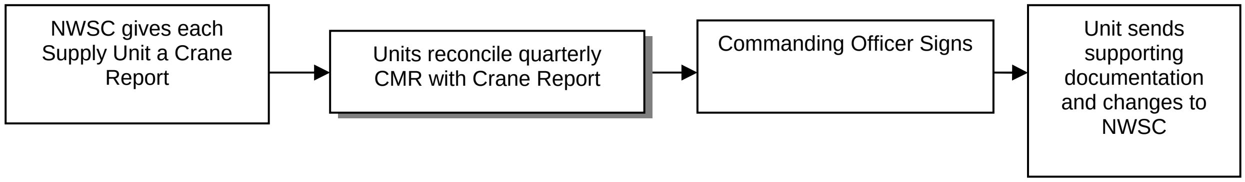

Figure 2. Marine Corps Armory Annual Inventory Process

B. RFID

RFID is considered part of the group of Automatic Identification (Auto ID) technologies. An RFID tag is an item that transmits the identity of an object (and its unique serial number) using radio waves. Barcodes, optical character readers, and retinal scans are also part of a long list of Auto ID. Many businesses have sought these technologies to reduce the time and labor required to input data and to improve data accuracy (Bhuptani & Moradpour, 2005, pp. 20, 42). In the following sections, the thesis group will discuss the history of RFID, RFID system components, uses for RFID, and the benefits and challenges of RFID.

1. History of RFID

The origin of RFID can be traced to World War II. The Americans, British, Japanese, and Germans were using Radio Detection and Ranging (RADAR) to search for approaching aircraft. The problem with RADAR was that there was no way to identify which aircraft belonged to which country. The British quickly solved this problem when British scientist Watson-Watt designed the Identify Friend or Foe (IFF) system by allowing RADAR to pick up a transponder signal located on the aircraft (Landt, 2001). In the 1950s and 1960s, passive RFID technology continued to grow radio transmission systems. In the 1960s, Electronic Article Surveillance (EAS) or "1-bit" tags were developed as an anti-theft device. EAS proved to be the first commercial application of RFID use (2001). In the 1970s, RFID was developed for animal tracking, vehicle tracking and factory automation. In the 1980s, RFID companies began to grow due to the increased commercial applications of the technology. Toll roads are one example of commercial application of RFID that was used in Europe and in the United States. In the 1990s, RFID began to be used in applications such as ski passes and vehicle access. In the northeastern United States, the E-Z Pass system was developed for drivers to drive at normal speeds through a toll plaza and be billed later (2001). Today's RFID technology can be seen in everyday applications and in almost every small portable electronic device. Displayed in Figure 3 are systems, devices and interfaces that have active RFID technology.

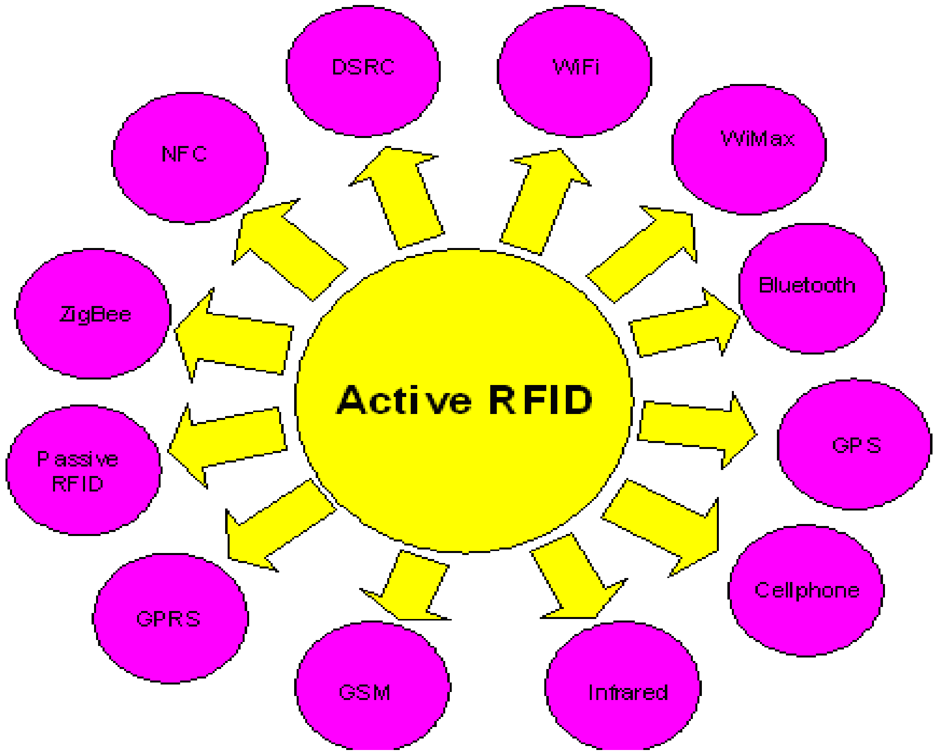

Figure 3. Active RFID Systems, Interfaces and Devices
(Harrop, 2006)

2. RFID System Components

RFID systems consist of two parts: the RFID tag and reader. The RFID tag carries information about the object and is located on the object to be identified. The RFID reader scans the RFID tag for the encoded information. The RFID reader interprets the information and, if needed, forwards it to a computer system (Finkenzeller, 2003). Most RFID tags consist of a microchip attached to a radio antenna.

a. RFID Tag

The RFID tag is a device attached to an item; it holds information about the item that can then be maintained on/retrieved and enables an item to be tracked. The RFID tag can be of various designs, materials, and/or sizes and hold a variable amount of information. Each tag is composed of three parts: the antenna, the microchip and the casing. There are several different antennas within an RFID system. There is an antenna located on the RFID tag, as identified in Figure 4 and Figure 5.

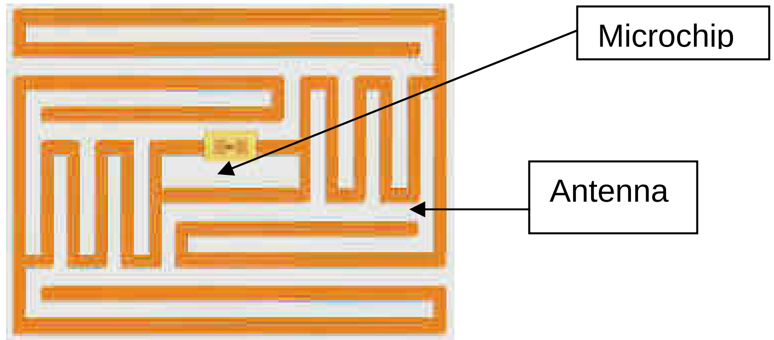

Figure 4. RFID tag

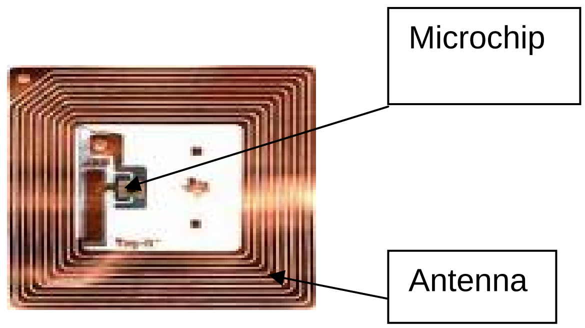

Figure 5. RFID tag

Currently, RFID tags can be active, semi-passive or passive. Active tags contain their own power source in the form of a battery. That power source allows the tag to have a longer read-range, better accuracy, and diverse information exchange, as shown in Table 1. The power onboard active tags allow them to transfer information (without an RFID reader to initiate their power). Due to the battery, active tags cost more than passive tags. Semi-passive tags have a small onboard battery. These tags cannot initiate communication and must be read by an RFID reader. Passive tags do not have batteries and, therefore, require an RFID reader to initiate their power in order to obtain and transfer information (Bhuptani & Moradpour, 2005).

Table 1. Tag Types Passive, Semi-Passive and Active
(Bhuptani & Moradpour, 2005, p. 42)

Tag Type	Frequency Type	Advantages	Limitations	Capabilities/Uses
Passive	All frequencies, especially LF, HF	Best in cost and life span	Identification only, less read range	Anti-theft supply chain management, inventory control, access control, animal tagging
Semi-Passive	All frequencies, especially LF, HF	Better in cost, life span, less sensors	Limited memory, battery dependent	Pallet level of supply chain management, inventory control, environment control
Active	All frequencies, especially UHF, Microwave	High memory, reading range, more sensors	High cost, battery dependent	Inventory management and control, electronic toll collection, real-time location management

Some RFID tags have an Integrated Circuit (IC). The IC is a microprocessor chip that stores information. When a tag is initiated, it can then perform some of the following tasks based on the way it is made (Bhuptani & Moradpour, 2005).

a. Write Once, Read Many (WORM)—The information inscribed on the tag is inscribed in the tag once with the capability of being read many times.

b. Read Only (RO)—The RFID tag can only be read; nothing can be written to the tag.

c. Read, Write (RW)—This tag can have information written to the tag and have the information read from the tag multiple times.

Tags typically have many different memory sizes, varying from 1 bit to several hundred bits. The amount of memory used or available on a tag is usually determined by the tag's application (Bhuptani & Moradpour, 2005). Some microchips are able to store up to 2 kilobytes of data. The chips usually contain information such as type of product, date of shipment, date of manufacture, destination, sell-by date, and expiration date. Tags containing 1-bit memory cards have no unique identifier and only make their presence known when initiated by an RFID reader. The memory on tags is usually extended from 16 bits to several hundred bits. An RFID tag used for inventory purposes would require less memory than an RFID tag which is designed to record, track and analyze information.

Different RFID tags have the capability to measure, monitor, and save information about their environments. RFID tags have the capability to create routine processes and to reduce errors by limiting human intervention. They can also transfer information quickly and continually track the status of items.

b. RFID Readers

An RFID reader retrieves and processes information from the RFID tag. RFID readers typically contain a module (transmitter and receiver), a control unit and a coupling element (antenna). The RFID reader has three main functions: energizing, demodulating and decoding. RFID readers send radio frequencies to tags. For passive tags, the radio frequency is used to energize the passive tag so it can respond back to the RFID reader. Some RFID readers also have the ability to write information to tags. In addition, RFID readers can be fitted with an additional interface that converts the radio waves returned from the RFID tag into a form that can then be passed on to another system, such as a computer or any programmable logic controller. Anti-collision algorithms permit the simultaneous reading of large numbers of tagged objects, while ensuring that each tag is read only once (Head, 2008). RFID readers are usually made in mobile, handheld designs (Figure 6), but can also be stationary portals (Figure 7). Mobile readers are typically used in inventory processes to scan tagged items. Stationary readers are used to scan mobile items passing by (Obellos, Colleran, & Lookabill, 2007). Two good examples of this are a warehouse processing pallets as they are being moved or cars passing through a tollbooth. Individual RFID readers can be mounted on poles or structures to track or record assets with RFID tags such as the ones at tollbooths, as shown in Figure 8 and Figure 9.

Figure 6. Portable RFID Reader

Figure 7. Stationary Motorola RFID Reader

Figure 8. Pole-type RFID Reader

Figure 9. Vehicle Window RFID Tag

3. Uses for RFID

Modern technology has allowed for many advances in the field of electronics. In the past 20 years, RFID technology has had many advances as well. Many of the items that we use everyday are RFID enhanced, though the users may not know it. RFID technology has improved many of today's business applications through improved authentication, access control, people monitoring, environmental sensing and monitoring, convenience, process efficiency, and applications in supply chain management.

a. Authenticate

RFID tags can be embedded in or placed on people, products, equipment, and merchandise to confirm authenticity. This procedure contributes to reduced counterfeiting of products, reduced impersonation and increased security. In addition, the implementation of RFID technology for authentication allows for easier and quicker movement of items and people (Finkenzeller, 2003).

b. Access Control

RFID tags can be placed in carriers such as key chains and cards to provide or deny access to secure areas such as office spaces and storerooms. This use of RFID tags is an inexpensive way to authenticate, grant, track, and prevent access to key areas. The use of RFID technology can potentially replace personnel who control access to areas, sense and monitor environments, track and trace items and people, and assist in industrial automation and supply chain integration (Finkenzeller, 2003).

c. People Monitoring

RFID tags can be used to track people (especially children and the elderly) for safety, security, and health reasons. When used as a monitoring device, RFID technology can bring peace of mind and prevent security violations and mishaps (Finkenzeller, 2003).

d. Environment Sensing and Monitoring

RFID tags can sense condition changes such as temperature and pressure. Once the condition change happens, the RFID tag can record the time of the change. This capability can be most valuable in the supply chain if the exact time items are shipped and their condition level needs to be maintained to sustain the quality of the product (Finkenzeller, 2003).

e. Convenience

In many cases, RFID tags allow for a more efficient process, which could lead to reduced cost and could prevent redundancy. Such products as payment cards allow customers to conveniently and quickly pay for services and products. RFID-enabled key chains and cards allow customers to automatically create a billing transaction when passing through tollbooths or obtaining fuel (Finkenzeller, 2003).

f. Process Efficiency

RFID systems reduce data entry and transcription errors with the use of a reader. Scanning with a reader reduces time in processes. These improvements may allow for increased efficiency and a smoother process.

g. Applications in Supply Chain Management

Research in the Marine Corps and the other military services within the DoD study RFID applications to increase Total Asset Visibility (TAV) and inventory control. The DoD has seen how RFID technology is used in the business world and how it has helped to streamline the biggest retail businesses such as Wal-Mart, Target, and Home Depot. RFID technology is currently used in supply chain management in the areas of TAV and inventory control.

The researchers Fish and Forrest (2007) explain that Wal-Mart has become the dominant retail leader by using RFID tags for pallet tracking in its distribution centers. In June of 2003, Wal-Mart mandated that its top 100 suppliers put RFID tags on cases and pallets, later expanding to include another 500 suppliers (Fish & Forrest, 2007). Starting in October 2008, Wal-Mart's distribution center in Dallas, Texas, started levying fines to suppliers that did not comply with its mandate. The fines consist of a $2.00 charge for each pallet without an RFID tag (Blanchard, 2008). Wal-Mart believes RFID usage will provide asset visibility and reduce stockouts that prevent increased sales.

It is expected that the use of RFID technology within the military can provide better asset tracking, improve operations efficiency in acquiring material from suppliers and in delivering to units in the field (Business Wire, 2005). The military learned an important lesson during Operation Desert Storm from having lost and misplaced supplies, which added to the total cost of the war. In the following ten years, the DoD spent an estimated 100 million dollars implementing RFID technology (Gilbert, 2004). Like Wal-Mart, the DoD also mandated, in 2003, that defense suppliers use RFID technology. The DoD initially required the use of RFID tags for all 43,000 suppliers, but has since relaxed its policy due to the high cost of RFID systems and the emergence of comparative technologies.

Within the supply chain of the Marine Corps, RFID tags are currently being used by the Transportation Management Office (TMO) and Supported Activities Supply System Management Unit (SMU). RFID tags are used to improve asset visibility by tracking the location of packages transported to units by the TMO and SMU. The Navy also uses RFID technology to improve asset visibility by placing RFID tags on pallets for inventory control and item tracking. Additionally, troops in Iraq are using RFID tags on pallets and vehicles. RFID readers are set up at a distribution center in Kuwait, at the Iraq-Kuwaiti border and at checkpoints along the main roadways into Iraq. When trucks pass the readers, the location of the goods that are transported is updated in the US Department of Defense's In-transit Visibility network database. This enables commanders on the ground to see the precise location of replenishments needed to sustain operations (Roberti, 2005).

4. Benefits and Challenges for RFID

Supply-chain applications of RFID are beneficial to both the DoD and suppliers. RFID technology has enabled the recording of material transfer and enhanced TAV. In the limited implementations of RFID to date, the DoD has seen benefits in inventory management, operational improvements and asset tracking, as listed below.

Supplier Benefits:

- Improved planning,
- Faster demand responses,
- Reduced Bull Whip Effect,
- Streamlined business processes,
- Improved efficiency in the recall of defective items,
- Increased ability to ensure that product(s) remain stocked on DoD shelves, and
- Faster receipt of payments for supplied goods.

DoD Benefits:

- Improved inventory management,
- Improved labor productivity,
- Elimination of duplicate orders,
- Replacement of manual procedures,

- Automated receipt and acceptance,
- Improved inventory and shipment visibility and management,
- Reduced shrinkage,
- Enhanced business processes within the DoD, and
- Improved asset tracking. (DoD, 2007)

The benefits of RFID have been highly discussed; however, recent studies are showing the negative aspects of and concerns regarding the costs of RFID, lack of identification standards and training, degraded performance and privacy issues (Jones, Wyld, & Trotten, 2005). The costs of an RFID system include the costs for the RFID tags, software, additional hardware, process reengineering, solution testing, implementation and maintenance updates (Maloni & DeWolf, 2006, p. 27). When the DoD issued the RFID policy, it was recommended that the training and implementation be standardized amongst the various branches in the military. Currently, the standard for RFID training and the DoD Logistics (LOG)-Automatic Information Technology (AIT) training have not been developed. In the interim, each branch within the military is developing its own separate training plans. This separation in training can lead to the different branches duplicating efforts to accomplish the same goal. If each branch creates its own training plan, the total cost of implementing the RFID program is increased. In addition, the lack of communication between the military services involving the application of RFID systems could multiply errors. This may lead to the degradation and abandonment of RFID systems.

The performance of RFID tags can be degraded when placed on metallic objects, in the vicinity of water and in inappropriate temperature conditions. One of the many problems that RFID readers have is their vulnerability to outside RFID readers. An outside RFID reader can be described as one not belonging to the current system. Users of these outside readers have the potential ability to hack in and retrieve valued information. Therefore, outside RFID readers have the potential to be used as a weapon against other RFID systems. An outside RFID reader can be used to read data from an RFID tag, and that information can be used for purposes that may threaten the system. In a study documented in *Popular Mechanics* magazine, researchers were able to use off-the-shelf scanners to read account numbers and cardholder names off RFID credit cards. Researchers at the University of Massachusetts were able to construct scanners capable of skimming the cardholders' name and card number from a variety of first-generation RFID credit cards. They then found a way to transmit that data back to a card reader, tricking it into accepting a purchase (Johnson, 2007).

C. UID and IUID

(Unique Identification) UID can be described as a system of marking items with unique-item identifiers that have machine-readable data elements that can distinguish an asset from all other items. UID and Item Unique Identifiers (IUID) are often mistakenly interchanged with one another because they are similar-looking acronyms. The following sections pertaining to the history, types, uses, benefits and challenges, registry, and lifecycle of UID will clearly distinquish UID from IUID, which is the type of UID used by the DoD.

1. History of UID

The origin of UID started with the development of the barcode in 1948. A graduate student, Bernard Silver of Drexel Institute of Technology in Philadelphia, asked Norman Woodland from IBM to develop a system to automatically read product information during checkout. The two eventually created a device that they patented as "Classifying Apparatus and Method." This helped create the first barcode, which was a "bull's eye" symbol, made up of a series of concentric circles (Romando, 2006). Eventually, the barcode was commercialized in 1967 by RCA—implementing a scanner system in the Kroger stores in Cincinnati, OH.

The barcode evolved over the following 30 to 40 years from the grocery industry to the National Aeronautics and Space Administration (NASA). In 1990, NASA collaborated with the bar coding industry to develop a new type of barcode called the two-dimensional (2D) data matrix. The 2D data matrix allowed more data to be placed within the barcode, giving way to the term "unique identification" (Secretary of Defense, 2005). Original barcodes contained only 10 numeric characters. Barcodes have since changed to include 249 alphanumeric characters, which offer the potential for increased information handling. Table 2 shows the evolution of the barcode and the data elements that are contained in each type.

Table 2. Types of Barcodes
(Allen, 2008)

Types of Barcodes	Char Count	Barcode Characteristics
ABC1234XYZ	10	These are conventional one-dimensional barcodes. Both barcodes to the left contain 10 data characters, which can encode both numeric and alphanumeric data. However, the alpha characters are single case (usually defined as upper case). If lower case characters are required, then "Full ASCII Code 39" must be used, and the barcode increases in size as shown in the second example.
ABC1234xyz	10	
1234567890	10	This one-dimensional barcode can encode data characters in about half the space available. However, the symbology cannot encode alphabetic characters at all. Only numeric characters are permitted.
1234567890	10	Code 128 barcodes can encode alphanumeric characters. The numeric characters can be encoded in compact form. However, if alpha characters are included in the barcode, its size increases by about 50%. Code 128 codes are about the best that can be achieved with one-dimensional barcodes.
ABC1234xyz	10	
	10	This two-dimensional barcode contains 10 alphanumeric characters. With this number of data characters, there is no advantage over conventional barcodes.
	62	This two-dimensional barcode contains 62 alphanumeric characters. This is much more than can be achieved with a conventional barcode while retaining a manageable barcode size.
	249	This two-dimensional barcode contains 249 alphanumeric characters. This example shows the maximum amount of information that can be encoded in the barcode.

2. Creating an IUID

A UID is a unique identification used to track and identify items. The design of a UID allows it to store information similar to a barcode. As shown in Table 2 above, the 2D matrix design of the UID allows it to hold more information than a barcode. Changes can be made to a UID to make it different and unique from other

UIDs to conform to DoD requirements. The DoD requires that all UID be placed within a DoD UID Registry. This will prevent items within the DoD from having the same UID marking, regardless of the manufacturer.

The 2D data matrix is different by design from the other 2D barcode markings in Figure 10. Turning a 2D data matrix into an IUID requires that the Unique Item Identifier (UII) information be encoded into the 2D data matrix. A UII consists of a format code, data identifiers, enterprise identifier, part number and serial number that is unique across the DoD as described in Figure 11. Once the UII information is created within the 2D matrix, it becomes an IUID.

2D Data matrix PDF417 Maxi code QR code Aztec

Figure 10. 2D Barcodes
(MacDougall, 2007, pp. 15, 18, 19)

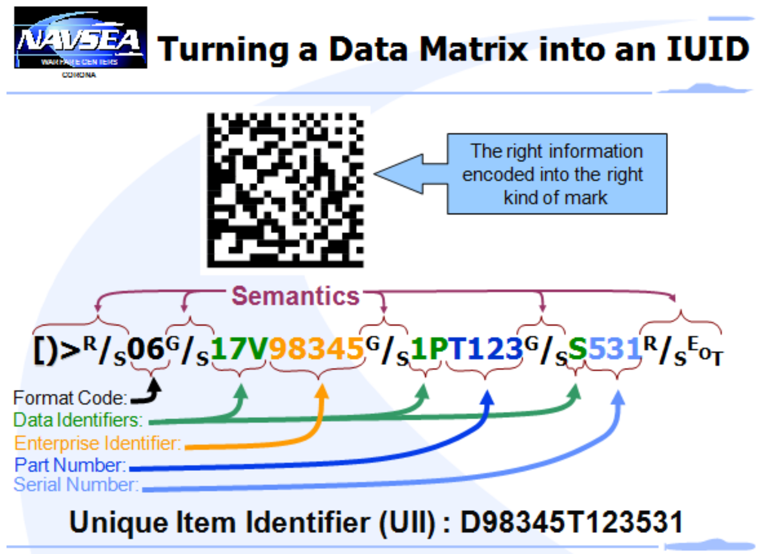

Figure 11. Unique Item Identifier
(MacDougall, 2007, pp. 15, 18, 19)

The DoD plans to facilitate item tracking with the use of IUID. The IUID will provide reliable and accurate information for financial, accountability and asset management purposes. IUID are used for lifecycle data visibility on any of the following items: assets with serial numbers, those worth upwards of $5,000, assets considered mission essential, those considered controlled inventory, and/or those that need permanent identification. The complete decision tree to determine if an item requires IUID marking is shown in Figure 12.

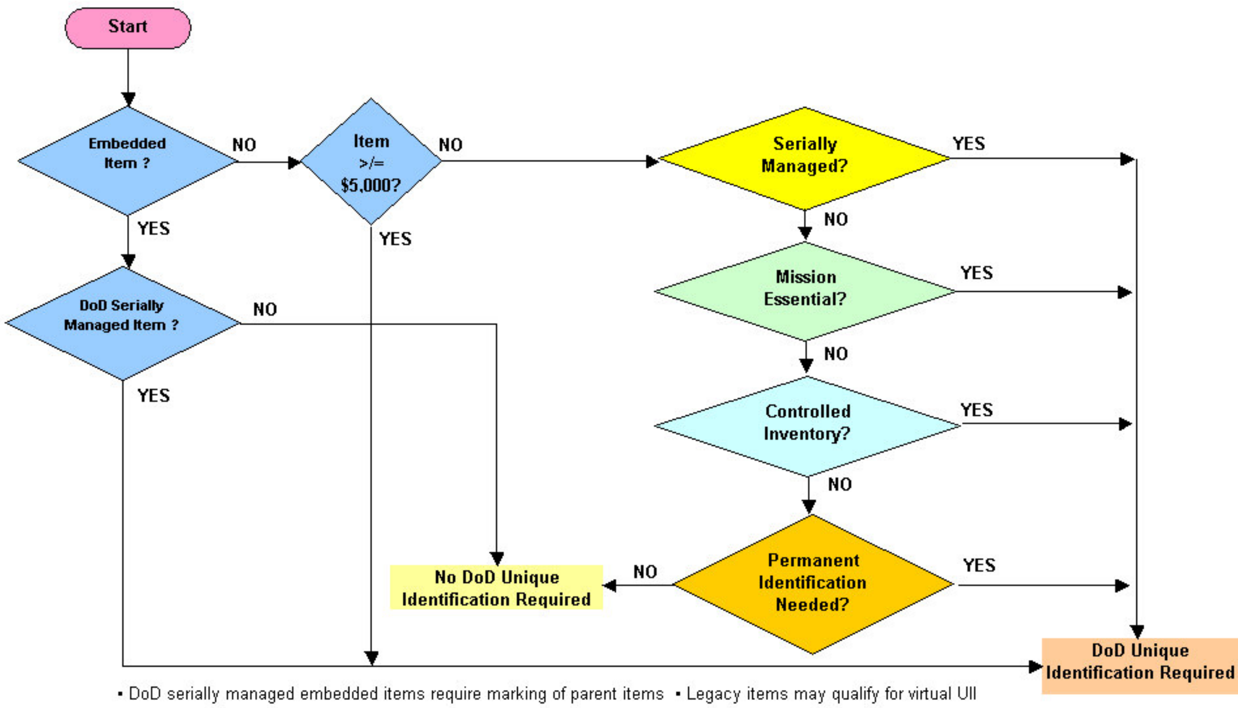

Figure 12. IUID Decision Tree
(Secretary of Defense, 2006)

a. UII Design

Manufacturers are now required by the DoD to mark assets identified in Figure 12 with an IUID. To do this, many manufacturers contract an enterprise agency that is responsible for assigning the UIIs. UII is the name for the type of data coded into the IUID. The enterprise identifier is unique. For items that are serialized, meaning each consecutive item that is produced is assigned the next unique serial number in a sequence, the UII data set includes the data elements of the enterprise identifier and the unique serial number. This is known as Construct 1. A construct is a set of rules for how the UII within the IUID data is derived. For items that are serialized within the part type, lot or batch number, the UII data set includes: the enterprise identifier; the original part, lot or batch number; and the serial number. This is known as Construct 2. Below are samples of Construct 1 and 2. Construct 1 is used if the serial number is unique within the enterprise identifier. Construct 2 is used if the serial number in not unique within the enterprise identifier but is unique within the part number (DoD, 2005).

Construct 1 UII

OCVA9 513B36452
(Enterprise Identifier)   (Serial Number)

Construct 2 UII

OCVA9 1234 513B36452
(Enterprise Identifier) (Original Part Number) (Serial Number)

The UII must also include semantics for formatting, as shown in Figure 12, from the International Standards Organization/International Electrotechnical Commission (ISO/IEC) 15434. "G/S" as seen in Figure 11, refers to the "Group Separator" character in the American Standard Code for Information Interchange (ASCII) character set. It is a non-printable character. "R/S EOT" as seen in Figure 11, refers to the "End of Transmission" character in the ASCII character set. It is a non-printable character. The construct can have no more that 50 characters. Those characters can be capital letters A through Z, numbers 1 to 9, forward slash (/) and hyphen (-). Lowercase letters, periods and asterisks cannot be used.

b. Types of IUID Labels

Many different types of IUID labels exist. The IUID marking can come in different sizes and formats (Figure 13). It can be embedded in the asset's material with dot peen and laser etching. It can also be applied to the surface of the asset by chemical etching, ink jet or adhesive tape. IUID tags are capable of storing small to large amounts of information. The information remains unchanged (i.e., static) within the tag once the tag is produced. The layout and type of a UID determines how well it can be read and how durable it will be. Once the IUID is created, it must be added to the UID registry that was created for the DoD.

Dot Peen **Chemical Etch** **Ink Jet** **Laser Etch** **TESA Tape**

Figure 13. Types of IUID

3. Uses for UID

UIDs provide a simple and inexpensive method of encoding text information that is easily read by inexpensive electronic readers. UIDs also allow data to be collected rapidly and with accuracy.

The primary purpose of a UID is to label the item with a unique number or character string. UIDs are used with a database application in which the data encoded in the barcodes is used as an index to a record in the database that contains more detailed information about the item being scanned. For example, when a checkout clerk scans a barcode UID on a product in a grocery store, the barcode data is fed into a computer that looks up the information in a central database and returns more detailed information about the item that was scanned, including, possibly, a description of the item and a price. By using barcodes, the grocery store does not need to put a price tag on each item in the store, and it can change the price for a particular item by modifying a single entry in the central database. It can also track how much of a product is currently in stock so that personnel know when to re-order more of each item as the number of items in stock falls (TAL tech, 2005).

UIDs can be used to improve any processes requiring the inputting of data. UIDs provide a quick and error-free means for inputting the data into an application running on a computer. Because UIDs are 2D barcodes, they are capable of containing significantly more data than linear barcodes. With UID, the potential for human error from manual data input is significantly reduced. Another application for UID is for inputting data without typing or transcribing. For example, one could encode information about a person in a barcode on an ID badge and then scan the ID card to input the person's information into a computer program. UID is also used to reduce time and errors in various business industries. In retail, UIDs can identify a product. In the shipping industry, UIDs are used to give information about the contents of packages. In the future, UID is expected to supply production details, such as batch number and use-by dates.

4. Benefits and Challenges of UID

The DoD has seen the benefits UID presents in TAV and lifecycle management—having been plagued by the inability to see assets as they are flown into theater and are in storage. In addition, when assets are not visible, they are difficult to manage. As discovered in Operation Desert Storm, when assets are lost, duplicate orders are made. This duplication of ordering assets directly increased the costs associated with the operation; duplication also has a direct impact on the funds that are available in the DoD budget. The DoD has chosen to use UID for asset tracking. The use of UID is capable of reducing these costs and providing other benefits such as:

- Item visibility, regardless of platform,
- Lower item-management costs,
- Line-item data for top-level logistics and engineering analysis,
- Accurate sources for property and equipment valuation and accountability,
- Improved access to historical data for use during systems design and throughout the life of an item,
- Reduced workforce burden through increased productivity and efficiency,
- Better item intelligence for warfighters for operation planning,
- Lower lifecycle costs, and
- Improved inventory accuracy.

There are also challenges associated with using UID. The type of UID marking, the material to be marked, and the environment are variables that decision-makers need to consider when implementing UID markings. Other potential challenges that occur when using UID marking are as follows:

- The UID mark is only durable if protected.
- Many marks do not perform well with liquids and abrasives.
- Some marks may not survive repair processes.
- Various surfaces may interfere with the adhesiveness of the UID.
- The cost of labeling equipment may vary with the type of UID marking.
- Certain UID markings require increased safety and training requirements.
- Some UID markings may require specialty tools that will increase total costs.

5. UID Registry

The DoD UID Registry assists the DoD with asset visibility across the services. The goal of this registry is to be a single-point system and to reduce the redundancy of multiple, separate systems. All DoD-acquisitioned items that meet certain specifications are entered into the DoD UID Registry. Contractors and/or suppliers enter information on new assets, while individual branches of the DoD enter information on legacy assets. The requirements stipulated in the contract written by the DoD are logistically difficult for many contractors and suppliers. Each supplier or contractor must input all the required information into the DoD UID Registry in order to comply with the DoD mandate. The required information in the registry is referred to as pedigree information and includes:

- Item Description, UID (consisting of concatenated DoD UII, or DoD-recognized UID equivalent),
- UII type, issuing agency code (if DoD UII is used),
- Enterprise identifier (if DoD UII is used),

- Original part number,
- Serial number,
- Unit of measure,
- Government's unit acquisition cost,
- Ship-to code,
- Contractor's Commercial and Government Entity (CAGE) code or data universal numbering system (DUNS) number,
- Contract number,
- Contract line, sub line, or exhibit line-item number, and
- Acceptance code and shipment date.

The intent of the registry is to make it easy for the DoD to access the necessary and relevant information about DoD-procured items. The acquisition, repair, and deployment of registered items are expected to be faster and more efficient for the DoD when using UID. In addition, the DoD UID Registry helps the DoD accomplish higher states of operational readiness and facilitates checking the status of assets in theater and in storage. Commanders and decision-makers should be able to use the registry to obtain information on an asset. Links to organic service systems, through the Global Combat Support System (GCSS) (Figure 14), will allow visibility to dynamic information about a particular asset. The DoD UID Registry will make information readily available to top-level decision-makers.

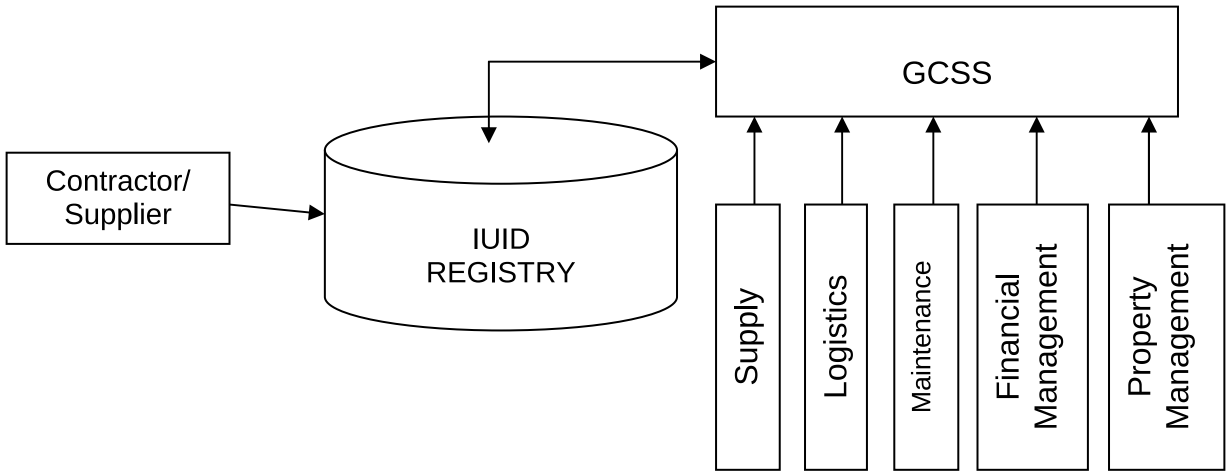

Figure 14. IUID Registry Process

6. UID Lifecycle

The goal of the implementation of IUID systems within the DoD is to allow each asset to be tracked throughout its life. Current DoD contracts are required to include the requirement for parts-markings—including UII-imbedded information for all items that require unique identification to be identified as outlined in the *DoD IUID Mandate*. The *DoD IUID Mandate* establishes the decision rules for determining if an item needs to be marked with IUID, as was shown in Figure 12. Based on this information, DoD suppliers assign and apply UII data elements and ensure uniqueness of the component data elements. The functional stakeholders can then update the UII information in the UID Registry. Additionally, the *Mandate* allows stakeholders to gather information on similar assets. Once the asset has met its useful lifecycle, it is disposed of. The DoD then records the termination of the UII. The UII is still kept on the asset to ensure that the asset does not make its way back into the supply system.

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III. Organizations, Systems and Operations

Many organizations within the DoD, Navy and Marine Corps are involved in the supply and management of weapons (Figure 15). Each organization affects the process in a different way. We examine these organizations to see how well they are suited to support the implementation of RFID and/or IUID in Marine Corps armories.

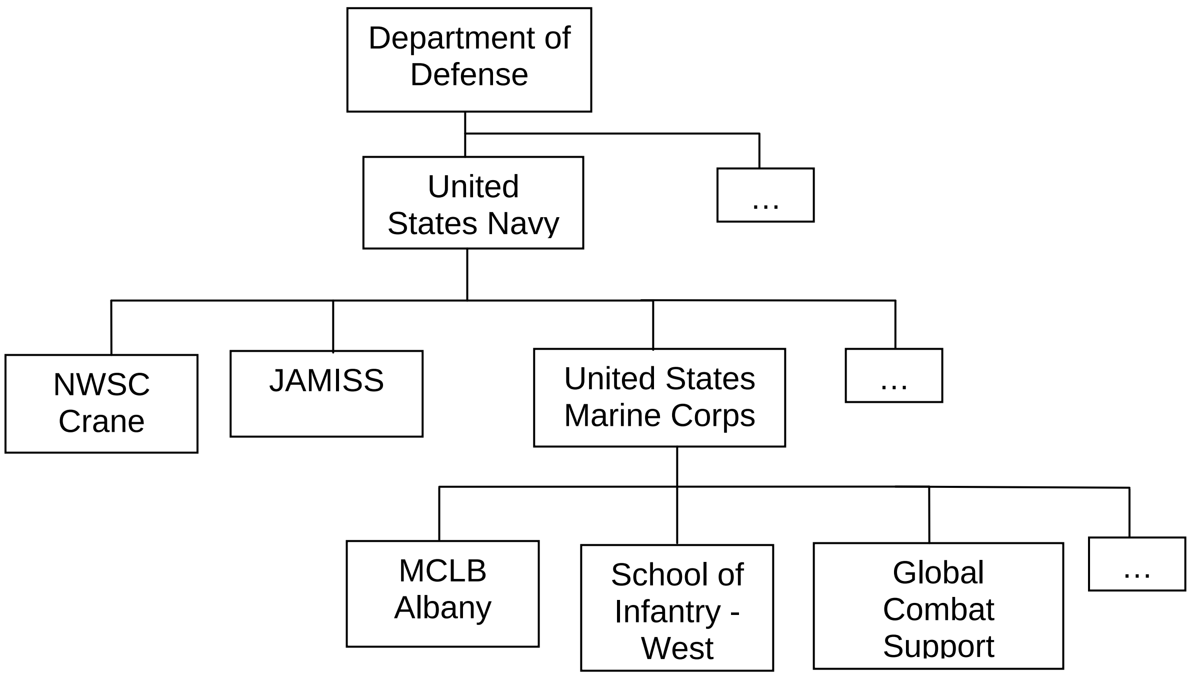

Figure 15. DoD/Navy/Marine Organization Chart

A. DoD

In July 2004, The Secretary of the Defense issued a policy regarding RFID that states:

> New solicitations for materiel issued after October 1, 2004, for delivery after January 1, 2005, will contain a requirement for passive RFID tagging at the case (exterior container within a palletized unit load or shipping container), pallet (palletized unit load), and the UID item packaging level of shipment in accordance with the appropriate interim/final *Defense Federal Acquisition Regulation Supplement* (*DFARS*) Rule/Clause or MIL-STD-130 as appropriate. (DoD, 2005)

The primary objective of the DoD Directive for UID implementation is to establish policy and prescribe the criteria and responsibilities for creation, maintenance, and dissemination of UID data standards for discrete entities (DoD, 2007). These standards will allow users on-demand information, which is essential to accountability, control, and management of DoD assets and resources. The mandate requires all assets procured under certain parameters to have UID markings. All assets must also have a globally unique serial number embedded in a 2D Data matrix barcode directly marked on the part or on a label affixed to the part. The information contained in the UID label must be stored in a DoD database called the DoD UID Registry. Any product label technology chosen should work along with or enhance the DoD UID registry and DoD mandate. This will allow the RFID/UID product to be an asset to DoD UID registry instead of becoming additional work to the inventory process.

It is important to understand how the DoD envisions the IUID implementation. The requirement is identified in many DoD policies and documents. The *Concept of Operations for IUID Enabled Maintenance in Support of DoD Material Readiness* describes the improvements and benefits that can be obtained from a fully IUID-enabled environment. Certain scenarios in the document are compared to current and future system capabilities in the Marine Corps in order to determine the feasibility of IUID within the Marine Corps armories (Symbol, 2005).

B. Navy

The Marine Corps falls under the Department of the Navy (DoN). Therefore, the Navy has departments that support the requirements of the Marine Corps. Navy Warfare Surface Center (NWSC) Crane is one of those departments. NWSC Crane supports the Marine Corps by assisting in the accountability of small arms assets that belong to the Marine Corps. The JAMISS is a system that was developed under the Navy's supervision that is designed to assist in the maintenance and support of military assets. Both NWSC Crane and the JAMISS are capable of improving small arms weapons management.

1. NWSC Crane

Among other responsibilities, the NWSC Crane is responsible for ensuring the accountability of small arms weapons in the Marine Corps. Individual units maintain weapons for training and operational usage. On a daily basis, weapons within the Marine Corps are received, transferred and released to users; these transactions are then forwarded to NWSC Crane, where the consolidated record of these changes are maintained and recorded. At any given time, NWSC Crane manages 632-700 different Crane reports for the Marine Corps. On a monthly basis, NWSC Crane receives by fax, e-mail, or mail record changes that equate to 40,000-70,000 transaction per month or 400-700 transactions per day per worker. The record changes are received and processed by any of the five logistic management processors working at NWSC Crane (Figure 16). The capability of NWSC Crane's processes must be examined to determine how effective they will be to a UID/RFID Marine Corps armory program.

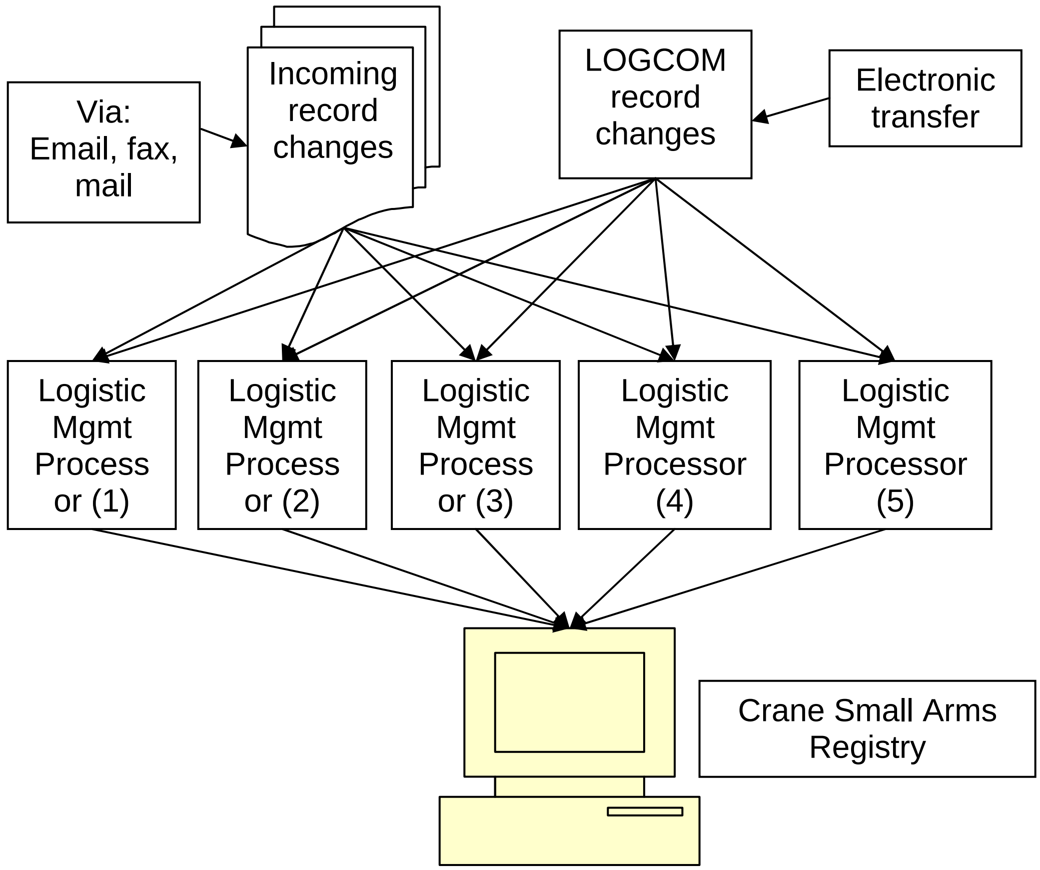

Figure 16. Crane Record Change Flowchart

2. Joint Asset Maintenance Integrated Support System (JAMISS)

The JAMISS is a Navy maintenance asset management system and is currently being used by the Marine Corps. It can be configured to manage assets using IUID or RFID. The Web-based system provides connectivity between the end-user and the program office. It is capable of maintaining and tracking detailed information on parts, maintenance and usage of assets with the use of UID or RFID.

The JAMISS requires each user to have a common access card (CAC) in order to maintain security levels. Sensors onboard assets identify health, usage and maintenance issues that are communicated to the computer system—indicating the identification, location, inventory, maintenance demand and operational status of each asset. This allows maintainers to make decisions about the upkeep and usage of the asset. The JAMISS has the capability to communicate with Marine Corps legacy support systems like Supported Activities Supply System (SASSY) and Maintenance Management System (MIMMS) in order to quickly and smoothly process repair part orders. The ability to communicate with the Marine Corps Equipment Readiness Information Tool (MERIT) and the Federal Logistics Data (FEDLOG) reduces clerical errors caused by transcription. Drop-down menus reduce the input of broad and non-descriptive maintenance information, further reducing transcription errors. The servers store the information for future use. The information is also forwarded to enterprise servers for higher-level backup. In addition, program managers and higher-level decision-makers filter the enterprise server information for visibility and usage data. This paperless system allows the Marine Corps program managers to better maintain assets and operational decision-makers to employ assets with maximum effectiveness.

C. Marine Corps

The Marine Corps currently has small arms assets that are marked with UID. The Marine Corps Logistics Base (MCLB) Albany receives these assets and distributes them to units throughout the Marine Corps. MCLB also handles the maintenance of those assets. One of the units to which weapons are distributed is the School of Infantry (SOI) West at Marine Corps Base Camp Pendleton. This unit has the largest armory with the Marine Corps. Units such as SOI are supported by logistic sections (such as supply maintenance) and admin that have legacy systems that are UID-compatible or communicate with each other. The Global Combat Support System Marine Corps (GCSS-MC) is the future system that is supposed to replace the separate logistic systems within the Marine Corps. The following section explains MCLB Albany, SOI West and GCSS-MC relationships to UID application in the Marine Corps.

1. Marine Corps Logistic Base (MCLB) Albany

The MCLB Albany, Georgia, handles the receipt of new weapons into the Marine Corps and their distribution to various units. The Fleet Support Department (FSD) at Logistics Command (LOGCOM) Albany, Georgia, has developed a streamlined receipt process for weapons. In addition, it is capable of pulling inventory information directly from individual units. This information can be consolidated and forwarded directly to NWSC Crane. This can possibly eliminate the current process of annual Crane reports conducted by individual units. Additionally, FSD is responsible for handling all depot-level maintenance of small arms within the Marine Corps. This material flow is shown in Figure 17. We examined the current FSD procedures to determine their effects on a Marine Corps armory system.

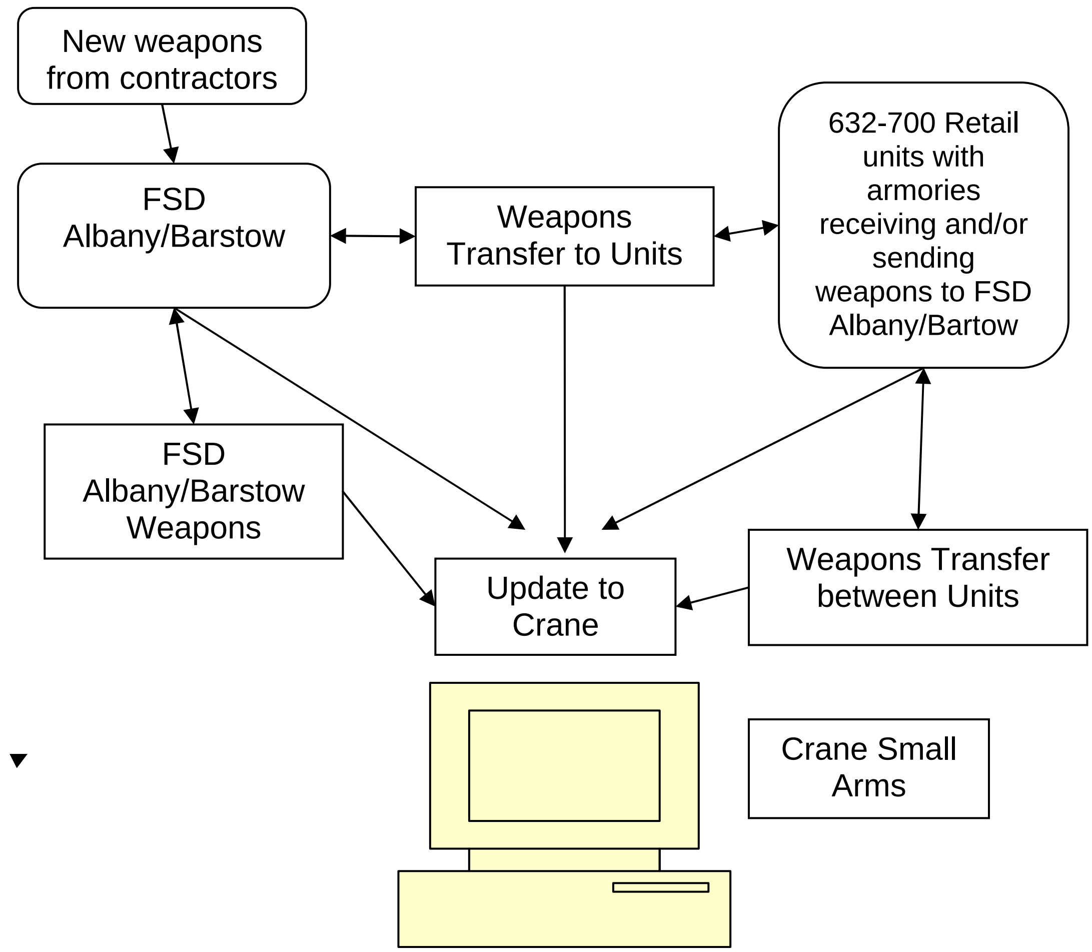

Figure 17. Flow of Weapons (Procurement to Disposal)

2. School of Infantry (SOI) West

When Marines graduate from boot camp, they attend the School of Infantry in SOI West, Camp Pendleton, or SOI East, Camp Lejeune. The SOI teaches entry-level Marines basic warrior skills. The school also teaches Marines, from corporal to lieutenant, advanced infantry and light armored vehicle skills. Marines who receive the infantry military specialty are trained at Infantry Training Battalion (ITB), and all non-infantry Marines are trained in basic infantry/Marine common skills at Marine Combat Training Battalion (MCTB). The SOI marks a transition in the professional training of entry-level students from trained Marines to Marine warriors (USMC School of Infantry (West), 2003). Each SOI has a large supply of gear to support the 14,000 students that go through the school annually. Each class of students constantly cycles through the combat gear that consists of vehicles, weapons and equipment. It is important to know how IUID-marked assets withstand usage from the Marines at SOI West, the largest armory in the Marine Corps.

3. Global Combat Support System (GCSS-MC)

The GCSS-MC is a portfolio of AIT systems that supports the logistics elements of Command and Control (C2), joint logistics interoperability and secure access to logistics data. At the core of the GCSS-MC is the Logistics Chain Management (LCM) initiative, which is the incremental implementation of commercial off-the-shelf software (Oracle e-Business Suite) to enable the Logistics Operational Architecture (LOG OA).

The first increment, "Block 1," provides initial capabilities for the GCSS-MC/LCM and is a separate acquisition program with its own milestone events. It is focused on improved supply and maintenance capability in the operating forces. The GCSS-MC will include the retirement of the following legacy systems: (SASSY), (MIMMS), Asset Tracking, Logistics, and Supply System (ATLASS) that are used to maintain the Marine Corps armory inventory.

The GCSS-MC is the medium for the exchange of information for future logistic systems in the Marine Corps that will be enhanced with the use of UID. It is essential for decision-makers to know when and how UID and the GCSS-MC will be incorporated if they are to improve Marine Corps logistics.

IV. Review and Analysis of Existing Studies

Various studies have been conducted with similar objectives to ours. However, they lack the integration of Marine Corps organization and systems. We review these studies to examine how or if they can contribute to the IUID and RFID usage in Marine Corps armories.

A. Anniston Army Depot, Ft. Carson (SMARTRACK)

A Small Arms Use Case Demonstration (SAUCD) at the Army's 2nd Battalion, 8th Infantry, 4th Infantry Division, tested the SMARTRACK automated Armory system. SMARTRACK is a fully automated electronic information software application and database management system, specializing in weapons tracking for military or law enforcement management environments. It accepts parameters to manage an unlimited variety of weapon-related equipment. Every SMARTRACK system is fully functional in a standalone environment, such as in a field or base deployment. It has the capability to network an unlimited number of individual armories to facilitate the exchange of data and physical weapons (Williams, 2007).

The SAUCD test included the following objectives (Krumhaus, 2008):

- Determine the feasibility of applying data matrix symbols containing unique item identifiers (UII) and/or barcodes to small arms in the field (Phase I),
- Determine the ability of a digital arms room system to use IUID to manage serially managed items stored in the arms room and to generate value for the Soldier (Phase II), and
- Assess the durability of standard IUID markings specified for legacy small arms (Phase III).

A team from Anniston Army Depot (ANAD) at Fort Carson, CO, was tasked to apply the IUID tags to the weapons using TESA tape. During the test, it was discovered that the IUID data matrix on new factory-marked M-4 semi-automatic rifle sustained damages. A picture of one of those weapons is shown in Figure 18. The physical damage might prevent the IUID from being read. If the tag is unreadable, the information has to be physically typed into a computer to perform the inventory process, significantly slowing down the automated process that SMARTRACK offers. The test concluded that achieving the potential benefits of digital arms rooms for the Army would require providing the armory with the capability to remark the weapon with IUID tags when the original markings is damaged or destroyed. As seen in Figure 18, a locally manufactured barcode was used to replace the damaged tag until a new IUID could be generated.

Figure 18. M-4 with damaged UID marking

During the SAUCD test, ID Integration, Inc.—a parts marking and system-integration company—conducted a barcode verification of small arms weapons at Anniston Army Depot at Fort Carson in August 2008. They advertise themselves as an independent systems integrator of industrial-marking systems offering hardware and software solutions, providing customers with unbiased choices for "best-in-class" performance—choices that are matched to the customers' unique application requirements (Anderson, 2008). They conducted a formal quality assessment of nearly 200 individual UID markings to evaluate tag damage levels after more than three months of field use. The evaluation included black anodized TESA tape, Aluma Mark aluminum foil and black anodized (direct part marking) DPM. The most significant influencing factor towards lowered tag quality was not damage, but production flaws during the laser marking process. TESA tape labels exhibited the lowest quality levels, with 20% not meeting the requirements of the Department of Defense Standard Practice Identification Marking of US Military Property, *MIL-STD-130N*. This was largely due to production flaws and the 1-part commercial clear coat that was used on top of the labels. The coating was easily scratched or flaked, leaving the tag less readable and subject to damage. The flat, black anodized labels from the weapons vendor (Colt) exhibited the best overall barcode quality results, with only 2% not meeting the requirements of *MIL-STD-130N*. However, the periphery of these labels exhibited a noticeable degree of chipping, possibly due to the choice of adhesive used. Non-flat aluminum foil labels (those with formed edges and corners) sustained a noticeable degree of denting & buckling that increased their chance of peeling off the weapon surface. These flaws also resulted in a degree of light shadowing that made scanning more difficult from certain angles. These conclusions are consistent with problems that are common to many types of tags. TESA tape and aluminum foil labels showed numerous types of durability issues. An armory using these labels may experience reading and/or durability problems that would interfere with the inventory processing times.

Sergeant Shorter, an armorer that worked at Ft. Carson during the SMARTRACK test, noted that after the weapons were used, the UID labels installed on the weapons were scratched beyond readability 3%-4% of the time (Shorter, 2008). This reinforces the observation that the leading factor behind lowered tag quality is not damage, but production flaws during the laser marking process.

B. United Kingdom RFID Weapons and Armoury Management System

We reviewed information about the development of a standalone computer-based management system for a police armory in the United Kingdom (UK). The system demonstrated how RFID technology was implemented to record the names of individuals who were issued weapons and to control and record their respective firearms. The UK police securely attached RFID tags to a range of weapons in use, and RFIDs were also incorporated within the identification cards of the respective officers. There were approximately 300 long arms and 50 pistols used in the demonstration. After the tag was fitted to the weapon, the RFID tag number replaced the serial number as the unique identifier; the tags were electronically scanned using a handheld reader, and the information was fed to a computer database. The initial fail rate was 2-3 RFID tags from the batch of 350. After the first year of operation, there were less than five RFID tags replaced due to read failures. Additionally, 2-3 of the RFID tags detached from the long-arm weapons due to adhesive issues during the first year (Dean, 2006).

The RFID tags were produced in two forms that were appropriate for the weapon type. They were also designed to fit the following criteria:

- Did not interfere with a weapon's usual handling,
- Did not interfere with a weapon's operation, and
- Fit in a place where it is accessible to be read and replaced if necessary.

These criteria led to a thin laminated self-adhesive RFID tag fitted to handguns (Figure 19). For long arms, an encapsulated RFID tag within plastic form was glued with strong adhesive to the weapon (Figure 20). However, these methods and placement may not be suitable for all handguns and long-arm weapons.

Figure 19. 9MM with RFID Tag

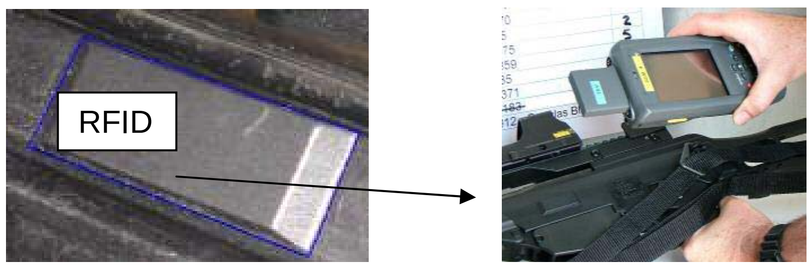

Figure 20. Long Arm with RFID Tag

The UK case study identified the following limitations to implementing RFID tags on small arms:

- Tag reading performance is likely to be affected when the RFID tag is fitted to metal.
- After-market grips containing metal inserts affect the performance of the RFID tag.
- The position of tag on the weapon must be carefully decided because its placement could interfere with the operation of the weapon.
- Lubricants are likely to cause adhesion problems during fitting of tags.
- The RFID tag used had a short read range. This required deliberate attention to the specific weapon being read to avoid erroneous readings. (Dean, 2006)

The limitations of this study are consistent with the implementation of RFID within a Marine Corps Armory system. The Marine Corps would need to encase the

RFID tag in order to protect it from damage during usage of the weapon. This system and test simply indicate that there are viable ways of marking or attaching an RFID tag to a hand weapon so the RFID tag is not exposed to the environment and abrasion caused by normal use. Table 3 compares IUID and RFID technology under the UK computer-based system. When RFID is compared to IUID, the capabilities appear balanced except for damage to tags and reading interference.

Table 3. UK Computer-based Armory System Analysis

	Time	Basic Accuracy	Capability	Damage	Interference
RFID	Weapons can be inventoried faster than before.	Scanning eliminates transcription, resulting in less errors on documents.	Inventory system are RFID based and are capable of allowing weapon issue from a second location	RFID sustains less damage because it is covered.	Metal can interfere with RFID reading.
UID	Weapons can be inventoried faster than before.	Scanning eliminates transcription, resulting in less errors on documents.	Inventory system is not IUID based. Technology would allow the system to be configured to use IUID for a cost.	IUID suffers more damage because it is exposed.	Damage to tag from environment or durability of tag may interfere with reading.

RFID tags used in the UK computerized armory system have less damage because they are encapsulated inside the weapon. The encapsulation protects the tag from the environment and assists in maintaining its durability. The current IUID used by the DoD is only protected from the environment by a coating on the TESA tape and data labels. Other forms of IUID labeling such as laser etching are not protected. In addition, current IUIDs have shown to have durability issues that were identified at SOI West, the Small Arms Use Demonstration at Anniston Army Armory Depot in Ft. Carson, and during the UID-marking pilot program at the US Army Armament Research, Development and Engineering Center, which is discussed in the next section.

The case study shows that existing technology has the capability to transmit weapons issue data from remote locations, such as a mobile issue point. A mobile issue point is supported by the armory and its database—as shown in Figure 21 (Dean, 2006). If the UK system is configured to use IUID, tags may become unreadable due to the current durability issues and reduced protection from environmental conditions. The inability to read the tags requires keeping current administrative forms to transcribe weapon issue information. These forms would continue to be physically sent to the armory from the mobile issue point.

The transcription of information increases the probability of error. Little's Law can be used to analyze this process. It states that the inventory in the process is related to the throughput rate and the throughput time by the following equation (Inventory= Rate*Time) (Schroeder, 2007). Little's Law proves that there is a direct relationship between time and inventory. An increase or decrease in time results in the same percentage of increase or decrease in inventory. The need for a Marine to transcribe data would require more time. Therefore, the time required to cover the variability caused by durability or engineering design of IUID tags will result in more inventory. The inventory would be Marines who are waiting in a queue to be issued or de-issued weapons. With the addition of each mobile issue point and the percentage of errors from transcription, the time required to transcribe and transport information to the armory will be multiplied.

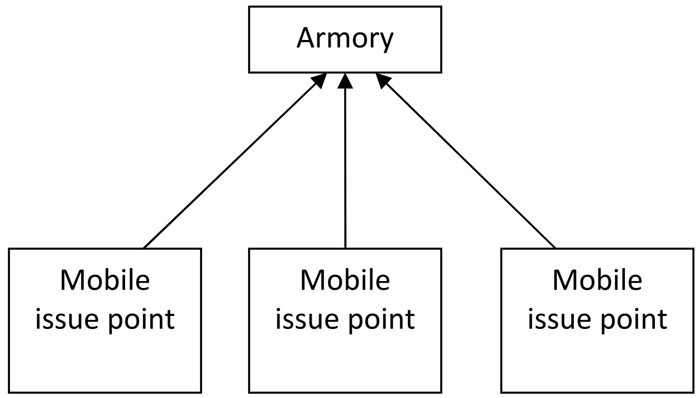

Figure 21. Data Transfer from Remote Locations

C. UID Marking Pilot Program

With the DoD decision to implement a policy to mark all small-arm assets with IUID, it needed to determine the most appropriate marking. With this goal, the DoD selected the Joint Small Arms Coordinating Group (JSACG) to conduct a test called the UID Marking Pilot Program to study environmental conditions on IUID marks attached to small-arm weapons. From May 2004 to September 2005, JSACG conducted environmental studies designed to investigate and identify current and future IUID markings technologies. In the first phase, the JSACG selected 30 (thirty) M-9 pistols and 30 (thirty) 240-machine gun receivers based on metal composition and multi-purpose use. The receiver is the main body of the weapon, not to include trigger mechanism, butt stock or barrel. The M-9 receivers were marked with 9 different methods, and the M-240 receivers were marked with 13 different methods (Table 4) (Boyle, 2006).

Table 4. UID Environmental Testing
(Boyle, 2006, p. 19)

Method	Coating	M-9	M-240
Laser Coat and Discolor	Krylon	N/A	2
	Bare Phosphate	N/A	4
	Anodized	4	N/A
	DataLase Clear coat	3	2
	Aluma Hyde II	2	2
Laser Etch & Clear Coat	Aluma Hyde II	2	3
	DataLase Clear coat	2	2
	Evershield	2	4
	No coating	2	3
Deep Laser Engraving	No Coating	4	6
	Aluma Hyde II	N/A	2
	DataLase	N/A	2
	Krylon	N/A	2
TESA Tape		9	8

The sample receivers marked with TESA adhesive labels, deep laser and laser etching UID were then exposed to salt fog, sand and dust testing. In the second phase, the remaining receivers were exposed to hot/cold temperatures, icing and chemical testing.

The tests showed that the laser coat, laser etching and coating, and deep laser engraving UID markings suffered significant damage and were not readable 100% of the time (Figures 22-25). Additionally, the JSACG concluded that the TESA adhesive labeling with clear coating was the most reliable and readable after exposure tests.

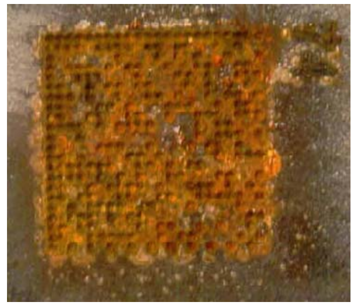

Figure 22. Deep Laser Engraving after Hot, Cold and Icing

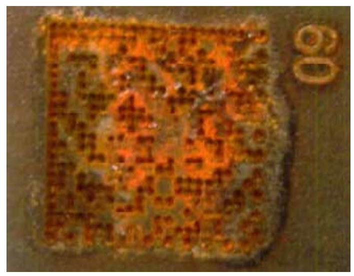

Figure 23. Deep Laser Engraving after Salt Fog

Figure 24. Laser Etch and Clear Coat after Hot, Cold and Icing

Figure 25. TESA Tape after Environmental Testing

The tests conducted by JSACG included 30 receivers. However, the sample size of each environmental test was much smaller. For example, only 9 M-9 out of the 30 receivers were tested with TESA tape. Without a large enough sample, the population is improperly represented. The reliability of this test could have been improved with a larger sample size. Therefore, high percentages of readable tags after testing does not necessarily equate to good reliability with a very small sample. Additionally, the exposure time for each environment condition should have been the same. All tests were conducted for a 24-hour period except the salt fog test, which lasted 240 hours. This significant timeframe difference must have skewed the results. Most important, the test failed to expose the UID tags to normal training and operational environments. Attaching UID labels to weapons instead of scrap receivers could have achieved this. Since this test was not performed, the results do not reflect an accurate simulation.

Based on the conclusions in the report, it was recommended that metal data plates or vinyl labels (TESA tape) be used on weapons going through the depot-level rebuilding process and on currently fielded weapons. A more comprehensive examination may have yielded different results and recommendations.

D. SOI West IUID Test and Evaluation

SOI West conducted its own test and evaluation of IUID using a sample of IUID tagged weapons within its own armory. The type assets examined are listed in the Table 5. The results of this evaluation showed that 44% to 87% of the tags were damaged, which is clearly unacceptable. Currently, there is no system in place to remark damaged IUIDs. Therefore, these averages would certainly result in a degradation and abandonment of an inventory system using IUID. This evaluation reenforces the idea that IUID tags currently used in the Marine Corps require some type of redesign to improve durability.

Table 5. SOI West Damaged IUID Results

Asset	Tested	Damaged IUID	Percent Damaged
M240B	264	117	44%
M249	164	93	57%
AN/PEQ-15	32	28	87%
AN/PVS-14	289	238	82%

V. Assessment of Current IUID Implementation Efforts in the DoD

The DoD and the organizations within it have concepts and systems that will affect the implementation of IUID in the Marine Corps. A closer look at these concepts and systems is needed in order to determine if they are compatible with each other. In addition, the thesis group would like to review the current IUID implementation efforts within the DoD, Marine Corps and Navy.

A. DoD

The DoD is the overarching entity that establishes concepts for the military services. Military services such as the Marine Corps are required to implement the application of such items as UID based on the vision of the DoD. Therefore, it is important to understand how the DoD envisions the implementation of UID. This section covers the DoD's Concept of Operations and various assumptions relevant to UID implementation.

1. Concept of Operations

The Concept of Operations for the IUID program expects that new IUID-enabled systems will be brought online and that older systems will be turned off. The success of UID implementation and usage within military logistics depends heavily on systems that are UID compatible and that allow the flow of UID from system to system. The concept of operations clearly states that the first order should be to identify how IUID data will enter the mainstream of existing systems and databases (Durant & Anderson, 2007). However, the Marine Corps has already began issuing new assets and legacy items with IUID markings without having current or new automated information systems to support UID. The Global Combat Support System-Marine Corps (GCSS-MC) is the operating system that will enable IUID asset information to be communicated throughout the Marine Corps. However, Block 1 of the GCSS will not be available until 2010 or later, and it will not allow IUID information to flow from system to system.

2. Field-level Assumptions

The Concept of Operations assumes that the Maintenance Management Programs (MMP) within the different military services are able to view the on-hand stock of the organizational supply units. In the Marine Corps, most supply sections are not allowed to maintain a Pre-expended Bin (PEB) of supply. Usually, the maintenance section maintains a PEB for certain parts and consumables with proper authorization. MIMMS, the system used by maintenance sections in Marine Corps, does not have the capability to allow the user to view the General Account Balance Files (GABF) that show what the SASSY Management Unit (SMU) has on-hand. The GCSS-MC is intended to supply this capability for the Marine Corps when it is brought online.

In field-level operations under the Concept of Operations, the MMP and associated systems all have UID-specific fields, but Marine Corps systems are not currently equipped with them. Block 1 of the GCSS, which is scheduled for 2010, will have fields for IUID. However, those fields will have no functions to enable linkage between other systems. It is not known in which block of the GCSS the IUID fields will have functions. To support such UID-capable systems, many affiliated sections such as supply, maintenance, and the TMO will require UID readers to read tags to document the transportation and movement of assets in the MMP and UID registry.

3. Sustainment-level Operations Assumptions

As mentioned in Chapter 4, the Concept of Operations document highlights several scenarios that describe an envisioned end-state of total asset visibility using IUID. Scenario 2 of the Concept of Operations document encompasses depot operations, supply interfaces, and lifecycle management. In this scenario, the depot-level production manager uses a depot information system (DIS) to run automated daily review of the supported services' maintenance databases. It may show, for instance, that an unserviceable, repairable item is being retrograded to the depot level. The national stock number (NSN) and IUID identify the asset. The DIS would crosscheck the IUID with the service's information network, potentially linked through enterprise resource planning (ERP) software, which reports the asset is already in transit via a commercial carrier and then provides a tracking number. Using the tracking number, the DIS is programmed to automatically track the status of the inbound item as it moves to the depot, indicating its time of arrival. Using the IUID provided, the production control manager opens a receiving-and-repair induction notice for the inbound asset (Durant & Anderson, 2007).

This scenario directly relates to the depot-level maintenance facilities within the Marine Corps at Albany, GA, or Barstow, CA. The depot-level maintenance facilities are able to see what weapons are inbound through the NWSC Crane small arms registry. However, this system does not include IUID fields. According to Kathleen Row, Senior Acquisition Quality Manager in the Small Arms Division of NWSC Crane, there are no plans in place yet to add IUID fields in the NWSC Crane small arms weapons registry. Because the system does not include IUID fields, the depot may not be able to pull inbound information from the small weapon registry. Therefore, the current plans at NWSC Crane does not match the Concept of Operations document.

When units in the Marine Corps ship items, they employ their local TMO office, which assigns a Transportation Control Number (TCN) to assist in receiving and tracking packages. An RFID tag is placed on most packages, based on the value of their contents and destinations. The location of tagged packages is identified when the RFID tag crosses a corresponding transponder. Many times, there is only a transponder at the exit of the delivering base and the entrance of the receiving base. Therefore, the asset cannot be tracked, which results in no visibility between military bases or destinations using the RFID. In order to get information that is more detailed, the third-party commercial carrier delivering the package would have to be contacted. Tracking the package using an IUID system would require the TMO offices within the Marine Corps to have IUID fields added to their systems, or for them to invest in new programs that include IUID fields and IUID-capable readers. According to the Marine Corps Lead on AIT, there are no known current or future Marine Corps TMO transportation systems that can or will track asset shipments by IUID. Additionally, the Office of the Under Secretary of Defense—Supply Chain Integration (OSD-SCI) has indicated that IUID is a supply concept and does not need to be carried over to transportation transactions. Therefore, IUID transportation organizations throughout the DoD will not incorporate system transactions to enable IUID tracking. This reinforces the idea that the DoD Concept of Operations is not in-line with the Navy's and Marine Corps' current or future capabilities.

B. Marine Corps

The flow of weapons through MCLB Albany is important to the individual armories throughout the Marine Corps. The capacity and flow of weapons though MCLB Albany affect the readiness of the units these weapons support. For this reason, it is important to understand the process flow of weapons at MCLB Albany. SOI is one of the units that receives UID-marked assets from MCLB Albany. The performance of UID at SOI will most likely mirror what will happen at smaller armories throughout the Marine Corps. As SOI is the largest Marine Corps armory, the GCSS-MC is the platform that will support its IUID tag information and allow that information to be passed throughout the Marine Corps. Therefore, it is imperative to examine if SOI IUID-tagged assets received from MCLB can withstand the usage from the SOI training environment long enough for the GCSS-MC to become operational.

1. MCLB Albany

In March of 2003, the Fleet Support Department (FSD) significantly improved its weapons receipt process with the use of barcodes. This improvement helped to reduce its process time, error rate, manpower required for receipts, and the amount of resources required to process incoming weapons. The initial process for both new procurement and items requiring maintenance was seen during the research team's visit to FSD and is described in the following steps:

1. A container of weapons is received into the warehouse.
2. Personnel open the container and inventory each item one-by-one to certify content and serial numbers, then validate it on the inventory list.
3. If any errors are found, the correction is annotated on the shipping document and stamped by personnel.
4. After the inventory, a quality control person checks the items.
5. One by one, the items are entered in the FSD database. Each item has at least two fields of data to include NSN and serial number.
6. The box is then sealed and placed on location to await shipment to a unit or to an external or internal maintenance facility.
7. The shipping information is then forwarded to the supply personnel, who electronically receive the items in Mechanization of Warehousing and Shipment Procedures (MOWASP). It then goes to the Weapons Serial File (WSF). The MOWASP is equivalent to the Mechanized Allowance List (MAL), and the WSF is equivalent to the CMR.
8. The shipping document, along with a cover letter itemizing the receipt of items, is compiled.
9. The cover letter, along with documentation, is forwarded to the FSD director for signature. This package is then express-mailed to NWSC Crane.

The FSD was able to smooth this process by using barcode lists received from the manufacturer. The lists were then scanned into an FSD database, which reduced transcription errors and processing time. However, weapons received from units are processed individually once received, since the users do not have barcode capability. Therefore, in the process described in Figure 26 (below), the material handler must manually input the information on each weapon in the database. This increasees the amount of time required for the material hander to do his job.

Additionally, when the information is forwarded to Crane by MCLB Albany, it is submitted electronically in a plain text format using Microsoft Notepad, as shown in Figure 27. This electronic transcription reduces the likeliness for error that is created when weapon information is typed on a cover letter, as in Step 9. This is because the information forwarded to NWSC Crane in Microsoft Notepad is in the same format that NWSC Crane is using in its data processing. Since NWSC Crane does not have to reformat the necessary data, its processing time is reduced.

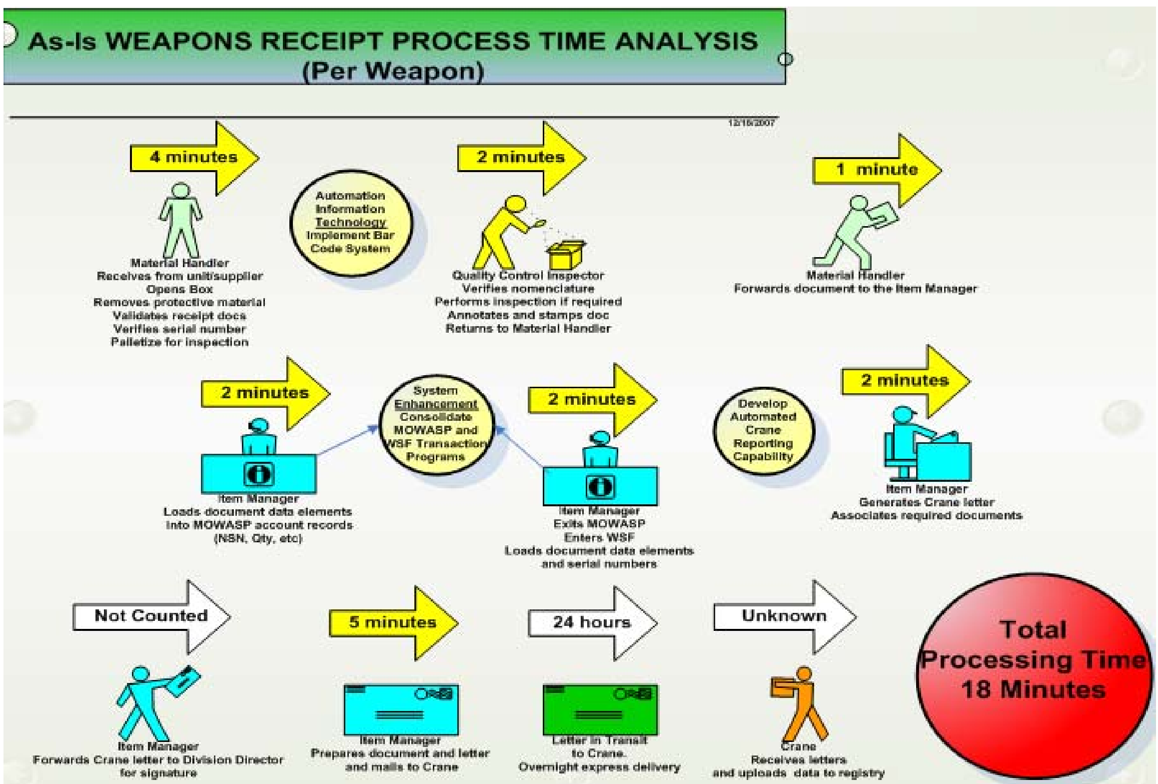

Figure 26. As-is Weapons Receipt Process Time Analysis
(Wilson, 2008, p. 4)

	UNIT From	To	document number	NSN	serial no	date
LOAD	M93055	MMSA01	M930558168E801	1005014123129	U49174	20080725
LOAD	M93055	MMSA01	M930558168E801	1005014123129	U47930	20080725
LOAD	M94145	MMSA01	M941458136E849	1005014711774	4493	20080725
LOAD	M94145	MMSA01	M941458141E877	1005007265636	5000913	20080725
LOAD	M94216	MMSA01	M942168145E030	1005007265636	M3023558	20080725

Figure 27. Notepad Data Information Sent to Crane

The Small Arms Maintenance section at LOGCOM conducts maintenance and repair on Marine Corps weapon assets. There is also a smaller area within the section that tests and creates IUID tags that are applied to Marine Corps assets. The maintenance section currently has the capability to place IUID labels on legacy weapons. As of July 2008, this section is not currently using the special printers to do so because personnel are waiting on instruction from Headquarters Marine Corps (HQMC) to specify what information is to be printed on the IUID tag. Additionally, it was discovered by James Gagnon, the engineering technician of the Industrial Engineering section at LOGCOM, that several weapons received by LOGCOM that are marked with IUID are not in the DoD UID registry as contracted and mandated by the DoD. Figure 28 shows a specific weapon with the IUID tag, and the screen shot (Figure 29) from the DoD UID registry shows that the weapon was never registered into the database. If the asset is not entered into the UID Registry, there will be no asset visibility as envisioned by the DoD. The Notepad format sent to NWSC Crane is similar to scanned information that can be forwarded to databases via barcode reader. Both the Notepad process and scanner enable the sender and receiver to reduce processing time.

Figure 28. M-240 Receiver Assembly

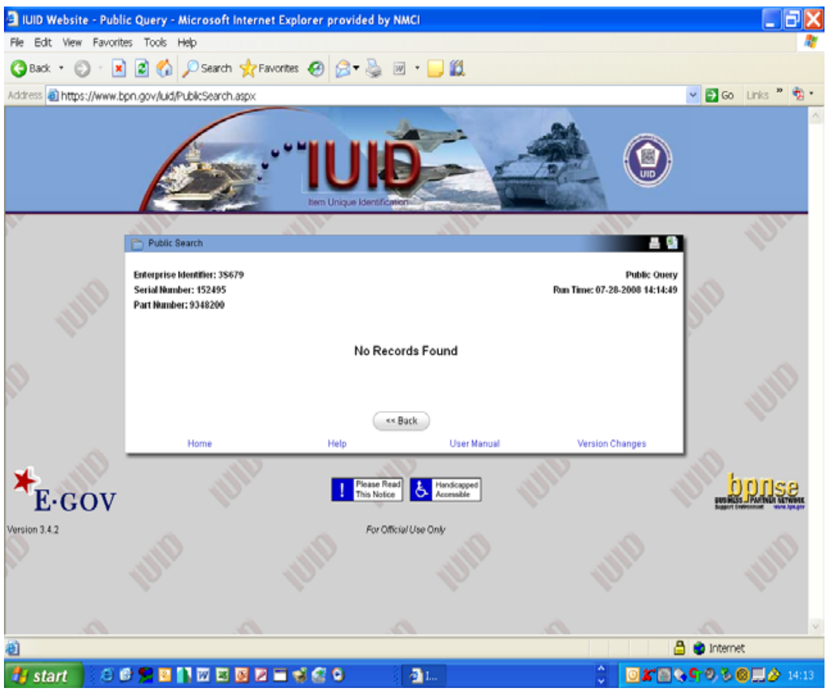

Figure 29. M-240 UID Registry Information

2. SOI West

The armory at SOI West is the largest armory in the Marine Corps. The implementation of IUID marked assets has led it to already mark many items. Small arm weapons and optics are marked with TESA tape and laser etching. SOI armory staff noticed that the IUID markings were becoming damaged after one student cycle (one student cycle being one month) and significantly damaged by the end of the second student cycle. Many of the weapons used by students at SOI do not endure the rigorous training they would receive at infantry units or in actual operational missions. Many machine guns are issued and are only used on the firing range. While on the firing range, the weapon is moved to and from the gun line; ammunition is inserted and fired from the weapon, and the barrel is changed when needed. The firing range environment does not expose the weapon and its IUID to constant movement through different terrain or movement in and out of vehicles. Nonetheless, tag damage happens, as shown in Figures 30-33 of weapons from SOI West with damaged IUID markings.

Figure 30. 249 Squad Automatic Weapon (SAW) Machine Gun

Figure 31. Night Vision Equipment

Figure 32. M-16A4

Figure 33. Advanced Combat Optical Gun sight (ACOG)

Based on the evidence from the pictures, it is obvious that there are durability issues concerning IUID markings at SOI West, which may interfere with the capability to read the mark and, therefore, track the asset. According to Robert Leibrandt, Deputy of Unique Identification Policy Office, inventory management cannot be accomplished (through the “Inventory + Tracking = Management” equation identified in the DoD Concept of Operations document) if the identity of a specific item cannot be tracked throughout its lifetime (Durant & Anderson, 2007).

3. GCSS-MC

The Government Accounting Office (GAO) has designated the DoD business systems modernization as a high-risk program because, among other things, it has been challenged in implementing key information technology (IT) management controls on its thousands of business systems. The GCSS-MC program is one such system. Initiated in 2003, the program is intended to modernize the Marine Corps logistics systems. The first increment is expected to cost about $442 million and is scheduled to be deployed in fiscal year 2010. The GAO was asked to determine whether the Department of the Navy (DoN) is effectively implementing IT management controls on this program. To accomplish this, the GAO analyzed the program's implementation of several key IT management disciplines, including economic justification, earned value management, risk management, and system quality measurement.

The GAO made recommendations to the Secretary of Defense aimed at limiting investment in the program, addressing its cost, estimating its schedule, managing its risk, and observing system quality measurement weaknesses. The DoD agreed in full or in part with the GAO's recommendations and described ongoing and planned actions intended to address the recommendations (GAO, 2008, p. 17).

The Marine Corps invested in 2003 GCSS-MC technology when it was innovative and prominent. In 2008, it continued to invest in the program. In order to adhere to contractual agreements ascertained during the acquisition process, the Marine Corps must accept the technology obtained in 2003 that will be implemented in 2010 (when Block 1 of the GCSS-MC is actually scheduled to be implemented). To avoid obtaining yesterday's technology tomorrow, the Marine Corps must invest more funds to upgrade the GCSS-MC program that is already behind schedule. Due to the continually increasing pace of improvements in technology, current technology loses its value at a much greater rate. Therefore, the GCSS-MC is also losing its value at a much greater rate. Block 1 of the GCSS-MC will be available to the end-user no earlier than 2010. The GCSS-MC full implementation plan for Blocks 2 and 3 is unknown. The Marine Corps is unable to gain system integration knowledge each year the GCSS-MC is not available to the end-user. Logistical and operational knowledge will also be delayed. The GCSS-MC loses value each day it is unavailable to the end-user (due to knowledge unattained about the system). The GCSS-MC is the medium of exchange that will enable IUID usage in the Marine Corps. Additionally, Block 1 of the GCSS-MC will include IUID fields. However, those fields will be nonfunctional. It is unknown within which block of the GCSS-MC that the fields will have functional capabilities, which would allow IUID to have interlinking capabilities (Morton, 2008).

Implementation of IUID within the Marine Corps depends on the success of the GCSS-MC; therefore, system integration, logistic, and operational knowledge will be delayed for IUID. As a result, IUID technology organic to the Marine Corps is devalued with each delay of the GCSS-MC. This is due both to the system's lack of availability and to rapid improvements in technology.

C. Navy

The Navy provides paid support to the Marine Corps to assist in the accountability of small arm assets. NWSC Crane plans to improve its system. These improvements could reduce the time NWSC Crane and supported units require to report weapon changes. The JAMISS is an established system that could possibly be used to assist in the process of weapons in the Marine Corps. The effective use of these resources could positively affect the processes within Marine Corps armories.

1. NWSC Crane

The Marine Corps funds the Navy approximately $650,000 per year to cover the labor for five logistic management processors who enter weapon transaction into the NWSC Crane database. These changes consist of NSN, quantity, nomenclature, serial number and/or unit change. If there are errors in the documentation requesting the change, the individual logistic management processor contacts the unit by phone or e-mail first, and then by mail if no response is received by the first two attempts. NWSC Crane previously had backlogs of changes from supported units caused by lack of manpower. This backlog would prevent visibility of changes sent by Marine Corps units. As a result, annual Crane reports could be received by units from NWSC Crane without annotated changes. Once NWSC Crane increased its manpower, it eliminated its backlog. NWSC Crane's current process and policy is to process any change within 24 hours of receipt.

Crane's weapons reporting section is currently developing a program to improve its process. The web-based program will include a computer screen that contains all required fields for using units. Users will fill the required data fields that annotate their changes, which will automatically update the NWSC Crane weapons records system. This system will not require any hard documents to be submitted to NWSC Crane, and it will not allow invalid data, such as erroneous NSN or duplicate serial numbers to be submitted—reducing the number of errors that enter the database. Electronic signature blocks for workers and supervisors will replace signed cover letters and documents that were previously faxed, mailed or scanned to NWSC Crane.

Since the Small Arms Registry section at Crane completes transactions within 24 hours of receipt, errors are found within 24 hours or shortly after. This means the same number of errors that were found under the cover letter, fax or mail system previously used is found within a shorter amount of time. This time reduction results in shorter processing times for FSD Albany/Barstow, fewer errors due to electronic data transcription at FSD and NWSC Crane, and rapid error correction.

All the changes made by the units and the FSD are captured in a database at LOGCOM called the Master Data repository. This repository allows LOGCOM to have the same visibility and reporting capability as the Small Arms Repository at NWSC Crane.

2. JAMISS

The Joint Asset Maintenance Integrated Support System (JAMISS) currently has the capability to submit information to the UID Registry. Work is currently being conducted at Crane to allow the JAMISS to be able to pull information from the UID registry. The JAMISS can be employed to track the maintenance and equipment usage. Additionally, the JAMISS can be used to smooth out the inventorying and ordering process of weapons. The JAMISS is able to incorporate any identification platform selected such as barcode, UID and/or RFID. The JAMISS staff is not required to analyze or test RFID or UID, but to support the implementation of a system that may use such products as UID and RFID (Edwards, 2008).

There are challenges to the JAMISS program's employment in other venues such as Marine Corps armories. The JAMISS can communicate with legacy systems such as SASSY, which support the CMR that store the inventory of weapons within the Marine Corps. Yet, the Marine Corps is moving toward the GCSS-MC, which will replace the SASSY- and MIMMS-based system. It is questionable whether the Marine Corps should invest in a system like the JAMISS that will show how well it can support the systems SASSY and MIMMS; and that are intended to be replaced by the GCSS-MC.

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VI. Analysis

RFID and IUID technologies are currently being used throughout the DoD. It is difficult to determine at this time if either product is better than the other. To determine which is more suitable to improve small arms processing within the Marine Corps, an analysis needs to be conducted. The thesis group decided to use purpose and performance in comparing RFID and IUID technologies. In addition, we used operational availability and a questionnaire to determine the durability of IUID tags and the effect on armory readiness within the Marine Corps.

A. RFID vs. IUID Management Definition and Purpose for the DoD

The purpose and definition of RFID and IUID technology throughout the DoD and business world are important for our study. These definitions determine how RFID and IUID will be implemented and managed throughout the DoD organizations. For this reason, the definition of IUID management by the Air Transport Association (ATA) and the purposes of IUID/RFID as noted by the Defense Acquisition University (DAU) require review.

1. Traceability for Asset Visibility

The ATA e –Business Forum focused on UID and asset tracking and attempted to explain how IUID would lead to effective management of DoD assets. The ATA uses the formula of Identity + Track = Manage (Leibrandt, 2007). By this formula, if the DoD can identify and track assets using IUID, then it will achieve management of the assets. However, the traceability and asset visibility of small arms marked with IUID will be less than that of other assets marked with IUID. This is caused by the reduced durability of IUID tags on small arms. IUID may be more durable for assets where the IUID label or tag is less susceptible to damage or exposure to the environment. For these assets, the “Identity + Track = Manage” formula may work.

ATA outlines traceability for asset visibility of small arms (Table 6). In the table, two of the many traceability purposes of small arms are property management and maintenance history. If, during the traceability events of storage and usage outlined in Table 4, the IUID label becomes damaged and unreadable, then the label's effectiveness and degree of visibility is reduced. Therefore, the "Identity + Track = Manage" formula is invalid for such assets because the traceability is lost.

Table 6. Traceability Matrix for Asset Visibility
(Leibrandt, 2007, p. 15)

TRACEABILITY MATRIX FOR ASSET VISIBILITY			
Degree of Visibility	**Applies to Material Classification**	**Traceability Events**	**Traceability Purpose**
By quantity, by lot or by serial number	Class VII-Small Arms, Cryptographic Equipment, Radiological Equipment	Acquisition, Storage, Usage, Maintenance, Disposal	Stewardship Responsibility, Property Management, Failure Analysis, Safety Assurance, Maintenance History, Operational Use History, Warranty Compliance, Military Equipment Valuation, 24/7 Security

2. Purposes of RFID and IUID

The Defense Acquisition University (DAU) sites the differences between UID and RFID (Table 7). The purpose of RFID technology is for supply-chain tracking and for automatically acknowledging the receipt of materials. The purpose of UID is lifecycle data visibility. The purpose of RFID technology fits the needs of the armory, which is to smooth the process and to reduce time of weapons issue and inventory. However, the purpose of IUID does not completely fit the needs of the armory. Although data visibility is wanted, it is up to the units to maintain and update the data. Maintaining and obtaining the lifecycle information data within all the different logistic and maintenance tracking systems with the Marine Corps is extremely difficult. Further difficulties are added because a weapon does not usually remain with one unit for the duration of its lifecycle. In addition, lifecycle visibility does not always equate to process reduction. The designs of RFID and UID are central to their purposes. Therefore, it makes more sense for users to choose a product whose purpose fills their needs and requirements. Based only on the data in Table 7, decision-makers may find RFID technology more suitable for receiving and tracking Marine Corps armory assets.

Table 7. UID vs. RFID
(Defense Acquisition University, 2004)

UID vs. RFID

	UID	RFID
Marking	Item	Package
Technology	2D Data Matrix	EPC RFID tag
Purpose	Lifecycle data visibility	Supply chain receipt/tracking
Threshold	$5,000, some exceptions	None
Implementation	January 1, 2004	January 1, 2005

3. IUID vs. RFID Performance Analysis

Table 8 compares RFID and IUID based on their theorized capability to perform in environments that are part of small arms weapons management: armory, armory maintenance, supply, TMO, Depot Repair Maintenance Organization (DRMO) and the GCSS-MC. The usefulness of RFID and/or IUID in each environment is graded from 1 (poor) to 4 (excellent). Each operational area is considered to be of equal importance; therefore, an average of score was taken for RFID and IUID to provide their overall grades.

Table 8. IUID vs. RFID Performance Analysis

IUID (Lifecycle)			RFID (Tracking)		
Armory	Inventory Processing	**4** **3**	Armory	Inventory Processing	**3** **4**
Armory Maintenance		**4**	Armory Maintenance		**3**
Depot	Maintenance	**2.5**	Depot	Maintenance	**2.5**
Supply	Inventory	**3**	Supply	Inventory	**3.5**
TMO	Tracking	**2**	TMO	Tracking	**4**
DRMO		**3**	DRMO		**3**
Legacy/GCSS-MC	Block 1	**1**	Legacy/GCSS-MC	Block 1	**4**
Average Score		**2.8125**	Average Score		**3.375**

Excellent	4
Good	3
Fair	2
Poor	1

The following sections describe the grade rationality for each section in Table 8. Each section is graded for IUID or RFID based on the given purpose of each from Table 7.

a. IUID Analysis

i. Armory

Inventory: IUID labels can be used most effectively in the inventory process. Unlike RFID scanning, scanning by IUID allows only one label to be identified at a time. This process eliminates the possibility of mistakenly identifying numerous labels or the wrong label. In addition, scanning reduces serial number transcription errors. For these reasons, IUID was given a score of 4 for the armory.

Issuing and Processing: IUID labels would only allow items to be scanned one at a time for issuing and processing purposes. This individual scanning processing would require more time in comparison to RFID. Due to the time factor, IUID does not appear to perform as well as RFID for issuing and processing. Therefore, it is given a score of 3 for issuing and processing.

Any damage to the IUID would prevent reading by scanners and require replacement that would slow down processing time. The job IUID performs could be replicated by tags provided by automated armory inventory systems such as Strong Tech and SMARTRACK.

ii. Armory Maintenance

The JAMISS system could be used at the unit level with IUID to track the maintenance history of assets with IUID labels. IUID labels could also enable maintenance sections to quickly inventory items that are on-hand. Finally, those items could be tracked by IUID from intake, to repair to ready-for-issue. Due to these benefits provided by IUID in maintenance, IUID was given a score of 4 for this section.

iii. Depot Level

Maintenance/Inventory: At the depot level, IUID labels would smooth the receipt and storage of assets by reducing time and errors. Many of the maintenance processes at the depot level would involve removal of and/or severe damage to the IUID label. Therefore, the benefits of the IUID labels would be lost after the maintenance process. At some point, the damaged IUID label would have to be recreated. Due to benefits and drawbacks of IUID at the depot level, the thesis group gave IUID a score of 2.5 at the depot level.

iv. Supply

If IUID labels are used as an inventory tool at the armory, the results could be reported to the supply section in less time and with more accuracy. However, the supply section would need to complete the same amount of work to input the inventory changes into the ATLASS and SASSY systems. This is because legacy systems such as ATLASS and SASSY are not configured to receive information from scanners or IUID labels. Since IUID could improve the accuracy of work received but not the processes within supply, IUID was given a score of 3 by the thesis group for the supply section.

v. TMO

Tracking: The Transportation Management Office (TMO) already uses RFID to track packages. Therefore, it could use IUID to track the contents of the packages by placing a copy of the IUID on the outside of the package. However, the TMO is only interested in tracking the package itself. The sender and receiver are the parties most concerned with the contents of the parcel and would be ones reaping the benefits from IUID, not the TMO. Based on this analysis, IUID received a score of 2 from the thesis team for the TMO.

vi. DRMO

Assets are sent to the Depot Repair Maintenance Organization (DRMO) because they are damaged beyond repair, are not worth repairing, or are no longer needed by the unit. Items turned into the DRMO are more likely to have damaged IUIDs. However, if the IUID is undamaged, processing could be faster. If personnel can scan or quickly identify the IUID on the item, they can annotate its status in the UID registry. This will reduce the likeliness of the same item being sold back to the DoD as a new product once it is disposed of. However, anyone who obtains an item with an IUID marking from the DRMO can remove and change both the IUID and serial number of the item. This will enable that old item to enter the system as if it were new without detection from the UID registry. IUID does provide benefits to the DRMO; however, the DRMO's work can quickly be overcome by deceit. For this reason, IUID was only given a score of 3 for the DRMO.

vii. Legacy programs/GCSS-MC

Under the mandate and concept of operations of the DoD, an extensive operations of interlinking system is required to meet DoD expectations and requirements. The UID registry, the GCSS-MC, supply, unit-level maintenance, depot-level maintenance and the TMO would all need to work together. All of the computer systems within those sections would also have to be IUID compatible. The current Marine Corps legacy systems are not IUID compatible. The GCSS-MC is predicted to consolidate and replace the legacy systems. However, Block 1 of the GCSS-MC will have IUID implementation without functionality. Therefore, the benefits of IUID will not be reached with legacy systems or with the first phase of the GCSS-MC. Individual sections such as the armory that may use IUID can transfer limited benefits such as reduced errors and time to other sections. However, legacy systems hinder the capacity of using IUID. Based on this analysis, IUID is given a low score of 1 for legacy programs and GCSS implementation.

b. RFID Analysis

i. Armory

Inventory: RFID can be very effective in the inventory process of weapons. However, with RFID, an inventory (done by antenna only) results in an inventory of tags but not items. Inventories done by antenna do not require visual verification. Therefore, an inventory done by antenna when an asset is removed or stolen and the RFID is removed from an asset would result in the same inventory as an RFID attached to the asset. Since RFID provides benefits and has shortcomings that may be overcome by sight verification, it was given a score of 3 by the thesis team.

Issuing and processing: For issuing and processing, use of RFID would reduce the processing time of issuing and processing. An RFID could prevent an un-scanned item from leaving the armory. This is something an IUID could not do. RFID would appear to do very well issuing and processing and, thus, was given a score of 4 for this section.

ii. Armory Maintenance

The JAMISS system is capable of using RFID to accomplish maintenance management requirements. RFID could enable maintenance sections to quickly inventory items that are on hand. The location of those items could be tracked by antenna from intake, to repair to ready-for-issue. RFID appears that it would work just as well as IUID in the maintenance section. However, the JAMISS system has not yet been tested with RFID. Since these tests have not been conducted, there may be some unforeseen problems that come with using RFID with the JAMISS to manage the maintenance of assets. For the above reasons, RFID received a score 3 from the thesis team for the maintenance section.

iii. Depot

At the depot level, RFID would smooth the receipt and storage of assets by reducing time and human transcription errors. Assets equipped with RFID would be automatically received through scanning. The scanning process would eliminate transcription errors in that process. Assets arriving to depot-level maintenance are usually disassembled and stripped down to bare metal. RFIDs attached to these assets will have to be removed, or they may become damaged in the repair process. Therefore, the benefits of the RFID would be lost after the maintenance process. At some point, the RFID tag would have to be replaced. Due to benefits and drawbacks of RFID at the depot level, the thesis group gave RFID a score of 2.5 at this level.

iv. Supply

If RFID tags are used as an inventory tool at the armory, the results of the inventory could be reported to the supply section in less time and with more accuracy than IUID. This is because an RFID system will allow multiple items to be scanned at once. However, for IUID, there is a need to physically touch each weapon in order to get the correct angle needed to scan the weapon's IUID tag. Additionally, if sight verification of assets is conducted before an inventory, this would guarantee that all weapons are accounted for and insure that no weapons have been tampered with or have had their RFID tags removed.

Given both these processes, the supply section would still need to complete the same amount of work to input the inventory changes into the ATLASS/SASSY system. This is because the legacy systems are not configured to receive information from scanners of RFIDs. Since RFID technology could improve accuracy of work received but not the processes within supply, RFID was given a score of 3.5 by the thesis group for the supply section.

v. TMO

RFID technology has proven to be effective in the tracking and accountability of assets. RFID technology has also smoothed the processing of work within the TMO. Based on the verifiable information, RFID was given a score of 4 by the thesis team for TMO.

vi. DRMO

Assets that are sent to the DRMO are usually damaged beyond repair, are not worth repairing, or are no longer needed by the unit. Items that have been turned into the DRMO are more likely to have damage to the RFID tag based on the assets condition and reasoning for being sent to the DRMO. However, if the RFID tag is undamaged, it could allow for faster processing times.

Items that go to the DRMO are sometimes delivered to a DRMO facility located on another base. These RFID tags could be used to track on-hand items that will not be immediately discarded. The RFID tags could be used to assist in the inventory process of the assets before final disposition is decided. Due to these benefits, RFID was given a score of 3 for the DRMO.

vii. Legacy programs/GCSS-MC

RFID tags can improve the processes of the armory and other associated sections without the need for secondary applications such as the UID registry. The use of RFID tags can positively affect different sections without requiring the inventory and management of new and different systems required by the DoD. For this reason, RFID was given a score of 4 by the thesis team.

c. IUID vs. RFID Performance Analysis Summary

According to the average scores in Table 8, RFID tags are more suitable for improving Marine Corps inventory and tracking processes for armory assets. However, the difference between the scores is only .463. This difference may not prove to be significant enough to make a definite determination on which technology should be considered for use in Marine Corps armories.

B. Operation Availably (A_o)

The test at Anniston Army Depot, FT Carson of SMARTRACK uncovered questions on the scanning capability and durability of IUID (Figure 18). The test conducted by the JSACG revealed that laser etching is not durable when exposed to various environmental conditions. Although the test conducted may not have been scientifically or statically organized enough, the results suggest significant attrition rates in use of TESA tape and laser etching IUID, which will lead to reduced scanning capability. The durability issues that affect scanning capabilities of IUID tags lead to the inability to reduce the weapons processing time of inventorying.

A basic measure of reliability for repairable systems can be expressed by the following Mean Time between Maintenance (MTBM) equation. MTBM can be explained as the average time between system maintenance requirements or events. MTBM can be calculated by the formula:

$$MTBM = 1 / (1 / MTBM_u + 1 / MTBM_s)$$

Since tags will be repaired when the weapon has been brought in for scheduled or unscheduled maintenance, the Mean Down Time (MDT) will increase for both scheduled and unscheduled maintenance. Operational Availability (A_o) is the probability that a system or equipment, when used under stated conditions in an actual operational environment, will operate satisfactorily when called upon (at any random time). The operational availability is a commonly used readiness measure for weapons systems. This value provides the percentage of weapons that are in a mission-capable (MC) status; this value also represents the percentage of time a system is in MC status. Therefore, the formula can be rewritten as:

A_o = number of MC systems / total number of systems

Or the formula can rewritten to include MTBM:

A_o = MTBM / MTBM + MDT = Uptime / Total time

where MDT is the total elapsed time required to repair and restore a system to full operational status, and Total Time = Uptime + Down Time.

Due to the durability issues surrounding the engineering of the IUID labels, it is safe to assume that a percentage of the labels will need replacement. The replacement of the IUID tag will be considered maintenance to the asset. This will increase the amount of maintenance required for the asset compared to the time required before the asset had an IUID tag. According to the A_o formula, the longer the assets are under repair, the worse the A_o will be because when the MDT is increased, the operational availability will decrease. Therefore, there will be fewer small arms assets available for issue to Marines.

Due to the importance of armory assets and their involvement in the training of Marines, it is most likely that Marines will issue such assets even though they have IUID damage. If this is the case, the IUID system will quickly degrade due to a lack of priority associated with the replacement of tags. Once the number of tags is reduced, the benefits of reducing process times and error will suffer.

C. Questionnaire

Our thesis group created a survey to see if there were any current issues with IUID tags on weapons within Marine Corps armories. Initially, the survey was introduced by phone and sent via e-mail to a sample of armories. Due to a small number of replies from the e-mailed surveys, our thesis group made the decision to visit Marine Corps Base Camp Pendleton, CA. Marine Corps Base (MCB) Camp Pendleton was a suitable survey site due to its proximity to the Naval Postgraduate School and the large number of armories located on the base.

1. Survey Method

The group selected 38 armories from the MCB Camp Pendleton for the survey. We chose those armories at random. Each participant selected to complete the survey was chosen because he/she was on duty during our visit. All of the 38 participants were in charge of separate armories (there is no overlap of arms between participants). The participants in the survey were initially asked if their armory had assets that were marked with IUID. Almost all the participants were unaware of what an IUID was. Therefore, each survey was introduced to the participants with a brief introduction of IUID. The brief introduction included a definition, purpose, samples and pictures of IUID. Two armories that did not have assets with IUID tags did not participate in the survey. The survey questionnaire, which is shown in full in the Appendix, was composed of seven questions specifically regarding IUID tags and physical damage. Each question is given below and is discussed in the Survey Findings section. The questions are as follows:

1. On what types of weapons are IUID currently marked? When did you start receiving weapons with IUID?
2. Are IUID tags on currently marked assets showing physical damage?
3. What seems to be the cause of the physical damage?
4. How long does it take for IUID to sustain damage from initial weapons issue?
5. What type of physical damage is visible?
6. What IUID reading capability do you currently have?
7. How many weapons do you currently have with damaged IUID, and what is your total inventory?

2. Survey Findings

Question 1: On what types of weapons are IUID currently marked? When did you start receiving weapons with IUID?

The group found that the most common weapons the armory personnel listed with IUID markings were:

- M16A4/M4 Rifles
- Optics/weapon sights (RCO, PEQ-15 and PVS-14)
- M240B machine guns
- MK19, 40mm machine gun grenade launcher
- M16-SE variants rifles

Armory personnel stated that weapons with IUID markings were received by participating armories from July 2006 to September 2008. Some participants were not sure as to when the weapons showed up with IUID in the armory. Due to the possibility of different batches of weapons arriving at the armory at different time intervals, it is impossible to estimate how long the IUID lasted before receiving any damage. But this time can clearly be no longer than two years.

Question 2: Are IUID tags on currently marked assets showing physical damage?

Of the participants surveyed, 45% stated that there was damage, and 55% (Figure 34) said there was no damage. Four participants out of 38 stated there was no damage, but indicated different causes of damage in follow-on questions. If these 4 participants answered question 2 in error, which is indicated by their later answers, then the number of participants who had IUID markings with damage would increase to 55%. Additionally, 14 of the 17 participants that noted no damage also stated that the perspective weapons were not issued for use. Of those participants who have issued weapons, 61% stated that they have weapons with IUID damage. However, it is unknown whether these IUID tags can withstand normal usage from training because the weapons were not issued. Even without considering the unissued weapons, the thesis group considers alarming that 45%-55% of the armories state that they have damaged IUIDs.

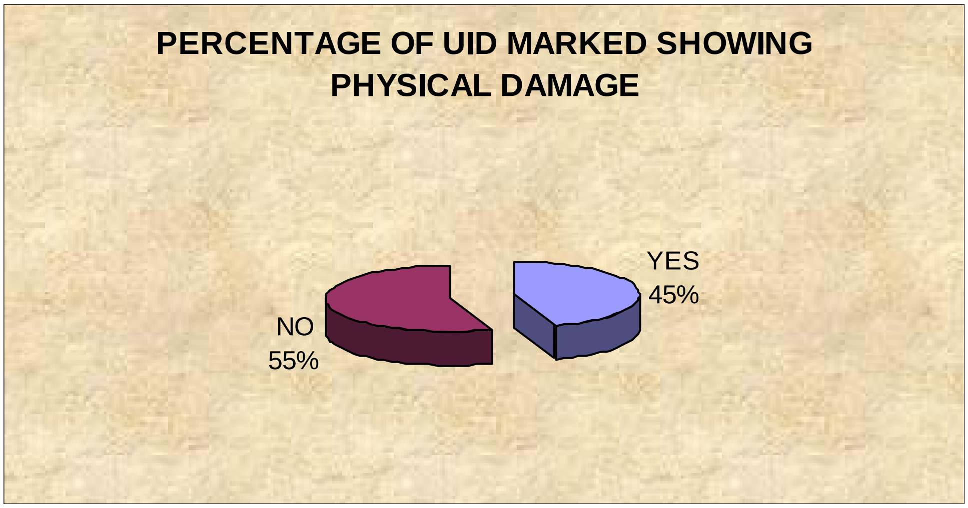

Figure 34. Percentage of UID Marked Showing Physical Damage

Question 3: What seems to be the cause of the physical damage?

The survey indicates wear-and-tear and tampering as the two identifiable causes of physical damage. Of the armories surveyed, 50% stated that the cause of physical damage to IUID was from wear-and-tear, while 11% stated that damage to IUID was from physical tampering (Figure 35). This may indicate that further knowledge and training on IUID technology is needed for the end-users within the Marine Corps. This knowledge may lead to a reduction in damage caused by tampering and wear-and-tear. A significant 39% of armories surveyed indicated that there was no damage. Of the undamaged IUID marked weapons (Figure 36), 73% of the armories noted that the weapons had not been issued. This leads the thesis team to believe that when the weapons are issued, the percentage of weapons with damaged IUID tags will increase significantly.

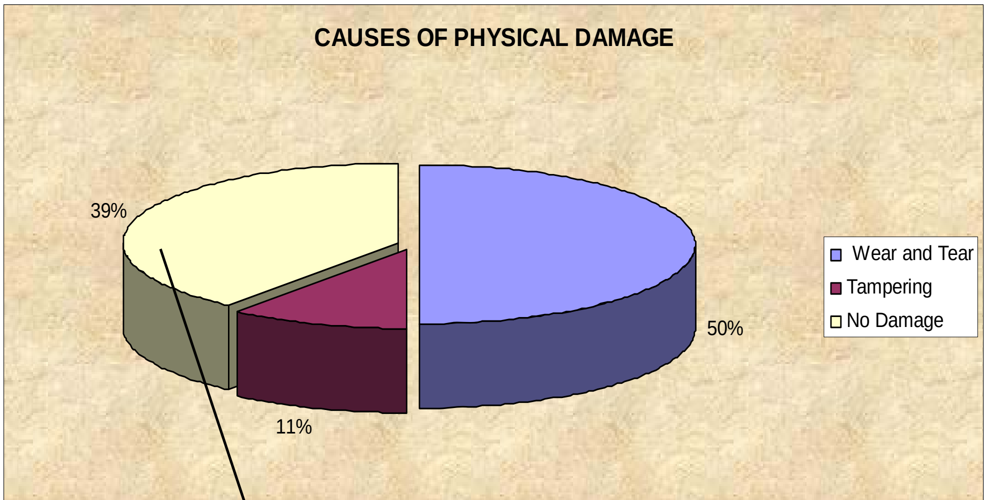

Figure 35. Causes of Physical Damage

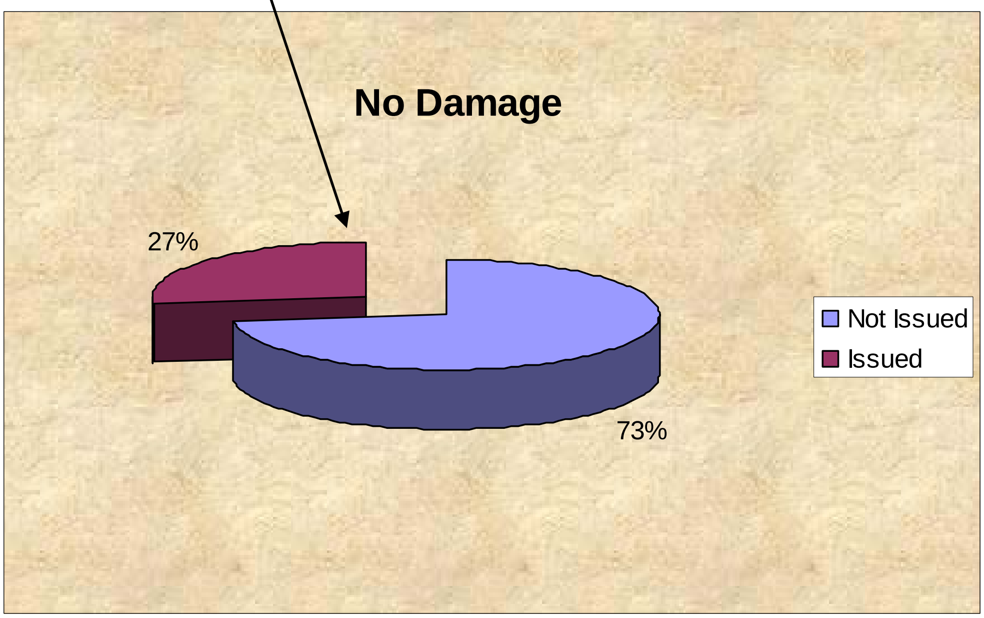

Figure 36. No IUID Damage Breakout

Question 4: How long does it take for IUID to sustain damage from initial weapons issue?

The participants in our survey results indicated that IUID tags could have possibly sustained damage anywhere between 1 to 12 months after initial weapons issue. It is difficult to determine how durable the IUID tags are based on the times reported. This is because usage of assets at each armory differs. Some armories may expose their weapons to more rigorous training environments than other armories. In addition, armories may issue their IUID-labeled assets at different frequency levels. Follow-on studies with IUID labels should be done comparing armories with similar issuing patterns and training packages. This may result in data that will lead to more decisive conclusions on the durability of IUID labels. Figure 37 gives the estimated timeline from survey participants of how long it takes for IUID tags to sustain damage.

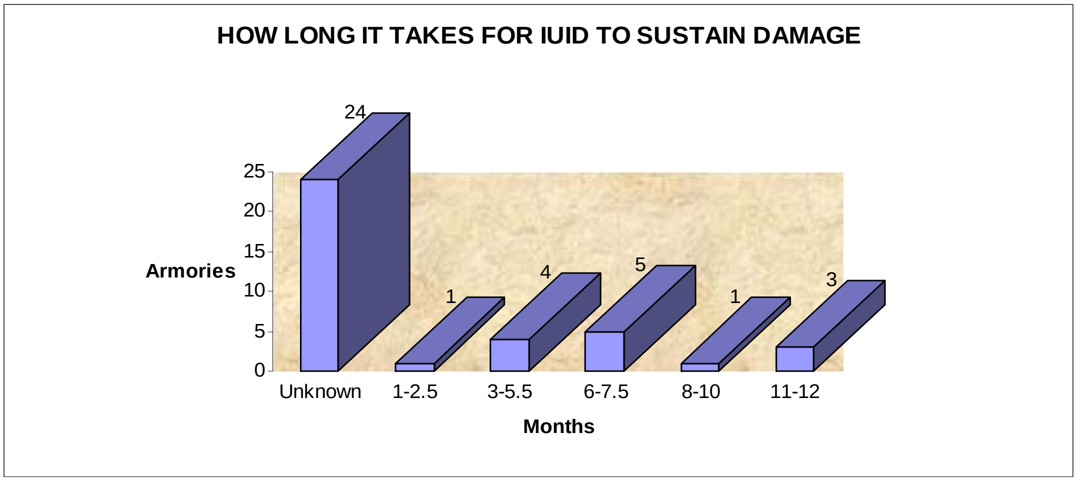

Figure 37. IUID Damage Time Intervals

Question 5: What type of physical damage is visible?

When asked what type of physical damage was most visible, 49% stated peeling; 41% stated scratching, and 10% stated other (Figure 38). Several of the participants in the 10% "other" category mentioned there were IUID labels that fell completely off the weapon. Falling off and peeling damage suggests there are engineering issues with the adhesiveness of the IUID labels. The scratching damage to the IUID labels most likely occurred from normal usage or possible tampering. During the survey, the thesis team noted there were two different types of IUID markings (adhesive tape and chemical etch) for the same type of small arms asset. This difference also contributes to the increased variability in durability. By limiting the types of IUID labels used on the assets, the Marine Corps could reduce the variability of the IUID labels' lifespans. By managing a smaller number of IUID label types, the armories could possibly reduce replacement costs of IUID labels.

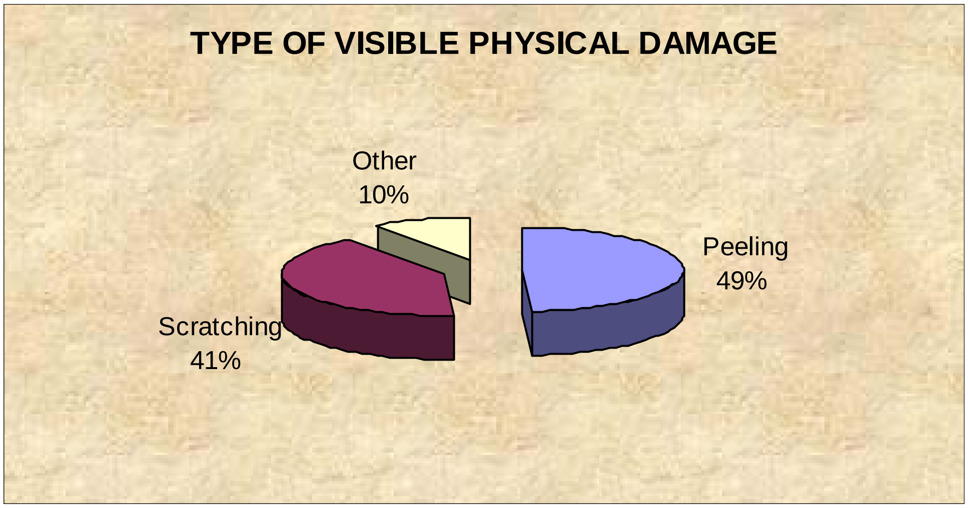

Figure 38. Types of Visible Physical Damage

Question 6: What IUID reading capability do you currently have?

When asked what IUID reading capabilities were available, all armories reported no equipment was available to read IUID tags. Since the Marine Corps armories have no capability to read the tags, it is unknown how well the tags could be read before and after damage. Without scanners, the armories are unable to implement inventory procedures for using IUID labels. Meanwhile, the IUID labels are incurring substantial damage without exporting data to an automated inventory system.

Question 7: How many weapons do you currently have with damaged IUID, and what is your total inventory?

The final question to all the armories addressed the number of IUID tags with damage and their total on-hand inventory. In the survey, across the 38 participating armories, the participants stated that 3,273 weapons out of 12,260 were said to have damage. This indicates that 26.7% of the weapons within the armories surveyed had damaged IUID tags. Since the participants earlier stated that some of the undamaged tags were on weapons had not even been issued yet, the damage percentage of IUIDs on issued weapons must be even higher.

3. Additional Survey Comments and Suggestions from Participants

Several participants included many comments and suggestions on their surveys. Some participants stated that they were unaware of the IUID markings on the weapons and wanted to know the purpose of such a tag. This question remains consistent with the thesis group's initial contacts with various Marine Corp armory personnel. Others wanted to know if all the weapons were being fitted with IUID tags, and if so, would there be a scanner available in the near future to capture the information on the tag?

Two participants who knew what IUIDs were noticed that the serial number stamped on the weapon was different from the one on the IUID tag. This discrepancy brings into question: how many weapons are mislabeled, and when and where did this error occur in the tagging process? In addition, some of the survey participants felt that IUIDs are another device that Marines may tamper with. This raises issues concerning durability and lifecycle of IUID tags.

As mentioned previously, there is a serious need to train Marines on IUID technology. The training may reduce tampering. This may increase the lifespan of the IUID tags on small arm assets. Currently, the tags within existing Marine Corps armories are showing a lifecycle of less than two years due to durability. Through training and increased awareness of IUID, Marine Corps leadership can potentially decrease the high damage rate to armories' tags. The survey data further indicates that a there is a high percentage of peeling and scratching on the IUID tags. This may be due to a design flaw that needs to be improved upon. If improvements can be made in the training of Marine Corps personnel and design of IUID tags, this could ultimately lead to a decrease in MDT. This will increase operational availability of IUID tags on small arm assets. As a result, IUID could improve the processes of issuing, receiving, and inventorying small arm assets.

VII. Recommendations

In order to make UID successful in the Marine Corps, several changes must be made. The flow of weapons to and from MCLB Albany could affect the readiness at supporting units. At the same time, delays in the GCSS-MC will prevent logistic sections beyond the armory from fully benefiting from Marine Corps armories' use of UID.

A. LOGCOM

Currently at FSD Albany, weapons requiring disposal or maintenance are received and placed into a database. All information is manually transcribed. This process creates the possibility of error since the processor must manually type each field of information about the item. We suggested that LOGCOM provide individual units with an electronically generated barcode for each asset that does not have an IUID. The barcode could be e-mailed by LOGCOM and printed by the using unit. This will improve the shipping process for assets shipped from using units to LOGCOM.

Once the asset is delivered to LOGCOM, the barcode sheet on the outside of the container can be used to verify the receipt of the shipment. This will allow the shipment to be properly receipted for and stored away, if time does not allow the container to be opened and completely inventoried on receipt. The barcode sheet in or on the box can be used once the shipment is ready for processing. If the barcode sheet on the outside is damaged or lost, the copy inside can be used instead. The use of barcodes and scanners to transcribe the information significantly reduces processing time and transcription errors.

The maintenance support provided by LOGCOM is shared by MCLB Barstow, California, and MCLB Albany, Georgia. The workload is decided by a variety of factors, but the primary driver is the geographical location of the supported units (i.e., West Coast units are generally supported by MCLB Barstow and East coast units by MCLB Albany). We recommend that further studies be performed to compare the units supported by LOGCOM. The transportation cycle-time, manpower and labor cost are some of the factors that should be considered. These factors should be evaluated to reveal how much work each depot facility should handle based on its capacity. LOGCOM should be informed when to shift maintenance work to another depot facility based on workload capability. As a result, the capacity of each depot facility could be used more efficiently.

B. Headquarters Marine Corps, Installations and Logistics

The Marine Corps currently funds the manpower of the logistics processors at NWSC Crane, who input the data received from the Marine Corps depots and using units. This cost is approximately $650,000 annually. Once NWSC Crane has implemented its real-time system, the processing time for transcribing data should decrease, which should immediately require less manpower. This is because the supporting units would input the data online. The system will reject invalid data information, which would reduce errors and reduce process time by preventing NWSC Crane staff from contacting units concerning submitted errors. Key personnel at NWSC Crane believe it will take several months to over a year to reduce manpower under the real-time data system. Headquarters Marine Corps, Installations and Logistics may want to evaluate the efficiency of the real-time system at NWSC Crane to see if manpower and funding can be reduced.

The Master Data Repository at the Logistics Capability Center in MCLB Albany captures and consolidates the information sent to NWSC Crane from the using units and depots. With management, the Master Data Repository database is capable of accomplishing the duties of the small arms registry at NWSC Crane. It may be worthwhile for the Marine Corps to see if the Master Data Repository could enhance or replace the work currently being performed by NWSC Crane.

C. Armory

Basic knowledge about IUID should be provided to all armory personnel. This training will reduce physical damage to IUID tags, as well as any possible damage that might occur due to tampering. Based on our research, we believe the durability of current tags requires improvement. Armories should track how IUID tags are damaged to identify the causes of damage. This data could be used by engineers to redesign current IUID tags and to develop a better method in marking small arms assets. In order for individual armories to be successful with an IUID system, the thesis group believes the following would have to occur:

- All of the serialized armory assets within Marine Corps would require IUID markings. This would be accomplished by passing all legacy assets through a maintenance depot to be marked. However, this would be extremely difficult and would either interrupt training and operations at the individual units and or the maintenance depot.
- Armories would also have to maintain the capability to remark damaged IUID to prevent serious interruptions to inventory and issuing procedures.

Marine Corps leadership will be very reluctant to release armory assets to the maintenance depot for remarking if there are no functional problems with the asset. This is because training and readiness is more important to Marine Corps leadership than improved processing times within the armory. Therefore, each armory could be required to mark each legacy asset within the armory and upload the IUID information into the UID registry. This would require each armory to have the capability and training to mark each serialized asset. Supplying the training and equipment to each armory may be financially challenging.

D. Marine Corps

The Marine Corps began investing in the GCSS-MC in 2003 when it was innovative and prominent. In 2008, it continued to invest in the program. The Marine Corps will adhere to contractual agreements ascertained during the GCSS-MC acquisition process. By doing this, the Marine Corps will accept the technology obtained in 2005 that will be implemented in 2010 (when Block 1 of GCSS-MC is actually implemented). To avoid obtaining yesterday's technology tomorrow, the Marine Corps will have to invest more funds to upgrade the GCSS-MC program that is already behind schedule. Due to the constant improvements in technology, current technology looses its value at a much greater rate. Therefore, the GCSS-MC is loosing its value at a much greater rate. Block 1 of the GCSS-MC will not be available to the end-user until 2010. (This is the earliest possible time.) The GCSS-MC's full implementation dates for Blocks 2 and 3 are still unknown. The Marine Corps is unable to gain system integration knowledge each year the GCSS-MC is not available to the end-user. Logistical and operational knowledge will also be un-obtained with each delay. The GCSS-MC is the medium of exchange that will enable IUID usage in the Marine Corps. Thus, implementation of IUID throughout the Marine Corps depends on the GCSS-MC's success. Therefore, system integration, logistic, and operational knowledge will be delayed on IUID also. As a result, IUID technology organic to the Marine Corps is devalued with each day the GCSS-MC is not up and running. This is due both to knowledge unattained about the system from a lack of usage and to rapid improvements in technology. The GCSS-MC should be created with full IUID capability and implemented as soon as possible in order to obtain the benefits of IUID.

Based on this thesis and other studies, we believe that the durability problems with IUID tags may replicate themselves throughout the Marine Corps or in other military branches. Leaders in the IUID industry should develop a tag that withstands the rigors of Marine Corps usage. We suggest that the Marine Corps become the proponents of this change in order to improve the durability of the IUID tags used by the Marine Corps.

E. Summary

The DoD definition of IUID includes the identity of a marked asset throughout its lifecycle. A sophisticated data system within the Marine Corps and other services is needed to manage all IUID-marked assets to capture lifecycle data. The cost of a complete DoD IUID system is tied to the cost of the GCSS-MC, because it should incorporate IUID fields. The cost of the GCSS-MC Block 1 is currently at $442 million (GAO, 2008). This cost does not include capabilities that will meet the expectations of the DoD Concept of Operations. It is not known in which block of the GCSS–MC the capabilities will meet the requirements of the DoD's Concept of Operations. It is recommended—based on the research done and information acquired—that the Marine Corps continue to pursue business system modernization based on its needs. The vision and concept of operation for UID by the DoD should be reevaluated. The revamping of the vision should include considerable input from leadership within the military branches who will recoup the benefits of the system.

Based on existing studies and the thesis team's survey results, we conclude there are engineering concerns involving the durability of IUID tags. Currently, due to the lack IUID scanners, it is unknown whether there are further issues concerning IUID tags and processing assets within Marine Corps armories.

When RFID was compared to IUID in the thesis, RFID was shown to be more suitable for tagging small arm assets. However, this thesis did not include a durability study on RFID tags. Follow-on studies should be done on RFID tag durability with small arm assets. A combination of the both RFID and IUID technologies could produce a system that is better than using them separately. This possible solution should also be investigated in a follow-on study.

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Appendix A. Survey Questions

UID physical condition Survey on weapons in Marine Corps Armory

The following is an informal survey to be used by students of the Naval Postgraduate School in Monterey, CA, who are in no way affiliated with IUID manufacturing or retailing of any products in this particular industry. The results of the survey will be used for academic purposes only and will remain anonymous.

Survey Questions

1. On what type of weapons are UID currently marked? When did you start receiving weapons with IUID?

____

____

2. Are UID on currently marked assets showing physical damage?

Yes No

3. What seems to be the cause of the physical damage? (e.g., wear & tear, tampering, asset abuse or unknown)

____

____

4. How long does it take for IUID to sustain damage from initial weapon issue?

____

____

5. What type of physical damage is visible? (e.g., scratch, partial peeling, complete peeling, etc.)?

____

____

6. What IUID reading capability do you currently have (e.g., reading, reading and recording, etc.)?

____

____

7. How many weapons do you currently have with damaged IUID, and what is your total inventory?

____

____

We appreciate your cooperation. Please return this survey to rrharris@nps.edu. Comments and suggestions are welcome!

____

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- Strategic Sourcing

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