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Analysis of Tobyhanna Army Depot's Radio Frequency Identification (RFID) program: RFID as an asset management tool

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MONTEREY, CALIFORNIA

MBA PROFESSIONAL REPORT

Analysis of Tobyhanna Army Depot's
Radio Frequency Identification (RFID) Pilot Program:
RFID as an Asset Management Tool

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June 2005

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13. ABSTRACT

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**ANALYSIS OF TOBYHANNA ARMY DEPOT'S
RADIO FREQUENCY IDENTIFICATION (RFID) PILOT PROGRAM:
RFID AS AN ASSET MANAGEMENT TOOL**

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ABSTRACT

The purpose of this MBA project is to identify the potential value of Radio Frequency Identification (RFID) used for inventory and asset management at the Tobyhanna Army Maintenance Depot. Tobyhanna Army Depot recently partnered with WhereNet Corporation for a pilot program to incorporate a real-time locating system that uses RFID. The pilot program tracks the AN/TPS-75 and AN/TRC-170 systems through the maintenance processes to determine if RFID is beneficial. The RFID asset management system proved beneficial to increase process efficiency and reduce the number of wasted labor hours used to find misplaced items. The cost-benefit analysis at the Tobyhanna Army Depot RFID pilot program indicates a Return on Investment of less than one year and supports previous research conducted on RFID as an asset management tool. Tobyhanna's investment in advancing technology essentially paid for itself within one year when measured in labor cost savings and yielded an annual savings of 837 Repair Cycle Time days. Since the primary infrastructure for RFID is already funded and fully operational, the payoff period on incremental investment is likely to be much shorter in the future.

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LIST OF ACRONYMS AND ABBREVIATIONS

AIT:	Automatic Identification Technology
AMC:	Air Mobility Command
DLA:	Defense Logistics Agency
DoD:	Department Of Defense
EPC:	Electronic Product Code
HAZMAT:	Hazardous Materials
MIT:	Massachusetts Institute of Technology
MSDS:	Material Safety Data Sheets
NPS:	Naval Postgraduate School
RF:	Radio Frequency
RFID:	Radio Frequency Identification
ROI:	Return on Investment
TDC:	Theater Distribution Center
USTRANSCOM:	United States Transportation Command

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I. INTRODUCTION

A. PURPOSE OF THIS STUDY

The purpose of this MBA project is to analyze the potential cost and benefits associated with the implementation of the Radio Frequency Identification (RFID) infrastructure at Tobyhanna Army Depot, a full-service repair, overhaul and fabrication facility. Tobyhanna Army Depot initiated an RFID pilot program in November 2004 to assess the benefits of the technology. SYS-TEC Corporation secured the contract as prime for the WhereNet Corporation and implemented an RFID infrastructure that provides real-time asset management capability. Tobyhanna selected the AN/TRC-170 and AN/TPS-75 systems for the pilot study. This project compares the cost of implementing the RFID solution to the net benefits associated with improving process flow of the two system's overhaul and repair activities. As part of the overhaul and repair process, the respective Prime Shops disassemble the system and distribute the components to multiple locations within the Depot. The secondary purpose of this study is to determine future applications of the existing RFID infrastructure. The potential benefits expected from the technology are:

- Increased productivity of personnel. Personnel no longer have to search for parts required for system reassembly. Parts can be easily located with RFID and the time saved can be used for other productive purposes.
- Inventory cost avoidance. Real-time asset visibility of critical components reduces the likelihood of having to reorder time critical parts that cannot be located within the facility.
- Increased productivity through process improvement. RFID provides real-time visibility and tracking capability of parts and equipment throughout the facility.
- Increased productivity produced by the alert function. RFID provides both a real-time tracking capability and historical log of component dwell times. The alert function within the RFID management system can be programmed to notify supervisors if materials have been in a specific shop for more time than required. This information provides important information to managers to manage process flow actively.

B. WHAT IS RFID?

Radio Frequency Identification (RFID) technology was first used by the British military during World War II and its first commercial activity occurred in the 1980's.[1] Many major companies consider RFID to be the replacement technology for bar codes and industry is beginning to implement the technology for use in supply chain management and to enhance internal process efficiencies. The technology uses low-level radio frequency signals to transmit and receive data. RFID tags are microchips that can be detected without the line-of-sight visibility between the microchip and the reader that bar coding requires. RFID not only enables companies to track goods and assets in real-time, but also offers the ability for useful data collection without the manual labor associated with barcodes and hand-held scanners, while minimizing the potential for human error.

RFID infrastructure consists of multiple components including the RFID tag, the tag reader, radio frequency antennas and a network computer system. The tag reader generates a low-level radio frequency magnetic field that is transmitted through an associated antenna. When an RFID tag passes through the magnetic field of the reader, the tag circuitry activates and sends a signal containing the memory contents of the tag through its antenna. The reader receives the signal and processes data prior to submission to the host computer system. There are two primary types of RFID tags, active and passive, and each has advantages and disadvantages.

1. Active Tags

The main difference between the two types of RFID tags is that active tags have an internal battery source and passive tags do not. The advantage of the active tag is that it transmits its own signal, which increases the read range of the tag and gives it greater memory compared to the passive tag. The disadvantage is that active tags are more

[1] Reik W. Read, Michael Grabenstein, Patrick A. Snell, Susannah Doyle, Timothy P. Byrne, and Tyson Smith. *RFID Explained - A Basic Overview.* Robert W. Baird & Co. Inc. February 2004, p. 3.

expensive, are larger and have a shorter life. A summary of the differences of the main characteristics between active and passive tags is shown below in Table 1.[2]

Characteristic	Passive Tags	Active Tags
Communication power supply	External – From reader	Internal battery
Read range	Up to 15 feet	Up to 250 feet*
Write range	0.5x to 1.5x as read range	1X read range
Storage capacity	Relatively less	Relatively more
Susceptibility to interference	Higher	Lower
Tag cost	$0.35 to several dollars	Over $20
Life of tag	Up to 20 years	Roughly 5 to 10 years
*Some read ranges extend well beyond 250 feet in ideal conditions.		

Table 1. Characteristics of Active and Passive RFID Tags

2. Passive Tags

Passive RFID tags do not have a power source and use energy from an incoming signal to simply reflect the signal received by the reader to transmit information. This requires a strong radio frequency (RF) signal from a reader and limited available energy constrains the RF signal strength returned from the tag.[3] For this reason, passive tags can only operate over very short ranges and require line of sight visibility for successful operation. In contrast, an active tag, when activated, sends a signal capable of being read at much greater distances.

C. PREVIOUS RFID RESEARCH AT NPS

There have been three MBA professional reports recently completed at the Naval Postgraduate School (NPS) that discussed different approaches to the use of RFID within the United States military. The first two studies considered the impact of RFID in supply

[2] Reik W. Read, Michael Grabenstein, Patrick A. Snell, Susannah Doyle, Timothy P. Byrne, and Tyson Smith. *RFID Explained - A Basic Overview.* Robert W. Baird & Co. Inc. February 2004, p. 7.

[3] Deputy Under Secretary of Defense (Logistics and Material Readiness). *United States Department of Defense Suppliers' Passive RFID Information Guide Version 6.* August 31, 2004, p. 3. http://www.acq.osd.mil/log/rfid/index.htm. Accessed May 9, 2005.

chain logistics, which is the focus of current Department of Defense (DoD) initiatives to provide total asset visibility of all cargo movements in support of the war fighter. The third study provided a cost-benefit analysis of implementing RFID as a real-time asset management tool within a military hospital.

1. USTRANSCOM and In-transit Visibility

The MBA report of June 2003 focused on the Air Mobility Command (AMC),[4] the organization responsible for all military transportation and falls under USTRANSCOM that is now responsible for establishing the global RFID infrastructure. The purpose of this study was to assess the potential value of RFID to AMC if used in its worldwide network of ports to manage the supply chain. The study concluded that there are benefits to using RFID but more pilot studies are needed to fully quantify the value of the technology.

2. Value of Supply Chain Logistics Information

The MBA professional report of June 2004 focused on what a Supply Officer was willing to pay for real-time information and visibility of items in the supply chain in an attempt to quantify the value added by using RFID in supply chain logistics.[5] This study concluded that real-time logistics information is valuable and is "must have" information in order to effectively support the warfighter. The study noted that RFID provided tangible benefits including reduced labor and consumption of parts as well as intangible benefits of better access to information to allow for better management decisions concerning allocation of limited resources.

3. Management of Medical Equipment

The most recent MBA professional report dated December 2004 focused on the value of RFID as an asset management tool.[6] The purpose of the study was to identify

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[4] Marcelo Hozven and George Clark, *DoD Supply Chain Implications of Radio Frequency Identification (RFID) Use Within Air Mobility Command (AMC*), MBA Professional Report, Naval Postgraduate School, December 2003.

[5] Christopher Corrigan and Jayson Kielar, *The Value of Logistics Information to the Warfighter*, MBA Professional Report, Naval Postgraduate School, June 2004.

[6] Joaquín A Sánchez and Sergio Chávez and Richard Nixon, Medical Equipment Management Through *The Use of Radio Frequency Identification (RFID*), MBA Professional Report, Naval Postgraduate School, December 2004.

the value of RFID in the management of medical equipment at the Naval Medical Center in San Diego. The study concluded that the value of RFID was in costs savings generated by eliminating replacement costs of lost equipment and improved manpower utilization by avoiding the time required to find lost equipment. This study presented a

Return on Investment analysis that showed a positive Net Present Value and a payback of less than a year for the implementation of RFID in that specific application and environment.

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II. RFID IN INDUSTRY AND IN THE GOVERNMENT

A. INDUSTRY

The two most general uses of RFID in industry are in the supply chain (open system application) and in specialized asset management systems (closed loop applications). Each of these two uses presents a very different business case analysis for assessing the benefits of RFID.

1. Open System Application

There is a tremendous amount of RFID visibility generated by mandates from large retailers like Wal-Mart and Target to implement RFID throughout their supply chains. Use of RFID in supply chain logistics is considered to be an open system application because it involves multiple stakeholders with each having different transportation, warehousing, and manufacturing processes.[7] Implementing RFID in open systems is difficult because of stakeholder differences and the large number of items to be tracked throughout the process. Item level tracking throughout the supply chain is still cost prohibitive for widespread implementation because of the large investment required for RFID tags, reader infrastructure and the current lack of implementation standards.

Creating an accepted standard is the most important requirement for full implementation of RFID in open system applications. The Auto-ID center is a research project at the Massachusetts Institute of Technology (MIT) supported by seven major universities throughout the world.[8] The Auto-ID Center developed the EPCglobal network as a non-profit organization to develop and implement global Electronic Product Codes (EPC) as the next standard to replace bar coding. Developing and implementing EPC standards will ultimately drive down costs since it will encourage more industries to apply the technology. As the demand for RFID technology increases, manufacturers will respond to the demand by developing new processes that ultimately drive down manufacturing costs. Continued advances in RFID tag technology is expected to improve

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[7] Psion Teklogix Incorporated. *Understanding RFID and Associated Applications,* May 2004, p. 10. http://www.psionteklogix.com. Accessed May 2005.

[8] http://www.autoidlabs.org/aboutthelabs.html. Accessed May 2005.

quality, reduce size, and lower the price of each tag. Large retailers are dictating the implementation of RFID in logistics and this is increasing the adoption of the technology. Greater adoption leads to lower costs and ultimately supports the business case for a positive return on investment (ROI). Currently, it is difficult to develop a business case that shows a positive ROI for open system applications because the cost of tags is too high.[9] Large retailers are forcing the implementation of RFID because they have the most to gain from its implementation and they large enough to require it for their suppliers even without a proven positive ROI.

2. Closed Loop Applications

In contrast to the open system application, a single system owner controls the closed loop RFID application. Closed loop applications provide a stand-alone solution that employs a specific usage application of RFID and has clear economic advantages over supply chain applications.[10] The closed loop system works independently of global standards. The closed loop system user is not as concerned about compatibility with suppliers like the open system user since there is lesser need for total efficiency under the closed loop architecture.[11] The automotive, healthcare and retail industries currently use RFID for inventory and asset management within controlled areas not requiring open transmission of data or supplies among external business partners. It is much easier to show a positive ROI for RFID implementation in closed loop applications and the payback is often 12-18 months, and many times less than a year.[12]

The cost of the RFID tags is the driver for achieving a positive ROI. A closed loop system will have a fixed number of tags that can be reused whereas the open loop application (supply chain) will have a variable number of tags that depends on the level of item tagging. It is more expensive to tag individual items as compared to crate or pallet level tagging. After the initial investment in a closed loop application, ongoing

[9] Bert Moore *RFID: Is This The Year?* Automatic ID News. January 1999. http://www.idat.com/a-rfid1999.html. Accessed June 2005.

[10] Psion Teklogix Incorporated. *Understanding RFID and Associated Applications,* May 2004, p. 10. http://www.psionteklogix.com. Accessed June 2005.

[11] Ibid, p. 13.

[12] Wes Iverson. *Will RFID Pay Off for Manufacturers?* Automation World. November 2004. http://www.automationworld.com/articles/Features/998.html.

system costs are relatively low because the tags can be reused allowing for amortization of costs over its service life that essentially makes it a fixed cost. If the tag costs $20 and you plan to use it over a period of 20 years, then it costs only $1 per year per tag as compared to an open loop application where it will cost $20 per tag every time a tag is placed.[13] Companies are beginning to implement RFID within their closed loop systems because in many cases it can be implemented with immediate benefits and a quick ROI. Researchers predict steady growth in the use of RFID for closed loop applications including healthcare, manufacturing, and other asset management applications as the price of tags and readers continues to fall.[14]

Today, manufacturing and distribution systems have generally remained separate, but there are a large number of closed loop manufacturing systems that operate successfully. Most of these involve tracking of reusable containers (such as a tote or cage) or a fixed asset (such as an automobile). These applications also include writing and rewriting data to tags as they are reused.

a. Automotive Industry

The automotive industry is the world's largest user of RFID and it has used it in production control and other applications for more than ten years. The industry spends about $600 million a year on RFID technology, which represented about half of the RFID market in 2003.[15] A 2004 AMR Research survey of vehicle manufacturers found more than 35 percent of respondents use RFID for material management and more than 22 percent use RFID to track racks or totes, and in both cases strive to improve internal operations.[16] Daimler Chrysler uses their asset management system to track product-specific racks and high-dollar components like engines. They attach RFID tags to the chassis of vehicles in production. The tags contain custom information such as the paint color or other custom requirements to be matched in production. The tags guide the

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[13] Brian Albright**.** Frontline Solutions. *'Eye' Spy.* Duluth: October 2002. Vol. 3, Issue 11, p. 16.

[14] Bruce Hudson. *RFID: Waiting for Its Wal-Mart Moment.* META GROUP April 9, 2003.

[15] Noppawan Bunyongasena, Florian Lohff, Naree Tubpun, Lei Xu, and Zhisong Zhang, *RFID in the Automotive Industry*, Institut für Wirtschaftsinformatik Humboldt University Berlin, July 2004, p. 5.

[16] SASITS – South African Society for Intelligent Transport Systems. *EXPAND RFID*. May 15, 2005. http://www.sasits.com/index.php?page_id=662&id=41. Accessed May 2005.

vehicle and parts through the production process for maximum efficiency.[17] They also use RFID tags to manage supply inventories to prevent them from being lost or stolen and to replenish inventories at low levels.

Volkswagen initiated small scale pilots to track racks and containers and has been able to reduce annual costs for maintenance, management and replacement by 15 percent. Volkswagen implemented a reusable RFID system to track 35,000 vehicles through the entire preparation process before cars are picked up by customers. This has improved quality and customer satisfaction.[18] In 2002, Volkswagen also implemented a "Smart Warehouse" project to manage spare parts with RFID tags. This system ensures inventories are maintained at minimum levels as well as parts supplied to the appropriate shops for production.

Toyota and Ford both implemented a complete tracking system that follows vehicles through all production stages and to final assembly using reusable tags. At the Ford plant in Cuautitlan, Mexico, the RFID system can tell what has been done to each vehicle and what remains to be done in the production process.[19] Before RFID, progress sheets were created manually at each stage in the production line. Now, these sheets are created automatically. The RFID tag is updated and the element of human error has been eliminated. In June 2004, Ford opened the first 'wireless factory' in Detroit using RFID to run real-time locating services and automated inventory replenishment capability to manage the entire production process.

b. Healthcare Industry

RFID offers several benefits in the healthcare market including patient tracking and asset management. Accuracy of patient records is extremely important and RFID provides the ability to better manage patient information. RFID offers an opportunity for an enhanced record keeping infrastructure that can be used to track

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[17] SASITS – South African Society for Intelligent Transport Systems. *EXPAND RFID*. May 15, 2005. http://www.sasits.com/index.php?page_id=662&id=41. Accessed May 2005.

[18] Noppawan Bunyongasena, Florian Lohff, Naree Tubpun, Lei Xu, and Zhisong Zhang, *RFID in the Automotive Industry*, Institut für Wirtschaftsinformatik Humboldt University Berlin, July 2004, p. 7.

[19] Dick Johnson. *RFID Tags Improve Tracking, Quality on Ford Line in Mexico*. Control Engineering November 1, 2002. http://www.manufacturing.net/ctl/article/CA257232?pubdate=11%2F1%2F2002. Accessed June 2005.

patients as well as the medications administered to them.[20] RFID can help document what, when and by whom a medication was administered to a patient. Erroneous patient data, including administering incorrect medications or dosages, is a major factor resulting in serious or potentially fatal medical mishaps. According to the Institute of Medicine, between 44,000 and 98,000 Americans die from medical errors annually and medication-related errors for hospitalized patients cost roughly $2 billion annually.[21] These statistics have dramatically increased the demand for fail-safe accuracy in managing patient care and RFID is providing an effective solution. In RFID equipped facilities, patients wear wristbands containing RFID tags encoded with medical information. All medications contain RFID information and a patient's RFID tag can be cross-referenced with a prescribed medication to ensure that it is appropriate for that patient. If the patient has an allergy that will prevent him from taking a medication, this information will be displayed on the computer system.[22] This system has reduced the possibility for human error and prevented many medical mishaps that occurred regularly in the past.

RFID is also be used to manage assets throughout a hospital facility to eliminate loss and to use equipment more efficiently. This was the topic of a recent Naval Postgraduate School NPS MBA Professional Report entitled, *Medical Equipment Management Through the use Of Radio Frequency Identification (RFID)* completed in December 2004. It illustrated how RFID may be used in the environment for asset management. The report concluded that investment for this type of application would give a positive ROI and a payback within one year.

c. Retail Industry

Marks & Spencer is one of the UK's largest retailers, selling its own brands of clothing, food, and house wares. The company has a closed loop system because it sells its own brands of merchandise and does not purchase or coordinate with outside suppliers. Marks & Spencer sells over 350 million clothing items each year and

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[20] Psion Teklogix Incorporated. *Understanding RFID and Associated Applications,* May 2004, p. 12. http://www.psionteklogix.com. Accessed June 2005.

[21] Institute of Medicine web site, http://www.iom.edu/subpage.asp?id=14980. Accessed June 2005.

[22] SATO America, Incorporated. *SATO RFID White Paper*. August 31, 2004. p. 8. http://www.satoamerica.com. Accessed June 2005.

started a pilot program in 2003 to tag individual garments using RFID to automate inventory and stocking.[23] Mobile carts are used throughout the store to take daily inventories and information is transmitted to a central database to check inventory levels against a stock profile that triggers replenishment orders if needed.[24] This effort gives employees more time to spend on customer service instead of counting inventory. The company plans to expand this pilot for managing apparel inventory from nine to 53 of its outlets during the second quarter of 2005.[25]

In 2003, Marks & Spencer replaced cardboard boxes used to transport fresh flowers with reusable plastic containers with embedded RFID tags. RFID is being used to manage delivery and receipt inventories from distribution centers and subsequently to individual stores. In 2002, the company completed a successful trial using RFID to track 3.5 million produce delivery trays to stores in its grocery division. These trays are being used in six to ten distribution centers that receive food and produce. The centers verify what is received and dispatched through reusable RFID tags that help lower inventory costs.[26] In both of these cases, RFID tags will help to identify "best before" and "use by" dates to ensure the customers receive the highest quality products.

d. Other Closed Loop Applications

RFID is used in closed loop applications in a wide variety of industries in a wide range of applications. A few examples are described below:

> Associated Foods Stores, a Salt Lake City-based grocery distributor, cut the number of tractors in its fleet from 120 to 67 after installing an RFID real-time locating system. After adopting RFID, the Spanish facility of Proctor & Gamble, the US manufacturer of family, personal and household-care products, not only reduced the number of its forklift operators, but also virtually eliminated shipping errors. Air Canada cut the number of food carts it loses annually by more than 80 percent and cut trucking costs because its RFID system means food carts were moved fewer times. Scotland's Courage Brewery, among the largest in the United

[23] Susan Kuchinskas. *U.K. Retailer Tests Smart Tags on Clothing.* Ecommerce. October 16, 2003

[24] Frontline Solutions. *Marks & Spencer Expands RFID Trial.* Frontline Solutions. April 2005. p. 11.

[25] Gene J. Koprowski. *RFID Drives Food, Fashion Operations in Europe.* MacNewsWorld. May 3, 2005. http://www.macnewsworld.com/story/42762.html. Accessed June 2005.

[26] Ibid.

> Kingdom, found its RFID system reduced the number of lost kegs and cut the time between refills from an average of 47 days to 40. The company not only saved millions of dollars, it also increased revenues by more than 3 percent.[27]

3. RFID Adoption

RFID can provide real-time visibility, gather data without line-of-sight, reduce labor requirements, eliminate data errors, hold substantial amounts of data, withstand harsh environments, be read in bulk, and can be updated easily with new data. There are many applications for RFID that have a tremendous benefit for those that have implemented it into their operations. Many companies believe that RFID is strategically significant to their futures, but investment in the technology is still relatively low and they are reluctant to fully commit to RFID or incorporate it into their strategic planning.[28] RFID use has been limited to specialized roles like reusable container tracking in closed loop applications due to cost barriers as well as a lack of accepted standards, technology challenges and performance limitations. Some others reasons for the reluctance of adoption include lack of business resources to study the benefits, existing high levels of process automation and control, difficulty of integration with existing systems, lack of developed business cases showing positive ROI, lack of full understanding of the technology and uncertainty in the benefits that the technology actually provides.

The most obvious reason for slow adoption is the cost to implement RFID without a clear potential for a positive ROI. Businesses have not dedicated resources to study RFID or to develop the business case for its use since it is difficult to assess the costs and the benefits to determine an accurate ROI. RFID costs significantly more than existing barcode technologies that perform similar functions for materials and warehouse management applications, and the cost of an RFID tag is so much higher than a bar code label that it cannot be economically justified in certain applications. Over the last 15 years, the warehousing and transportation industries have achieved a high level of automation and process stability. In these situations, RFID is expensive for the

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[27] TradeLink-eBiz. *Tuning into RFID.* October 2004. http://www.tradelink-ebiz.com/english/331n08or3m9a51l/newscast/tp_0410a.html. Accessed June 2005.

[28] Stefan Stroh, Dr. Jürgen Ringbeck, and Dr. Elgar Fleisch. Booz Allen Hamilton and St. Gallen University. *RFID Technology: Innovation Driver for Logistics and Industry?* Frankfurt, April 2004, p. 4.

incremental value that it can add to this highly automated environment. Bar-coding has helped warehousing and transportation companies continuously improve shipment tracking and 99 percent of shipments are already delivered problem free which greatly limits the potential value added by RFID implementation.[29]

Reluctance in the adoption of RFID is also due to an uncertainty in the measurable benefit provided by the technology. Small retailers do not expect to see increases in revenue within five years of implementation of RFID partly because there is a lack of awareness of how the technology can benefit them.[30] As a result, overall retailer investment in the technology has been low. As well as working to develop a global standard, the Auto ID center is working to develop business models that illustrate the value (revenue generated or cost reductions) of implementing the technology to help increase RFID adoption.[31] As industry standards evolve, and more companies implement the technology, the benefits will become more obvious to the entire retail industry and adoption is expected to increase more rapidly. Costs are forecast to decline and it will be much easier to show a positive ROI for RFID investment.

One example of adoption without understanding the full value of implementation is a project initiated by Woolworth Group PLC to track trucks carrying products from distribution centers to stores.[32] Woolworth Group is a UK retailer with more than 4,900 stores focused on home, family and entertainment. Their concern, similar to other large retailers, was with product visibility and actively managing the supply chain in an effort to reduce the amount of shrinkage. Woolworth was not able to benchmark their

[29] Stefan Stroh and Jürgen Ringbeck. *RFID: Thinking Outside the Closed Loop.* The WAVE Report on Digital Media published by 4th Wave, Inc. November 5, 2004, p. 4. http://www.wave-report.com/archives/2004/04431001.htm. Accessed May 2005.

[30] Deloitte Touche Tohmatsu, Retail Systems Alert Group. *RFID: How Far, How Fast: A View from the Rest of the World.* Chicago: Deloitte Touche Tohmatsu. November 8, 2004, p. 3. http://www.deloitte.com/dtt/research/0,1015,cid%3D65296%26pre%3DY%26lid%3D1,00.html. Accessed April 2005.

[31] Hisakazu Hada, Yukiko Yumoto, Mikako Ogawa and Jiro Kokuryo. *Toward An Auto-ID Network That Really Changes the World*. Ph.D. diss., Keio University. Sept 23, 2004, p. 1. http://www.m-lab.ch/auto-id/SwissReWorkshop/papers/TowardAnAutoIDNetworkThatReallyChangesTheWorld.pdf. Accessed April 2005.

[32] AIM Global. *RFID ROI: When You Don't Have the Numbers.* November 2003. http://www.aimglobal.org/technologies/rfid/resources/articles/oct03/roi.htm. Accessed May 2005.

processes before implementation in order to quantify the savings, but they still found many benefits including: process improvements, better asset management, real-time notification of delivery errors, and reduced product losses. The Woolworth approach was to choose an area that made the most sense based on the largest potential loss without fully developing the business case, but most companies are unwilling to take such risk without hard numbers that support the decision. This implementation of RFID is an example that suggests tools are needed to quantify the costs and the benefits of RFID technology in order to adequately assess whether the decision to install the required infrastructure will lead to a positive ROI.

Dell Computer Corporation has taken a different approach. The company developed a balanced scorecard to assess individual opportunities for implementing Auto-ID technology.[33] The Dell scorecard analyzes benefits, costs and future considerations of RFID implementation as shown in Figure 1.

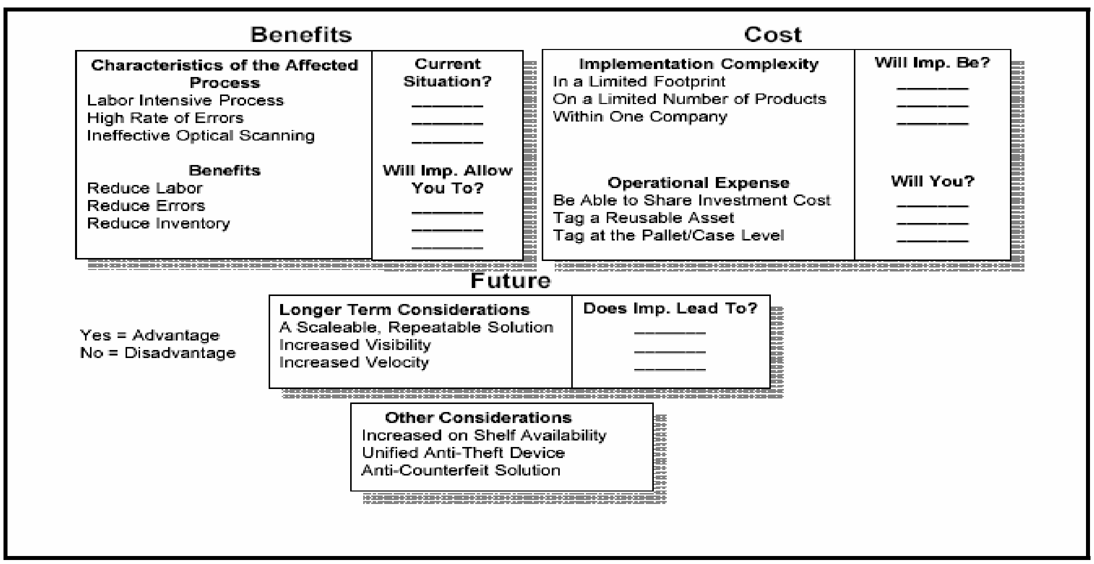

Figure 1. Dell Radio Frequency Identification Scorecard

This scorecard helps assess metrics within each category for advantages or disadvantages of implementation of new RFID projects. If there are more advantages than

[33] Mark Dinning and Edmund W. Schuster. *Getting on Board: Building a Business Case for RFID at Dell*. Nashua, NH, APICS - The Performance Advantage. October 2004. http://www.apics.org/Resources/Magazine/Past/October2004/default_October2004.htm. Accessed April 2005.

disadvantages, the project will be evaluated further for a potential ROI. In order for a project to be considered at Dell, it must show savings in items like labor, process improvements, lower inventory costs, etc. Dell concluded that their biggest hurdle to overcome is the integration of technology into their existing infrastructure.

It is clear that businesses need to develop more tools in order to adequately assess the full benefits of RFID. However, throughout industry there are some common themes that must be considered for successful implementation of RFID. Business must understand the basics of RFID, implement the technology with strategic purpose, and incorporate other process improvements to support the improvement initiative. One of the benefits of RFID is that it allows businesses to automate inventory management process and potentially save on manpower. Taken further, RFID automation can help reduce inventory levels and free up resources that can be used in other investments. Understanding these basic relationships in other areas can help build a better analysis to show a positive ROI.

The media has given a lot of attention to Wal-Mart's mandates for its suppliers to use RFID on all shipments. The expense for 100% compliance is high because of the variable cost of the tags, and many companies are only investing minimum amounts to meet Wal-Mart's mandates. In order to gain the most benefit from RFID, businesses must move beyond the "slap and ship" idea and look for the closed loop applications within their own control to make it worth the investment. Wal-Mart has already done this for their distribution centers and stores and is looking to bring their suppliers into the same practice. There are many benefits that companies can find in the closed loop applications, as well as within the supply chain, and businesses need to take a big picture view of the overall business model to maximize ROI. The RFID business case has not been fully developed with this idea in mind. The sole pursuit of mandate compliance alone yields little chance for a positive ROI.

RFID is a tool that can be used to find other improvements within the business process and it should not be implemented in isolation of making other improvements and leaning efforts. "Just like when many CEOs put in their first ERP systems, if they simply automated what they already had in place, they didn't get the benefits," says Tom Miller, president of Intermec Technologies, an Everett, Wash.-based company that supplies bar-coding and RFID systems. "They found they had to change their business processes."[34] Industry is finding that RFID is a proven process improvement enabler, a highly capable technology when implemented intelligently and a like all technologies will evolve and continue to improve.

B. WHERENET

Tobyhanna Army Depot partnered with WhereNet Corporation for the pilot program testing the merits of the RFID application with the depot. "WhereNet's core focus is to optimize supply chain flow in the industrial manufacturing, automotive, and retail industries, and the transportation and logistics markets."[35] As part of the company's planned diversification, WhereNet placed recent emphasis on applying its RFID technology to government applications. The following excerpts were taken from a WhereNet Application Note titled "Wireless Supply Chain Technology for Military Transportation, Logistics & Security."

> WhereNet offers unprecedented wireless location and communications solutions for managing mobile resources. These solutions are time and cost-saving alternatives to the traditional methods for identification and tracking of critical materials. WhereNet addresses the weaknesses of conventional supply chain management systems by providing instantaneous location and tracking throughout the supply chain for total asset visibility…As priorities shift, the ability to quickly and efficiently move critical goods becomes imperative. Real-time base/facility management keeps materials flowing smoothly through the supply chain…Essentially, just about anything that moves throughout a facility can be tagged and tracked in real-time. Because the WhereNet system can instantaneously locate yard assets within ten feet, finding time-critical equipment and cargo has never been easier. Once tagged, materials can be tracked and located continuously throughout a base or facility equipped with the WhereNet system. Additionally, for added security, alerts can be

34 Dale Buss. *The Race to RFID*. Chief Executive. New York: Issue 203, November 2004, p. 32.

35 WhereNet Website, http://www.wherenet.com/about.html. Accessed April 2005.

configured that if anything moves out of a defined zone, such as ammunitions dump, an alarm is instantaneously sent via the 802.11 infrastructure to a computer, telephone, pager or PDA.[36]

C. DEPARTMENT OF DEFENSE

1. Introduction

DoD is in the process of transforming the way it operates through business process improvements in an effort to emulate best business practices of industry. The DoD Implementation Plan for Logistics Automatic Identification Technology (AIT) outlines a general concept of operations for implementing AIT in the DoD and establishes standards and criteria for when and where certain tools should be used. It also outlines required actions for implementation and assigns specific agency responsibility for completing them.

The DoD is committed to the transformation of its logistics business processes through the implementation of technology. As the executive agent for logistics, the Defense Logistics Agency (DLA) established the DoD Logistics AIT office to promote, manage and implement AIT and to develop doctrine and standards throughout the implementation. The AIT toolbox includes technologies such as barcodes, optical memory cards, smart cards, radio frequency data communication, RFID and satellite tracking systems. The purpose for implementing AIT is to improve business processes and enhance war-fighter readiness. AIT is important for gathering quick, reliable data on assets in storage, in-transit, in use or during manufacturing. It will facilitate the capture, formatting and transfer of asset data to information systems for managerial decisions and requires minimal human intervention.

2. DoD Mandates

RFID is a primary component in the full suite of AIT tools that the DoD plans to implement, and the current focus for RFID is supply chain logistics. The memorandum mandates that DoD agencies immediately implement RFID capabilities to support

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[36] WhereNet. *Wireless Supply Chain Technology for Military Transportation, Logistics and Security.* WhereNet. June 2003. http://www.wherenet.com/pdf/homelandsecurity/App%20Note.Military.Trans.Log.Security.6.30.03.pdf. Accessed April 2005.

Combatant Commanders for global in-transit visibility and operational requirements.[37] Currently, all of the services within the DoD are using RFID for in-transit visibility to maintain control of assets across all logistics functions. Most RFID applications being used today consist of active tags for in-transit visibility of major end items and large cargo movements. Passive RFID applications have been limited to small pilots throughout the DoD agencies and implementation of new projects continues with the most recent mandate. The incorporation of RFID is to "take advantage of the inherent capabilities of RFID to improve our business functions and facilitate all aspects of the DoD supply chain."[38]

All of the DoD mandates focus on the supply chain, and the benefits that are expected to be achieved by using RFID are substantial. Essentially, DoD will require RFID tags on everything beginning January 2007, including all crates and pallets shipped within the DoD distribution network. The Defense Distribution Center manages 22 depots in the United States, Japan and Europe and stocks over four million items from construction and medical supplies to clothing, electronics and of course military materials.[39] It processes more than 23 million transactions per year. DoD officials plan to eventually require all suppliers to use RFID to manage these transactions to improve efficiency and speed up the process for all parties involved. The DoD focus is on external suppliers since the number of stakeholders involved makes it the most difficult to manage. The long term intention is to include RFID for "all aspects" of the DoD supply chain, including its own distribution network that has grown extensively over the past 10 years. With the number of daily business transactions performed, there is an enormous potential for savings. In its latest RFID procurement contract with Savi in 2003, the DoD said the real-time technologies today can be used for both in-transit and asset-visibility operations, including inventory and warehouse environments, maintenance, repair and tracking facilities, in-transit and checkpoint transportation,

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[37] Under Secretary of Defense (AT&L). *Radio Frequency Identification (RFID) Policy*. Washington D.C. October 23, 2003, p. 18.

[38] Ibid, p. 4.

[39] Bob Brewin. *Setting the stage for RFID.* FCW.com. September 27, 2004. http://www.fcw.com/fcw/articles/2004/0927/news-rfid-09-27-04.asp. Accessed May 2005.

hazardous materials handling, transactions at custody exchange points and controlling military convoys, among other applications.[40] These applications include both closed loop and open system applications. The Department of Defense is just following the lead of implementing new inventory-control systems that large industry businesses like Wal-Mart have already implemented.

3. Radio Frequency Identification Implementation

The Department of Defense has been using RFID for more than ten years and it started in the Persian Gulf as a result of supply chain problems that were encountered in the first Gulf War. Active RFID tags were used to track containers to Kuwait to prevent duplicate requisitioning of supplies.[41] The success of this initial use of RFID in the Persian Gulf started the initiatives that are being implemented today. The worldwide RFID network provides nodal tracking of equipment and cargo and is used to track 25,000 containers every day and includes over 750 nodes at airports, seaports and rail terminals.[42] This system is still being used today in Afghanistan and Iraq. In July 2002, General Tommy Franks, Commander of the United States Central Command, issued a directive to tag all air pallets and containers with RFID tags.[43]

a. Theater Distribution Center

The Theater Distribution Center (TDC) near Camp Doha in Kuwait is one of many examples where the system is working extremely well.[44] Once perceived as a "black hole" for supplies, now cargo "is flowing through rapidly," as stated by Harry Meisell, PM AIT's head of RFID operations for the United States military and NATO. The established network reads active tags as cargo leaves the distribution center in Kuwait that are subsequently tracked at checkpoints throughout Iraq until it arrives at the

[40] Logistics Today. *Savi Technology Awarded $90 Million U.S. Military Contract*. Washington, D.C. February 10, 2003. http://logisticstoday.com/sNO/4941/LT/displayStory.asp. Accessed June 2005.

[41] Michael Fickes. *RFID at the DoD*. Government Security. December 1, 2004. http://govtsecurity.com/mag/rfid_dod/. Accessed April 2005.

[42] UNISYS. *Radio Frequency Identification: Moving Beyond the Hype to Maximum Value*. UNISYS White Paper, 2004, p 3. http://www.unisys.com. Accessed April 2005.

[43] Jackson, Joab. *The Little Chip that Could: Radio Frequency Tags Reshape Logistics.* Washington Technology. March 10, 2003. http://www.washingtontechnology.com/news/17_23/cover-stories/20202-1.html. Accessed April 2005.

[44] Mark Roberti. *RFID Upgrade Gets Goods to Iraq*. RFID Journal. July 23, 2004. http://www.rfidjournal.com/article/articleview/1061/1/1/. Accessed April 2005.

supply center in Balad, Iraq. At any given time, material within the network can be quickly located. The ability to track in-transit materials actively saves time and money since materials lost prior to RFID tracking had to be reordered.

The TDC uses active tags in a closed loop system once materials arrive from suppliers. The military has been using active tags since the early 1990s, primarily for pallet-level shipments and Savi is one RFID provider that has been providing tags to DoD since 1994 helping to create the Total Asset Visibility network. Within the network, tags are placed on pallets and reused throughout the Theater distribution channels and within the depots themselves.

As described in the TDC in Kuwait, the DoD has created an extensive network using RFID tags to track military containers and large assets. DoD has established readers in place across the United States, Europe, Asia and the Middle East allowing soldiers to track some supplies and equipment from the field.[45] This extensive network is separate from compliance mandates that DoD has issued. This network has been established to monitor environmental conditions, to track containers of goods moving across long distances, to provide increased visibility to those goods in transit, to speed up processing between hand-offs of the container, and to provide increased security.[46]

b. Navy Fleet Industrial Supply Center Norfolk Military Ocean Terminal

The Navy conducted a six-week RFID trial program in 2004 at the Fleet Industrial Supply Center at the Norfolk Military Ocean Terminal with Alien Technology Corporation. The purpose of the trial was to increase outbound shipping efficiencies and to test other RFID capabilities. The equipment used for the trial included 13 readers, 16 antennae and about 15,000 tags. Trial results showed that RFID increased the overall efficiency of the Norfolk Military Ocean Terminal including improvement of shipping

[45] Reginal Jay Leichty. *Radio Frequency Identification Devices: Advanced Wireless Technologies May Enhance Homeland Security* Telecommunications. Washington: Volume 6, Issue 2, 2nd Quarter 2004. http://www.hklaw.com/Publications/Newsletters.asp?ID=469&Article=2583. Accessed June 2005.

[46] Dan Gilmore. *Anatomy of an RFID Pilot.* Supply Chain Digest. February 2004, p. 3. http://www.scdigest.com/assets/reps/SCDigest_Anatomy_Of_RFID_Pilot.pdf. Accessed June 2005.

and receiving activities, improving loading accuracy and reducing time involved to located materials. Dave Cass, transportation analyst for the Navy stated, "it was far more capable than we had anticipated" and "it's an easier and more efficient process than our legacy documentation processes."[47]

4. Conclusion

Both industry and the government are placing a lot of attention on the open system logistical applications for RFID without much attention given to the closed loop applications. Many of the benefits are the same for both systems including real-time tracking of assets without line of sight requirements and reduced human errors through automation. The most common use of RFID within the supply chain is for closed-loop asset tracking that applies to many different situations. Closed loop applications use RFID to track or control the location of an asset. The asset might be a trailer in the yard or a reusable container that travels between fixed points in the supply chain. Closed-loop RFID applications are generally used when bar coding is impractical due to environmental considerations or the process flow is better suited for a scan-free solution. Even though most of the media focuses on supply chain logistics, a significant closed network has already been established in the Navy and efforts are being taken to implement RFID in other closed loop applications.

D. REASONS BEHIND THE PILOT STUDY

Colonel Tracy L. Ellis is the current commander of Tobyhanna Army Depot. In coordination with the Research and Analysis Division, Colonel Ellis approved the plan to utilize RFID as an asset management tool within the depot. Although this decision was not directly related to the DoD mandate concerning RFID, the decision to incorporate the technology into the manufacturing process certainly complemented the intent of the mandate.

[47] Kyra Whitten. *US DoD Completes Navy Trial Using Alien RFID*. Alien Technology Corp., Morgan Hill, California - Thursday April 22, 2004. http://www.equitekcapital.com/Investorinfo/Webpagecontent/alien_articles/aliendodpr.htm. Accessed June 2005.

During our interview,[48] Colonel Ellis cited five reasons that supported his decision to invest in the RFID pilot project.

- Tobyhanna has made great efforts to implement lean manufacturing principles throughout all levels of operations within the depot. As part of the internally driven lean initiative, the implementation of RFID technology provides a management tool that helps to reduce time spent manually searching for parts within the system.
- RFID provides an opportunity to improve internal accountability within the depot. RFID provides real-time and historical tracking data that practically eliminates the ability to deflect responsibility for failure to process an action in a timely manner.
- The Automatic Storage and Receiving Station (ASRS) is responsible for receiving and disbursing inbound parts for use within the depot, and RFID technology would allow accurate and efficient movement of parts within the warehouse.
- As Tobyhanna continues to integrate its newly developed Enterprise Resource Planning (ERP) tool into its management process, integrating RFID technology into the ERP software will ultimately reduce the number of redundant systems required by the leadership to effectively manage within the complex operating environment at Tobyhanna.
- The Department of Defense mandated a Unique Identification (UID) requirement[49] to create consistent numeric tracking for all items moving within the supply chain. RFID technology supports this initiative by its ability to incorporate UID into the tracking software.

The site visit to Tobyhanna visibly demonstrated the Depot's commitment to embracing technologies of the future. Tobyhanna has taken calculated risks on other technologies, to include the robotic fork lift system working throughout the facility, indicating that the facility is an innovator that strives to keep pace with advancing technology. As a result, Tobyhanna has learned that well-placed capital investment leads to greater efficiencies and savings that far exceed initial costs of implementation.

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[48] Colonel Tracy L. Ellis. April 4, 2005. *Interview by authors.* Tobyhanna, Pennsylvania.

[49] Under Secretary of Defense (AT&L). *Policy for Unique Identification (UID) of Tangible Items – New Equipment, Major Modifications, and Reprocurements of Equipment and Spares.* Washington D.C. July 29, 2003.

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III. TOBYHANNA ARMY DEPOT

A. INTRODUCTION

The United States Army operates within a three tiered maintenance support system. The lowest level of maintenance is called Unit Maintenance and is performed by the "operator, crew and company maintenance team."[50] The Intermediate Maintenance function is split into three entities. "Direct Support activities are found in divisional and non-divisional organizations. They repair and return equipment to the user and provide repair parts supply."[51] The second component of Intermediate Maintenance is the General Support Activity (GS). The GS activity performs the same level of maintenance, but returns its system.[52] "Intermediate General Support maintenance units are located at echelons above corps (EAC) and are characterized by commodity oriented platoons or commercial activities repairing components and end items."[53] Depot level maintenance "supports both the combat forces and the Department of Defense (DoD) supply system by overhaul and rebuild operations. Depot maintenance is performed by selected industrial-type activities operated by the Army, other military services, contracted commercial firms, or specialized repair activities."[54]

Depot level maintenance provides the DoD the capability to preserve capital investment by retaining government controlled in-depth repair capabilities. Depots have several missions that make them a unique fixture within the military maintenance structure. Depots are responsible for "the overhaul and rebuild of end items, assemblies, and modules; repairs requiring special environmental facilities; non-destructive testing of

[50] Department of the Army. *Unit Maintenance Operations*. Washington D.C. Field Manual, FM 43-5, September 28, 1988, p 1-3.

[51] Ibid, p. 1-3.

[52] Ibid, p. 1-3.

[53] Ibid, p. 1-3.

[54] Ibid, p. 1-3.

used parts; inspections and modifications requiring extensive disassembly or elaborate test equipment; cyclic overhaul and special maintenance programs; and the manufacture of parts not otherwise obtainable."[55]

B. MISSION OF THE TOBYHANNA ARMY DEPOT

While all depots maintain this level of capabilities, it would be too much to ask for all locations to be capable of servicing all types of equipment. For this reason, most depots specialize in repairing a specific type of equipment in an effort to focus technical expertise and create centers of excellence.

> Tobyhanna Army Depot is the largest, full-service electronics maintenance facility in the Department of Defense (DoD). The depot's mission is total sustainment, including design, manufacture, repair and overhaul of hundreds of electronic systems. They include satellite terminals, radio and radar systems, telephones, electro-optics, night vision and anti-intrusion devices, airborne surveillance equipment, navigational instruments, electronic warfare, and guidance and control systems for tactical missiles. Tobyhanna is DoD's recognized leader in the areas of automated test equipment, systems integration and downsizing of electronics systems. The Army has designated Tobyhanna as its Center of Industrial and Technical Excellence for communications-electronics, radar, and missile guidance and control. The Air Force has designated Tobyhanna as its Technical Source of Repair for command, control, communications and intelligence systems.[56]

> Tobyhanna is a recognized leader in systems integration and has vast experience in the design, development, fabrication, repair and overhaul of C4ISR systems and components. Tobyhanna provides its depot level services to all branches of the Armed Forces, and is proud of its ability to support deployed forces around the world. The Tobyhanna leadership continually seeks methods to continuously improve its operations through work force training and development, and the use of Lean Six Sigma processes.[57]

[55] Department of the Army. *Unit Maintenance Operations*. Washington D.C. Field Manual, FM 43-5, September 28, 1988, p. 1-6.

[56] Tobyhanna Website, http://www.tobyhanna.army.mil/toby/facts/facts.html. Accessed May 2005.

[57] Tobyhanna Website, Commander's Letter. http://www.tobyhanna.army.mil/. Accessed May 2005.

C. TOBYHANNA PROCESS FLOW

Industrial operations within Tobyhanna Army Depot consume over 1,000,000 square feet of space.[58]

Figure 2. Aerial View of Tobyhanna Army Depot[59]

Figure 2 depicts the industrial section of Tobyhanna Army Depot. Building 1 and Building 4 are the primary buildings used for the RFID pilot project currently underway at the depot, and these buildings are depicted by the black box in Figure 2. Although this segmented area represents a fraction of the overall workspace within the depot, the workspace used to overhaul the AN/TRC-170 and AN/TPS-75 is extremely segmented. Figure 3 provides greater detail of the work areas involved with the AN/TRC-170 and AN/TPS-75 overhaul process, and graphically depicts the difficulty associated with manually tracking process flow across work section boundaries.

58 Tobyhanna Army Depot Website, http://www.tobyhanna.army.mil/toby/organize/risk/firea.html. Accessed May 2005.

59 Tobyhanna Army Depot Website, http://www.tobyhanna.army.mil/toby/reporter/report.html. Accessed May 2005.

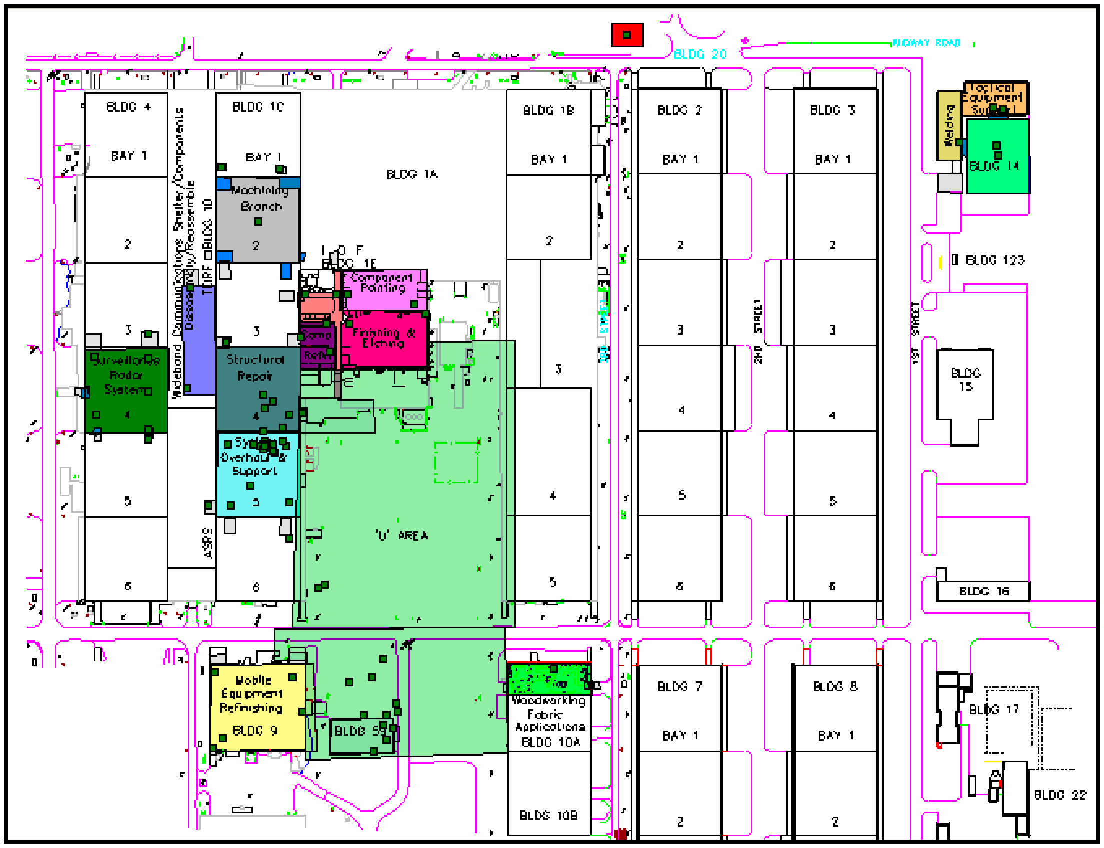

Figure 3. Tobyhanna Building 1 and Building 4 Layout

Figure 3 provides a graphical layout of Building 1 and Building 4. Building 1A houses most of the administrative offices associated with industrial operations. The Production Controllers for the AN/TRC-170 (Cindy Siblosky) and AN/TPS-75 (Pete Sabecky) systems work on the second floor of Building 1A. Although far removed from the overhaul work being done on the floor, each of these individuals has the opportunity to interact with process flow activities by using the RFID management tools available at their desktop computer.

The remaining four structures, Building 1C, Building 4, Tactical End Item Repair Facility (TEIRF), and the Industrial Operations Facility (IOF) are a series of bays that house specific work sections. Both the AN/TRC-170 and AN/TPS-75 have process flow activities throughout Buildings 1 and 4, but the central management functions occur within their respective Prime Shop. The AN/TRC-170 Prime Shop is located in Building 1C, Bay 5. The AN/TPS-75 Prime Shop is located in Building 4, Bay 4. The Work Leaders, Joe Symuleski for the AN/TRC-170 and Dave Riley for the AN/TPS-75, generally remain within their respective Prime Shop to conduct their managerial tasks.

Building 1C, Bay 2 houses the Machine Shop and the Structural Repair and Refurbishment Shop is in Building 1C, Bay 4. The Shelter Repair and Refurbishment Shops are in the Tactical End Item Repair Facility or TEIRF. The TEIRF is responsible for receiving the shelters associated with the AN/TRC-170, and manages the overhaul of the shelter separate from the remaining elements of the system.

There are a few locations that receive and overhaul the larger parts for the AN/TRC-170 and AN/TPS-75 that are located away from Buildings 1 and 4. The Paint Shop is found within Building 9, and conducts chemical plating, sand-blasting, and fresh paint for all large components. Building 10 houses the Woodworking and Fabrications shop and the Welding Shop is located in Building 14. Each of these buildings contains WhereNet hardware components to facilitate process flow management regardless of component location.

1. AN/TRC-170, Tropospheric Scatter Microwave Radio Terminal

There are approximately 66 AN/TRC-170 systems that enter Tobyhanna Army Depot each year for overhaul. One AN/TRC-170 is shown in Figure 4. The Prime Shop conducts the initial breakdown of parts for distribution to the various support shops. The average system breaks down into approximately 25-30 disassembled parts with each traveling to 3-4 support shops. When combined with the occasional part that requires rework or fabrication, there are approximately 120 traceable actions for each system.

> The AN/TRC-170s are complete Tropospheric Scatter (TROPO) or Line Of Sight (LOS) terminals that include antennas, radio transmitting and receiving equipment, and digital multiplexing equipment.
>
> Radio Terminal Sets AN/TRC-170 V2 and V3 are air or ground transportable troposcatter microwave radio terminals. These terminals provide secure digital trunking between major nodes of a TRI TAC communications network. The multi-channel radio terminal interfaces with other TRI TAC and current inventory equipment. TRC-170 terminals

are also used in stand alone applications; that is, as a transmission link not associated with a technical control. TRC-170 links might carry dedicated traffic to include analog and digital channels, point to point subscriber circuits, facsimile circuits and teletype circuits.[60]

Figure 4. AN/TRC-170 Tropospheric Scatter Microwave Radio Terminal

2. AN/TPS-75, Ground Theater Air Control System Radar System

Tobyhanna Army Depot inducts approximately five AN-TPS-75 systems per year into the overhaul process. The AN-TPS-75 system is shown in Figure 5. Each system breaks down into nearly 100 parts with each part moving to three support shops for overhaul work. When combined with the occasional part that needs fabrication or rework, there are approximately 350 traceable actions that benefit from RFID.

> The AN/TPS-75 is a mobile ground radar set designed to conduct long-range search and altitude-finding operations simultaneously. Data from the AN/TPS-75 can be combined with information from other radar to form an integrated picture of the aerial battlefield for theater commanders.
>
> The AN/TPS-75 Radar System is a mobile, tactical radar system capable of providing radar azimuth, range, height, and Identification Friend or Foe (IFF) information for a 240-nautical-mile area. This deployable and

60 http://www.globalsecurity.org/military/systems/aircraft/systems/an-trc-170.htm. Accessed June 2005.

transportable radar system is capable of providing long range radar data to support operations and control of tactical aircraft. The TPS-75 today forms the backbone of the US Air Force Air Defense system.[61]

Figure 5. AN/TPS-75 Ground Theater Air Control System Radar System

[61] http://www.globalsecurity.org/military/systems/aircraft/systems/an-tps-75.htm. Accessed June 2005.

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IV. METHODOLOGY

A. INTERVIEWS

1. WhereNet

As part of our research effort, we interviewed several people from WhereNet Corporation. The primary focus of our interviews with the vendor was to gain an appreciation for the technical parameters associated with hardware and software provided to Tobyhanna for the pilot project. Our first contact during the site visit to WhereNet Corporation in San Jose, California was Dave Wisherd. Although he introduced himself as the Chief Technology Officer and spoke to us for 30 minutes in that capacity, we soon learned that Mr. Wisherd carried another important title within the corporation. In addition to serving as the Chief Technology Officer, Mr. Wisherd serves as the Chairman based on the fact that he founded the company in 1997.[62] The time spent with Mr. Wisherd proved invaluable since we gained a full appreciation for the potential applications of RFID technology. While explaining both commercial and military applications of his company's technology, Mr. Wisherd physically demonstrated the hardware and software components involved in the RFID solution provided to Tobyhanna. Since the success of any RFID application is technology driven, speaking with the Chief Technology Officer served as a momentum builder for this study.

Immediately following our interview with Mr. Wisherd, we spoke with Matt Armanino who serves as the Senior Vice President for Sales and Field Operations. Mr. Armanino provided his vision as to how RFID technology could facilitate efficient military operations and explained how the company became involved with the Tobyhanna pilot program. WhereNet is making a concerted effort to broaden its involvement with military applications of RFID, and eagerly sought the opportunity to provide the requested solution to Tobyhanna Army Depot. As a sub-contractor to Systek, WhereNet provided the entire hardware and software solution currently in place at

[62] WhereNet Corp Website, www.wherenet.com Executive Staff, Accessed May 2005.

Tobyhanna Army Depot. To gain a further appreciation of WhereNet's developing relationship with the military, Mr. Armanino recommended that we conduct a follow-on interview with the WhereNet Federal Sector Director.

Michael Shea serves as WhereNet's Federal Sector Director and works away from the San Jose office in Chantilly, Virginia. Mr. Shea remains Tobyhanna's primary point-of-contact for the WhereNet solution in operation at Tobyhanna, and regularly visits the depot to provide support and coordinate for future contract modifications.

2. Tobyhanna Army Depot

Interviews conducted with personnel at Tobyhanna Army Depot during our site-visit provided us a depth of understanding about the RFID application that we could not otherwise have achieved. The interviews were all informal in nature, and the information collected served multiple purposes. Interviews with leadership and managers provided general insight into the reasons leading to the RFID pilot project, whereas interviews with those responsible for physically implementing the RFID hardware and software solution reflected a wide range of answers relating to the perceived effectiveness of the investment.

Colonel Tracy L. Ellis serves as the Commander of Tobyhanna Army Depot. As mentioned above, Colonel Ellis enthusiastically supported the concept of implementing new technologies into the overhaul and repair activities occurring at the depot. In fact, it was Colonel Ellis that upgraded the recommended use of passive RFID technology to the active RFID solution currently being used for the pilot project.

Ms. Sharon Smith is the Chief of the Research and Analysis Division for Tobyhanna Army Depot. Sharon provided us with detailed cost data for use in the project, and highlighted a potential bottleneck within the process flow diagram for all systems.

Mr. Ronald Rains is the Automatic Identification Technology Coordinator within the Research and Analysis Division. He served as our primary point of contact for the project, and provided a constant stream of valuable information that supports the cost-benefit analysis of the RFID pilot project.

The AN/TRC-170 Production Controller is Ms. Cindy Siblosky . She provided supporting data used to create the historical cost matrix for the AN/TRC-170 system, and provided keen insight into the productivity gains from RFID implementation as viewed from her level of oversight. The Work Leader for the AN/TRC-170 is Mr. Joe Symuleski and Ms. Sandra Morgan is a Shelter Team member for the system. Ms. Morgan is responsible for applying the RFID tags to components removed from the shelter portion of the AN/TRC-170, and she serves as the parts expeditor for her area of responsibility. Mr. Jeff Urbanovitch is the individual responsible for applying the tags to the individual components removed from the AN/TRC-170 system, and acts as the primary parts expeditor throughout the overhaul process.

The AN/TPS-75 Production Controller is Mr. Pete Sabecky . Pete is intimately familiar with the RFID management capabilities available to him, and provided valuable information concerning the benefits of implementing RFID tracking from a managerial perspective. Pete created a stand-alone spreadsheet that summarized historical cost data for the last four years. The Work Leader for the AN/TPS-75 system is Mr. Dave Riley. Dave personally conducts all RFID management tracking functions and serves as the primary parts expeditor for his system.

B. POTENTIAL BENEFITS AND METRICS USED

Implementing technological advances requires capital investment expenditures. In order for the investment to prove beneficial, the ROI calculation should yield a positive result. There are many different methods available to calculate costs and benefits. Some methods yield hard number results while other methods provide a more subjective analysis.

Colonel Ellis provided a few thoughts to consider as we developed our metrics for use in this study. Aside from mentioning the hard number metrics like direct cost savings, inventory shrinkage and productivity increases, he also delved into the less tangible savings opportunities associated with implementing RFID on the floor. Colonel Ellis predicted that RFID would increase management's overall confidence level by improving management effectiveness through real-time asset visibility of parts spread across the depot floor. He also believed that having the ability to prove the historical path of parts movement would reduce the opportunity to blindly point fingers within the inner-shops and prime shops.[63]

WhereNet Corporation provided a short synopsis of Tobyhanna's work activity prior to implementing their RFID solution in a White Paper titled "Depot Maintenance-Enabling Lean Building Blocks." The paper highlights the importance of metrics by stating, "the ability to measure performance is a fundamental requirement for improvement. Without measurement, the impact of initiatives or ideas cannot be quantified and, therefore, cannot be fully realized."[64] The paper continues by discussing some of the operational efficiency challenges that Tobyhanna faced. Some of the process control activities discussed included internal transportation delays, the observed ratio between cycle time to process components and actual touch time that indicated that parts are likely sitting around much longer than they should be, and excess motion required due to a poor layout and time required to track down parts in the system.[65]

After determining the potential benefits associated with the implementation of a RFID solution within the Tobyhanna Army Depot and reviewing what data was readily available for this cost-benefit analysis, we developed five metrics for analysis. There are several metrics that would require a subjective assignment of value not included in this study. In effort to maintain objectivity in our analysis, we focused our data collection efforts around the following five measurements.

1. Actual Direct Labor Hours: This value represents the total number of direct labor hours expended on overhauling a given end item. Each of the systems studied has an associated standard number of labor hours allotted for each overhaul activity, but the actual hours expended more accurately portrays the effort associated with each serial numbered item.

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[63] Colonel Tracy L. Ellis. April 4, 2005. *Interview by authors.* Tobyhanna, Pennsylvania.

[64] David Phillips, *Depot Maintenance - Enabling Lean Building Blocks*. Santa Clara, CA: WhereNet. http://www.wherenet.com. Accessed May 2005.

[65] Ibid, p. 2.

2. Actual Labor Cost: The actual labor cost is determined by multiplying the number of direct labor hours by the appropriate wage scale associated with the work activity. The Production Controllers pre-compiled the total labor cost for each serial numbered item which eliminated the need to compute the total labor cost from the individual components. We considered the fact that including figures for both actual direct labor hours and actual labor cost would prove redundant, but found a significant percentage difference between the two data points. This difference likely occurs from a combination of overtime differences and varying wage grade participation used in each activity.

3. Actual Material Cost: This number reflects the amount of money spent on direct material for each serial numbered overhaul. We expect this value to vary across each activity since items are only replaced and/or repaired as necessary.

4. Total Actual Cost: The total actual cost is a combination of actual labor cost and actual material cost. Again, we initially felt that this value might prove redundant since it represents a simple addition of two other values already included in the study. After reviewing the results, we intentionally left this value in the matrix to demonstrate the impact that varying material costs have on the cost pattern.

5. Repair Cycle Time (RCT): Repair cycle time is the number of days that passes from induction into the overhaul process until the Defense Logistics Agency signs for the item and enters it back into the wholesale system. The number of days represents actual business days and does not include weekends or holidays.

C. ESTABLISHING A DATA BASELINE

In an effort to establish a baseline for comparison, we asked each of the Production Controllers to provide data on systems that completed the overhaul system prior to the RFID solution implementation. For those data points developed after RFID implementation, we developed a value called RFID Utilization in an effort to quantify the amount of time RFID impacted the overhaul process. This value, measured as a percentage of work effort, represents the percentage of repair cycle time that the RFID solution was active while undergoing the overhaul process. The RFID solution went active in November 2004, and all percentages were calculated based on this timeframe. Systems that completed the overhaul process prior to November 2004 received a zero % value for RFID utilization, and systems that began the overhaul process in or after November 2004 received a 100% value for RFID utilization. As was the case for many systems, the overhaul process began prior to RFID implementation and finished after November 2004. For these items, we determined a value for RFID utilization based on the percentage RFID use for the RCT period

The AN/TPS-75 data had eight points of data with a zero percent RFID utilization rate, and seven data points that represented systems that partially used RFID during the overhaul process. Three of the AN/TPS-75 systems remained Work in Process (WIP) during data collection, and estimates of completion data were made for the statistical analysis. The RFID utilization rates for AN/TPS-75 systems that used RFID during the overhaul process ranged from 13 percent to 100 percent. Although the range spread dilutes the ability to statistically analyze progressive improvement after RFID implementation, the immature data set forced the creation of just two comparison data sets.

The AN/TRC-170 data presented 13 systems with 60 percent or less RFID utilization rate, and 14 data points that represented systems that used RFID for more than 60 percent during the overhaul process. The data for the AN/TRC-170 excludes 12 systems that had a zero percent RFID utilization rate. Although it would have been beneficial to use these data points to establish a zero percent RFID utilization baseline, an issue concerning a new requirement for muffin fan replacement added between four and six week delay for the systems affected by this parts delay. Excluding these data points from the statistical analysis forced the creation of two data sets divided at the 60 percent line of RFID utilization. Although not an ideal situation, it is more beneficial to have two data sets separated at an arbitrary point than to have the results skewed by an inconsistent data comparison.

V. DATA ANALYSIS AND RESULTS

A. ASSESSMENT ACCEPTANCE BASED ON INTERVIEWS

Integrating a new technology into an existing process is a complex task. The RFID hardware and software currently being used at Tobyhanna Army Depot represents a significant capital investment. The decision to spend more than $430,000 to install and maintain the RFID solution provided by WhereNet was made after careful analysis of the potential benefits expected from the initial investment. See Appendix A to view the "Depot Maintenance: Enabling Lean Building Blocks" paper that details the expected benefits of RFID. Tobyhanna forecasts to obtain a positive return on its initial investment, and relies on the ability of the users of the RFID application to gain efficiencies that will eventually yield the expected results.

As with any process improvement tool, the potential gains are limited to the ability to effectively implement the new asset. The act of integrating new hardware and software tools into an established process will not automatically create new efficiencies. Since RFID acts as a management tool, the only practical method of gaining maximum utilization of the asset is to obtain user acceptance of the new technology.

Installing new management tracking tools such as RFID requires the willingness of managers and workers to accept and adapt to the new procedures required by the new equipment. For many workers at Tobyhanna, the initial belief was that RFID would only add additional workload to an already busy schedule without immediate and measurable improvement. Jeff Urbanovitch, a parts expeditor from the AN/TRC-170 section, was very skeptical of the benefits associated with RFID. Upon interviewing him about the benefits witnessed personally by him, Jeff indicated that he felt RFID was costing him more time than it was worth. He spends approximately two hours applying the 30 RFID tags required for his system after breakdown. This equates to nearly 11 hours per month spent tagging the items given that the AN/TRC-170 team inducts an average of five to six systems per month. When asked how much time he saves per month expediting parts within the Depot, Jeff estimated that he saved two to three hours per week or 10 to 12 hours per month. Sandy Morgan manages the tag process for the shelter portion of the

AN/TRC-170 overhaul. The interview with Sandy revealed similar net benefit results for her efforts. Although it appears to be a net benefit of zero for Jeff and Sandy's efforts, there are many managers above their level that have the opportunity to actively manage parts flow based on these initial efforts.

The AN/TPS-75 requires approximately 4-6 hours of work per system to apply the 75 tags and input the required information into the desktop computer. The AN/TPS-75 section inducts just five systems per year, as compared to 66 systems inducted by the AN/TRC-170 section. Dave Riley is responsible for applying the tags to the system, and acts as the primary parts expeditor for his system. He estimates that the RFID tracking system saves him nearly five hours per week in time previously spent on manually tracking parts spread throughout the Depot floor. Whereas the net benefit for the AN/TRC-170 section was near zero, the net benefit for the tag manager/expeditor in the AN/TPS-75 section is approximately 225 hours per year. This equates to more than four hours per week that can now be used for much more productive efforts than walking the floor looking for parts. The difference in calculable net benefit between the two systems is directly attributable to the number of systems inducted by each section per year. When combined with the intangible benefits associated with total asset visibility, we still view the calculated zero net benefit of the AN/TRC-170 as a positive result.

Although most interviewees had differing opinions over the effectiveness of real-time asset management, one belief was constant throughout each and every interview. There was a general feeling that the mere act of placing an RFID tag and sending the item to an inner-shop for work gave the tagged item preferential treatment. When an item arrived to an inner-shop for work or repair, those with tags bypassed the queue since the workers within the inner-shops have full awareness that leadership is intently monitoring process flow of tagged parts. The only system acknowledged as having a fair chance at receiving similar treatment to tagged parts is Firefinder. The AN/TPQ-36 and AN/TPQ-37 radar systems receive continuous command oversight given the imperative nature of returning these systems back into the field to support the ongoing efforts in Iraq and Afghanistan. The preferential treatment given to tagged items was acknowledged by all levels of management, and confirmed by those directly involved with inner-shop work activities. This finding highlights the fact that initial studies of RFID benefits could be skewed in favor of demonstrating greater improvement than might otherwise be expected. This effect will be mitigated over time as more systems join the RFID program. As more systems use RFID for asset management, the number of tagged parts in the system will increase dramatically. True efficiencies associated with RFID might not be known until the floor is inundated with tagged parts.

One of WhereNet's primary selling points of its RFID solution is the ability to create alerts that highlight important diversions from standard practices. As an example, a manager is able to input a maximum dwell time permitted for a given part in a specific shop. If the part sits in the inner-shop for longer than the prescribed number of days, those on the established distribution list will receive an email alert identifying the problem. A more critical application of the alert system is the ability to receive a message if a part travels into a forbidden area. In the event that a part that cannot enter the elements accidentally moves outside, an immediate alert will be sent to prevent potential loss of the item. Although the alert capability is valuable, most managers expressed frustration with the inability to effectively action an alert once received. The common theme was that an alert is only as good as what is done after the alert is received. We view this problem as an internal communications problem as opposed to a sub-optimal feature provided by WhereNet. Managers cannot assume that an alert sent to an inner-shop is automatically acted upon, but must still remain proactive in managing the alert once received.

Since RFID is primarily a management tool, acceptance of the technology by the entire management team is essential for maximum benefit. The mere act of investing a large sum of money to integrate new technology into an existing process will not likely yield positive results unless other steps are taken to augment the effort. The AN/TPS-75 has embraced the concept of leaning out the overhaul process associated with their system, and all levels of management utilize the real-time asset management capabilities provided by the RFID solution. More importantly, the team has undertaken many steps to further lean out the overhaul process flow. Although the fact that many changes to process flow are occurring simultaneously with the implementation of RFID might complicate the ability to classify which changes are responsible for productivity gains, independent interviews with Pete Sabecky and Dave Riley allowed us to create an initial estimate of RFID's impact on the AN/TPS-75 system. Without consultation, both Pete and Dave estimated that 30% of all productivity gains achieved over the past several months are a direct result of the RFID management tool. Pete has an office far away from the depot floor, but remains actively involved in parts tracking by using the RFID tracking software on his desktop computer. Pete estimates that he saves 3-5 hours per week in time previously spent on the phone attempting to locate parts spread throughout the floor. At his level of management, Pete concerns himself with taking proactive measures to fix short-term problems hindering project completion. If Dave was unable to solve a parts problem on the floor, he passed the issue to Pete for resolution. Pete now has full visibility of all parts, and can quickly impact a situation before it becomes a bottleneck to the overhaul process. This net benefit is an example of where the zero net benefit result seen on the floor by the parts expeditors in the AN/TRC-170 system could provide positive benefits for others. Although the AN/TPS-75 Production Control team is actively leveraging the RFID technology as an augmentation tool to the ongoing leaning efforts, the same cannot be said for the entire AN/TRC-170 team.

Expecting to find similar applications of the RFID capabilities, we quickly realized that the level of system adoption varied greatly between the two systems. After finishing the interview process with the AN/TPS-75 Production Control team, we switched focus to members of the AN/TRC-170 Production Control team. We asked Cindy Siblosky how she felt the RFID application assisted her ability to manage parts tracking effectively on the depot floor, and learned that she rarely uses the RFID tracking software installed on her desktop. Since this was in stark contrast to the findings we had with Pete, we continued our line of questioning to determine why Cindy left this valuable tracking capability sitting idle. In all fairness to Cindy, we quickly determined that the sheer volume of assets inducted by her team limited the available time she had to track parts on the depot floor. Most of her time is spent managing higher level efforts, and Joe Symuleski on the shop floor represented the highest level of management that routinely used the RFID tracking capabilities. Further investigation revealed that the AN/TRC-170 section has not taken as many major steps to lean the process flow as the AN/TPS-75 section. Since RFID is primarily meant to augment other leaning methods, it was not surprising to find that the focus placed on RFID within the AN/TRC-170 section paled in comparison to that of the AN/TPS-75 section.

Each of the interviews provided valuable insight into the current state of the RFID pilot project underway at the Depot. The candid responses given by all interviewees allowed us to create a valid framework for assessing the costs and benefits created by the RFID solution. Our assessment of the differences between the management practices used within each system is not meant to question particular management styles. Our goal in describing how each section actively uses the available RFID hardware and software tools is to establish an initial framework for statistical and ROI analysis.

B. DATA ANALYSIS

1. AN/TPS-75 Data Analysis

The following describes the results of the data analysis conducted on the data collected for the AN/TPS-75 system. We compared data points representing zero RFID utilization rates with those that involved some level of RFID utilization during the overhaul process. Appendix B details the entire set of raw data for this system.

Table 2 depicts the change in average direct hours expended for each system between the two comparison sets of data. The average direct hours decreased by 16 percent for systems that had RFID involvement during the overhaul process. RFID implementation, along with other lean process improvement made by the AN/TPS-75 team, should yield labor hour savings over time. This positive result indicates that the process improvements yielded a labor savings when measured in hours. A corresponding decrease should be seen in labor cost, but the Table 3 reflects a smaller percentage gain in this area.

Group	AVG DIR HRS	Improvement From No RFID
No RFID	12,598	N/A
RFID	10,575	16%

Table 2. AN/TPS-75 Average Direct Hours Improvement

Table 3 shows that the average labor cost savings for systems using the RFID management tool is eight percent. This value falls below the 16 percent average direct labor hour savings, which indicates increased costs associated with the expended labor hours. Although not part of this study, the increase could occur due to additional overtime costs incurred to meet deadlines or by more direct hours being assigned to higher level wage grades. While important to find the root cause associated with the disparity, the key fact remains that the AN/TPS-75 team is obtaining an average savings of nearly $70,000 in direct labor costs per system after RFID implementation.

Group	AVG LAB COST	Improvement From No RFID
No RFID	$869,772	N/A
RFID	$800,137	8%

Table 3. AN/TPS-75 Average Labor Cost Improvement

The overhaul process mandates that certain parts be replaced and repaired regardless of condition, and Table 4 depicts the change in material cost. RFID technology and process improvement techniques cannot directly affect material failures discovered during the breakdown process. For this reason, the eight percent increase in material cost noticed during post-RFID implementation data points is not particularly alarming.

Group	AVG MAT COST	Improvement From No RFID
No RFID	$467,374	N/A
RFID	$503,023	-8%

Table 4. AN/TPS-75 Average Material Cost Improvement

Table 5 depicts the average total overhaul cost of the comparison data. We determined the total cost by simply adding the average direct labor cost to the average material cost for each category. Although the labor savings of 16 percent appears extremely encouraging at first glance, the labor cost has been tempered to an average total cost savings of five percent once combined with material costs. This result supports the notion that direct material costs are independent, and will not likely decrease as direct result of RFID technology.

Group	AVG TOT COST	Improvement From No RFID
No RFID	$1,337,146	N/A
RFID	$1,263,624	5%

Table 5. AN/TPS-75 Average Total Cost Improvement

Table 6 shows that the average repair cycle time for systems overhauled with RFID support decreased by 35%. We view repair cycle time as the most important metric used within this study since a decrease in repair cycle time translates to an increased ability of the end user to keep operational equipment on-hand. Given the fact that the AN/TPS-75 team inducts an average of six systems per year, a 35 percent reduction in repair cycle time equates to the team having the capability to process three additional systems per year. Even if there are not enough systems available to increase the annual amount to nine systems per year, the productivity gains benefit the end user by having a system returned more than 5 months earlier than previously experienced.

Group	AVG RCT	Improvement From No RFID
No RFID	**340**	**N/A**
RFID	**222**	**35%**

Table 6. AN/TPS-75 Average Repair Cycle Time Improvement

2. AN/TRC-170 Data Analysis

The following describes the results of the analysis conducted on the data collected for the AN/TRC-170 system. We compared data points representing RFID utilization rates equal to or less than 60 percent with those that involved more than 60 percent RFID utilization during the overhaul process. There are three types of AN/TRC-170 systems that enter the overhaul process at Tobyhanna. The V2 model has an average RCT of 150 days and the V3 and V5 models have an average RCT of 120 days. In an effort to avoid skewed analysis due to the variance in RCT's, we only considered the V3 and V5 models for inclusion into the data set. The data provided by the AN/TRC-170 Production Control team included just two data points for the V5 model, and the overhaul of both items was still in progress. Since there were ample data points for the V3 model, we ultimately restricted the study of the AN/TRC-170 system to the V3 model. Appendix C details the entire set of raw data for this system.

Table 7 reveals the fact that no savings in average direct hours is seen between systems with less than 60 percent RFID utilization and those with more than 60% utilization.

Group	AVG DIR HRS	Improvement From No RFID
<=60%	2,494	N/A
>60%	2,513	-1%

Table 7. AN/TRC-170 Average Direct Labor Hours Improvement

Table 8 shows a positive result when comparing average labor cost between the comparison sets of data. The three percent average labor cost savings is especially noteworthy given the one percent increase in the average direct labor hours noted in Table 7. This improvement could be attributed to a decreased number of overtime hours charged to the latter systems or a decrease in the average labor rate applied to the hours expended.

Group	AVG LAB COST	Improvement From No RFID
<=60%	$168,309	N/A
>60%	$162,817	3%

Table 8. AN/TRC-170 Average Labor Cost Improvement

Table 9 indicates a similar result for average material cost as noted in the AN/TPS-75 analysis. Implementing RFID technology is not likely to impact this metric, but it is important to note cost trends when conducting a broad-based cost analysis.

Group	AVG MAT COST	Improvement From No RFID
<=60%	$76,678	N/A
>60%	$90,612	-18%

Table 9. AN/TRC-170 Average Material Cost Improvement

Table 10 displays the average total cost comparison for the two data sets. The three percent labor cost savings was not sufficient to compensate for the 18 percent average material cost increase. The overall result was a three percent increase in average total cost for the items with a RFID utilization rate of more than 60 percent.

Group	AVG TOT COST	Improvement From No RFID
<=60%	$244,987	N/A
>60%	$253,429	-3%

Table 10. AN/TRC-170 Average Total Cost Improvement

Table 11 shows that despite the negative trend lines noted during the cost comparison, the repair cycle time for the AN/TRC-170 improved by eight percent for items with a RFID utilization rate of greater than 60 percent. This result demonstrates that RCT is not directly proportional to cost increases. The eight percent savings in RCT is extremely valuable given the number of systems processed annually by the AN/TRC-170 team. An eight percent decrease in RCT, if sustained, would allow for the completion of six additional systems above the annual average induction of 65 systems.

Group	AVG RCT	Improvement From No RFID
<=60%	117	N/A
>60%	107	8%

Table 11. AN/TRC-170 Average Repair Cycle Time Improvement

C. STATISTICAL ANALYSIS

For the statistical analysis, we narrowed the scope down to two metrics. Based on the noted anomalies between Average Direct Hours and Average Labor Cost concerning a lack of correlation between data results, we used the Average Labor Cost since we felt it more accurately portrayed the effects of RFID implementation. After discounting the impact that RFID has on potential material cost savings, we chose to eliminate material cost as a defining metric in our study. The secondary effect of removing the material cost is that the total cost metric no longer has validity for our cost-benefit analysis. Aside from Average Labor Cost, the only remaining metric used for statistical analysis is Repair Cycle Time.

To verify the statistical significance of the collected data for Labor Cost and Repair Cycle Time, we conducted four iterations of a Two Sample T Test. Results of the four tests are located in Appendix D. The null hypothesis for this analysis was that the No RFID data collected for the AN/TPS-75 and the <=60% RFID data collected for the AN/TRC-170 was equal to the corresponding comparison data of RFID and >60% RFID. The alternative hypothesis for each Two Sample T Test was that the No RFID data collected for the AN/TPS-75 and the <=60% RFID data collected for the AN/TRC-170 was greater than the corresponding comparison data of RFID and >60% RFID. After obtaining the descriptive statistics for individual data sets, we used the Two Sample T Test to generate a p value that indicates the statistical significance of the collected data.

The Two Sample T Test for RCT resulted in a p value of 0.00182 for AN/TPS-75 and a p value of 0.02661 for the AN/TRC-170. Both of these results indicate statistical significance well above the 0.05 confidence level, and we can easily accept the alternative hypothesis that the RCT data collected for the two systems is significantly different.

Similarly, we conducted a Two Sample T Test for labor cost. The resultant p value for the AN/TPS-75 was 0.1153 and the p value for the AN/TRC-170 was 0.2510. Both of these p values fall outside of the lowest generally accepted confidence level of .10, but results still indicate a moderate level of statistical significance for the labor cost data. Although unable to reject the null based on generally accepted confidence levels, it is important to note that the p values of 0.1153 and 0.2510 do not warrant total abandonment of the collected data.

D. RETURN ON INVESTMENT ANALYSIS

The total contract cost paid to WhereNet Corporation in order to establish the RFID pilot program was $433,960.26. The initial contract was $396,629.06 and a contract amendment added $37,331.20 to the overall contract cost. See Appendix F for copies of the original contract and the amendment.

Based on the data provided, we annualized the benefits measured for both systems. Although we included material cost as a metric in our study for comparison purposes, the results are not included in the ROI since RFID and other process improvements have no bearing on the overall materials required for each system. Since material cost is an integral part of the total cost, we chose to include the labor cost as the only dollar value metric used in the ROI analysis. The other two metrics used for the ROI are direct labor hours and RCT. We did not assign a dollar value to the RCT savings, but each RCT day saved is another day that the soldier, sailors and airmen have operational equipment for use. Although part of the interview process, inventory shrinkage due to lost items was found to be insignificant to this study. The value of lost inventory was negligible, and it is unlikely that the reported items would be tracked by an RFID tag. For this reason, inventory shrinkage is not considered as a cost in this study.

The following two tables depict the annualized savings associated for each system. During the interview process, we asked each team to estimate the impact that RFID had on the overall process given other leaning initiatives within their respective overhaul process. The AN/TPS-75 team estimated that RFID accounted for approximately 30% of the overall savings, and the AN/TRC-170 team indicated that all savings would be attributable to RFID since no other process improvements have been made during the time period under study.

AN/TPS-75 Savings per System	Per System Savings	*Attributable to RFID	Average Systems per Year	Annual Savings
Actual Labor Cost	2023	607	5	$104,452
Repair Cycle Time (Days)	118	35	5	177

*Based on assumption that 30% of AN/TPS-75 improvements are attributable to RFID

Table 12. AN/TPS-75 Savings per System

AN/TRC-170 Savings per System	Per System Savings	Average Systems per Year	Projected Annual Savings
Actual Labor Cost	-19	66	$362,472
Repair Cycle Time (Days)	10	66	660

Table 13. AN/TRC-170 Savings per System

Based on the results above, we estimate that the RFID pilot project will save $466,924 annually. Compared to the amount invested in the RFID solution provided by WhereNet, we calculate that Tobyhanna Army Depot will obtain full return on the initial investment in just over 11 months of use. Although recouping monetary investment is important in any business activity, decisions within the United States military are not always governed by the fiscal bottom line. In addition to the monetary savings noted in this study, there is a much greater benefit provided to the warfighter attributable to the RFID implementation. Each AN/TPS-75 and AN/TRC-170 system will make it to the field 35 days sooner and 10 days sooner, respectively. Annualized, this benefit equates to 837 RCT days saved.

Table 14 portrays the Discounted Cash Flows associated with this study. The initial cost in 2004 represents the total contract cost incurred by Tobyhanna Army Depot. The subsequent annual costs reflect the 18% maintenance contract cost that Tobyhanna incurs to support the RFID infrastructure. The annual savings for each system reflects the labor cost reduction determined from the study, and the Non-Discounted Total represents the simple summation of the costs and benefits for each year.

The calculations depict the results of four different discount rates. While the selection of the 5, 10 and 15 percent values were arbitrary, the 2 percent rate was chosen as a result of the guidance given in the Office of Management and Budget (OMB) Circular Number A-94.[66] All four discount rates provide a positive net present value with internal rates of return ranging from 58 percent to 81 percent. Positive net present value calculations indicate that it is beneficial to proceed with the project from a

[66] http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html. Accessed June 2005.

monetary standpoint. The fact that all four of the tested discounted rates yield positive net present values lends additional support that the RFID pilot project will provide positive benefits at discounted rates that exceed OMB guidance.

	2004	2005	2006	2007	2008			
Contract Cost/Annual Maint Cost	($433,960)	($78,113)	($78,113)	($78,113)	($78,113)			
AN/TPS-75 Annual Savings	$0	$104,452	$104,452	$104,452	$104,452			
AN/TRC-170 Annual Savings	$0	$362,472	$362,472	$362,472	$362,472			
							NPV	IRR
Non-Discounted Total	($433,960)	$388,811	$388,811	$388,811	$388,811		$1,121,285	81%
Discounted at 2%	($433,960)	$381,187	$373,713	$366,385	$359,201		$1,046,528	78%
Discounted at 5%	($433,960)	$370,296	$352,663	$335,870	$319,876		$944,745	73%
Discounted at 10%	($433,960)	$353,465	$321,332	$292,120	$265,563		$798,519	65%
Discounted at 15%	($433,960)	$338,097	$293,997	$255,650	$222,304		$676,088	58%

Table 14. Discounted Cash Flows for Tobyhanna RFID Pilot

E. LEARNING CURVE ANALYSIS

"A learning curve is a line displaying the relationship between unit production time and the cumulative number of units produced."[67] Learning curves help define the projected level of improvement in a given process over a period of time. The learning curve percentage, once established through mathematical derivation, helps to determine the amount of effort each successive doubled unit (1, 2, 4, 8, 16 etc.) will take to complete. If the second unit of a production run with a perfect learning curve of 90 percent took 1000 hours to complete the work effort, the expected work effort for the fourth unit is 900 hours (90 percent of 1000) and the expected work effort for the eighth unit is 810 hours (90 percent of 900). The determination of the learning rate is made calculating the percentage difference between the learning curve and 100 percent. In the case of the 90 percent learning curve noted above, the associated learning rate is 10 percent.

[67] Richard B. Chase, F. Robert Jacobs, and Nicholas J. Aquilano, *Operations Management for Competitive Advantage*, 10th edition, McGraw-Hill/Irwin, New York, 2004, p. 49.

There are three assumptions that support learning curve theory: [68]

1. The amount of time required to complete a given task or unit of a product will be less each time the task is undertaken.

2. The unit time will decrease at a decreasing rate.

3. The reduction in time will follow a predictable pattern.

Although the data sets collected for each of the systems in this study violate the assumptions listed above, it is worth noting that the underpinnings of learning curve theory have practical application to all of Tobyhanna Army Depot's work activities. After repeated attempts to fit the available data into a learning curve, we determined that the data set is too immature to allow for the creation of a statistically significant finding. In theory, it can be expected that the overhaul process will eventually conform to the stipulated assumptions and a valid learning rate will develop over time.

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[68] Richard B. Chase, F. Robert Jacobs, and Nicholas J. Aquilano, *Operations Management for Competitive Advantage*, 10th edition, McGraw-Hill/Irwin, New York, 2004, p. 49.

VI. OTHER USES OF RFID WITHIN A DEPOT MAINTENANCE FACILITY

A. INTRODUCTION

The Tobyhanna Army Depot is a full-service repair, overhaul and fabrication facility that provides services to the Department of Defense including maintenance of satellite terminals, radio and radar systems, telephones, electro-optics, night vision and anti-intrusion devices, airborne surveillance equipment, navigational instruments, electronic warfare, and guidance and control systems for tactical missiles. According to the Tobyhanna Directorate of Production Management, the depot services over 3,000 different electronics systems a year. Of those, there are over 50 systems that can potentially be considered for implementation of RFID to help manage the repair process.

The Tobyhanna Army Depot has recently established the basic RFID infrastructure with the current pilot program being used to manage the overhaul processes for the AN/TPS-75 and AN/TRC-170 systems. In the near future they intend to expand the system to include the Firefinder system (AN/TPQ-36 and AN/TPQ-37) and many others in the years to come.

B. SCORECARD APPROACH

1. General RFID Scorecard

How can Tobyhanna decide whether or not to implement RFID in their operations for a specific system? We decided to take a general scorecard approach to help answer this question. The balanced scorecard is a management system that can assist organizations with translating their mission, vision, and strategy into actions that can be measured in order to assess progress or in this case potential benefits.[69] Managers can use the Balanced Scorecard in the investment appraisal process. Traditional methods of financial assessments such as the discounted cash flows for measuring ROI may not properly assess the intangible benefits that can be generated with RFID. From this perspective, we developed a general RFID Scorecard shown in Figure 6 that shows RFID

[69] Balanced Scorecard Institute, http://www.balancedscorecard.org/basics/bsc1.html. Accessed June 2005.

implementation from four big picture perspectives: Financial, Stakeholder, Internal Processes, and Implementation Risk. This framework will provide the basis to develop metrics that will allow management and assessment of RFID implementation. As Figure 6 shows, the objectives within each perspective should relate back to the overall mission, vision and strategy of the organization.

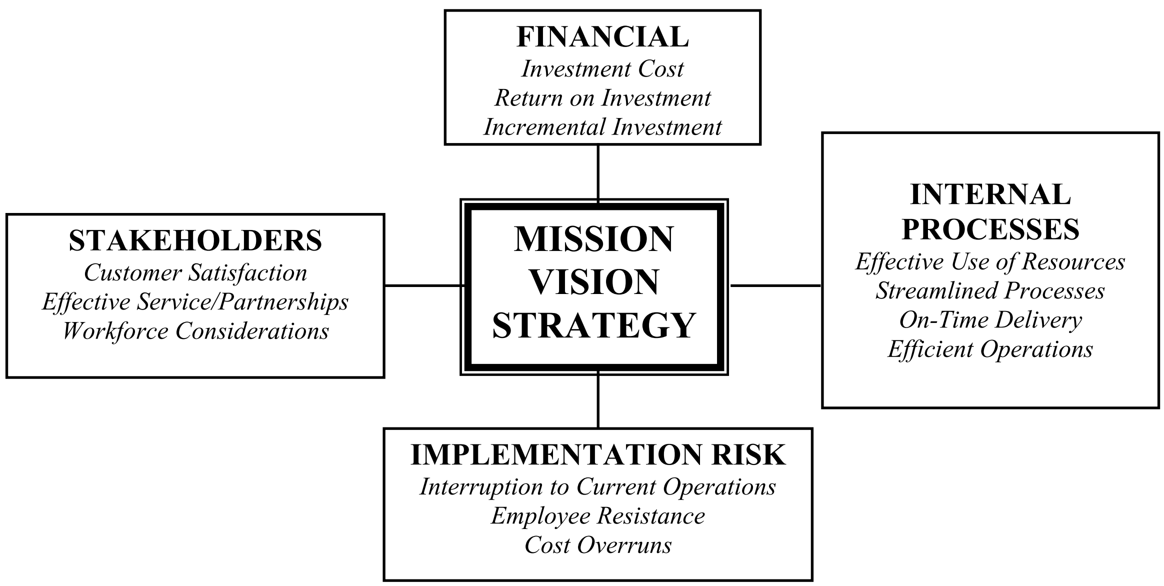

Figure 6. Tobyhanna General RFID Scorecard Perspectives and Objectives

a. Financial Perspective

The primary consideration for implementation of any new system within an organization is usually financial. The financial perspective will assist to ensure that enough resources are available for implementing a proposed implementation as well as to provide the appropriate analysis for determining if it is financially beneficial for the implementation. This should include a cost-benefit analysis as well as a ROI analysis to assess the viability of the project.

b. Internal Processes Perspective

This perspective analyzes the impact of internal processes on the business. It uses metrics to assess how well the business is operating and if resources are being used effectively and efficiently. Furthermore, this perspective helps to determine if the products and services conform to customer requirements. These metrics have to be carefully designed by those who know the business processes most intimately. Managers should have an understanding of how successful the business is in implementing process improvements and once implemented how well they are working to meet the intended purposes. This perspective should also include an analysis of other process improvements that can be implemented concurrently with RFID. RFID is a tool to assist with overall process improvement and is not as successful if implemented in isolation of other leaning efforts.

c. Stakeholder Perspective

Customers and employees of the organization are combined in the stakeholder perspective. This perspective considers stakeholder satisfaction, concerns and requirements required for success. Does the implementation have a possibility of improving customer quality or meeting other needs or requirements? Customers are the reason why an organization is in business, and implementation of any new technology should help make the overall process better for the customer. In the case of Tobyhanna, RFID has the potential to improve cycle time to return the systems to the customer in the field more quickly. Process visibility can also provide the customer with information that would not otherwise be available without RFID.

Managers should also consider the impact to the employees that will use the RFID system. It is imperative to communicate with the workforce before implementing a new technology to ensure that it can actually provide some benefit to the organization. Employees should understand the potential benefits that the technology can provide or resistance to the new technology is likely to occur. What training will be required to support the employees to implement the technology? This should be carefully planned to reduce problems with the future implementation. One example at Tobyhanna occurred with the training that was performed for the Container Program software module. The module for this software was not part of the initial installation and WhereNet attempted an impromptu training on the shop floor to show how it could benefit the users. Feedback from the employees was that the training was not well organized and that it seemed too complicated to use the new module.

d. Implementation Risk Perspective

The implementation risk perspective should consider issues that could lead to difficulties in implementation of the new RFID project. How likely is the workforce to accept the new technology? Will it be perceived as an additional level of control towards those that use it or as a tool to make their jobs easier. How well does the workforce accept change? Also, what impact will the implementation have on current operations? Is the implementation likely to reduce cycle time during the implementation phase? Will there be a significant learning curve or will adaptation come quickly?

2. Tobyhanna RFID Scorecard

How can Tobyhanna decide whether or not to implement RFID in their operations for a specific system? To answer this question, managers need to break down the benefits of the technology into measurable aspects as a tool to make an assessment for overall benefits to the facility. We have created a scorecard based on Dell's scorecard shown in Figure 1. The Tobyhanna RFID scorecard is shown in Table 15. These ideas are grouped into cost benefits and future considerations categories to simplify the analysis. The idea is to analyze the criteria for general benefits, costs and future considerations of RFID and then apply them specifically to Tobyhanna to establish appropriate metrics. These metrics can then be used to assess if there is an opportunity for a positive ROI from RFID implementation.

Table 15 shows a side-by-side presentation of the general criteria for use of RFID and the corresponding specific metrics that could be used at Tobyhanna for assessing new RFID projects. Each of the criteria described in the Tobyhanna RFID scorecard can be linked back to the RFID perspectives and objectives shown in Figure 6. This approach will allow Tobyhanna to select additional RFID projects that are most likely to achieve financial success. In Table 15, each metric is given equal weighting; however, Tobyhanna could apply different weights to each metric if they determine that some are more important than others. A weighting system could provide a means to better measure the strategic benefits of the project as part of the scorecard evaluation. We established the criteria for assessment based on what we learned in interviews of personnel at Tobyhanna, from our assessment of the key performance criteria and the specific benefits that RFID can provide to Tobyhanna.

GENERIC SCORECARD CRITERIA	**TOBYHANNA SPECIFIC METRICS**	
Benefits	Benefits	**Y or N**
Large number of components	Are there a large number of components/subcomponents to be tagged (>15 components/system)?	
Multiple process steps required making it difficult to track components	Are there a large number of inner shop actions (sum of inner shop visits for each component) that require tracking? (>15 actions) (3 components x 5 shops for each component = 15 actions for the entire system)	
Large time periods to do inner shop work.	Are there large dwell times (>3 days) on average required for inner shop processes?	
Large segmented workspace	Do greater than 50% of the components move more than two bays away for maintenance?	
Labor intensive manual tracking.	Is there be time savings tracking down components/subcomponents?	
Visibility and protection for high value assets / components		
Cost	Incremental Costs	
Use of existing infrastructure	Will implementation allow use of the existing infrastructure?	
Minimal impact to operations and few coordination requirements	Is implementation less than 2 products at a time?	
Incremental expense	Are there minimal additional expenses? Less than 20% of original cost or within budget?	
Future and Other Considerations	Future and Other Considerations	
Parts and process visibility	Increased parts visibility?	
Other process improvements	Increased process visibility or other efficiencies?	
	Potential to reduce cycle time per system?	
High visibility system	High visibility system	
	Total Advantages (Y)	
	Total Disadvantages (N)	

Table 15. Tobyhanna Radio Frequency Identification Scorecard

a. *Benefits*

What characteristics of maintenance shop processes are good candidates for using RFID? RFID can be of assistance on projects that have a large number of components that travel through multiple processes. Furthermore, if components must travel to areas that are not nearby the primary shop, or if the maintenance processes require the parts to remain in other areas for long periods of time, there is some benefit to using RFID. These aspects make it more labor intensive to track components throughout the facility and RFID can help eliminate difficulties of tracking components. Finally, if parts have a high value, or if they are critical components for completion of a system, RFID can provide real time tracking to ensure that positive control is maintained on those items at all times. As one worker at Tobyhanna told us, "I love RFID; now I can find my stuff."

b. *Cost*

New projects must be evaluated for their costs. Dell decided that it was most beneficial for them to implement RFID by narrowing the scope of application to those areas of their operation that were the easiest and provided the most potential for success. The situation at Tobyhanna is similar because it already has an infrastructure and can expand to take advantage of the existing infrastructure. The incremental cost of infrastructure is minimal since the majority of the infrastructure is already in place. Another consideration is the impact of the implementation to current operations. Can it be done without increasing the cycle time, creating a lot of confusion within the workforce, and in a manner that the progress can be tracked? Finally, the incremental expense must be within budget and reasonable as compared to the overall cost of the original system.

c. *Future and Other Considerations*

A supplementary benefit to RFID is the visibility of parts and process actions. Shop managers can use the real time tracking capabilities of RFID to analyze current operations to find process efficiencies. Furthermore, RFID can save labor time that can hopefully reduce the overall cycle time to complete the maintenance work on an individual system. Ideally, RFID should provide improved throughput because of the availability of better management information to help ensure that operations are working efficiently.

3. Firefinder System

Tobyhanna plans to expand the current RFID infrastructure for managing the overhaul process of the Firefinder system (AN/TPQ-36 & AN/TPQ-37). This system is one of the highest priority systems that Tobyhanna maintains because of the high use and visibility it currently receives in Iraq and Afghanistan.

The Firefinder consists of the AN/TPQ-36 & AN/TPQ-37 systems. During our site visit to Tobyhanna, we interviewed the work supervisors for the Firefinder systems. Kathy Winowich is the supervisor for the AN/TPQ-37 system. She estimated that the AN/TPQ-37 would require about 20 RFID tags for system. However, it does not require components to go to the inner-shops for maintenance. The parts only have to travel a maximum of two adjacent bays away for maintenance, which means that she does not have to spend much effort tracking parts. Shelly Sherman is the supervisor for the AN/TPQ-36 system and she estimated that the AN/TPQ-36 would require about 30 RFID tags for the system. Her system requires maintenance work from the inner-shops, but tracking parts is not difficult for the expediter because there are three primary locations that parts go for maintenance. Both work supervisors told us that they did not believe that RFID would be beneficial for managing the Firefinder system.

We used the scorecard to assess the Firefinder system and the results are shown in Table 16. The Firefinder system was evaluated from a general perspective to include both systems in order to illustrate the use of the scorecard. Without detailed process information, it is difficult to completely assess each system and we recommend that Tobyhanna perform a more detailed analysis in order to address the potential benefits of RFID for each system. The scorecard showed that there were seven advantages as compared to five disadvantages. This initial assessment gives an indication that there is potential for a positive ROI by using RFID to manage the Firefinder system.

GENERIC SCORECARD CRITERIA	TOBYHANNA SPECIFIC METRICS	
Benefits	Benefits	**Y or N**
Large number of components	Are there a large number of components/subcomponents to be tagged (>15 components/system)?	Y
Multiple process steps required making it difficult to track components	Are there a large number of inner shop actions (sum of inner shop visits for each component) that require tracking? (>15 actions) (3 components x 5 shops for each component = 15 actions for the entire system)	N
Large time periods to do inner shop work.	Are there large dwell times (>3 days) on average required for inner shop processes?	N
Large segmented workspace	Do greater than 50% of the components move more than two bays away for maintenance?	N
Labor intensive manual tracking. Visibility and protection for high value assets / components	Time saved tracking down components/subcomponents?	N
Cost	Incremental Costs	
Use of existing infrastructure	Will implementation allow use of the existing infrastructure?	Y
Minimal impact to operations and few coordination requirements	Implement additional projects less than 2 products at a time?	Y
Incremental expense	Are there minimal additional expenses? Less than 20% of original cost or within budget?	Y
Future and Other Considerations	Future and Other Considerations	
Parts and process visibility	Increased parts visibility?	N
Other process improvements	Increased process visibility or other efficiencies?	Y
	Potential to reduce cycle time per system?	Y
High visibility system	High visibility system	Y
	Total Advantages (Y)	7
	Total Disadvantages (N)	5

Table 16. Firefinder Radio Frequency Identification Scorecard

In the benefits section, we scored all but one of the metrics as disadvantages. The systems have a large number of components making it advantageous to use RFID, but there are not many maintenance actions required which limits the benefit RFID might have for the overhaul process.

In the cost section, we scored all of the metrics as advantages. Implementation of RFID to Firefinder will use existing infrastructure and the incremental expense will be minimal given the current investment in infrastructure.

In the other considerations section, we scored most of the metrics as advantages. Firefinder is a high visibility system and RFID will provide visibility to system parts and processes to assist with improving the overall systems management.

It is important to note again that the scorecard results will be different for each of the Firefinder systems. For example, the AN/TPQ-36 requires inner-shop actions and inducts about 50 systems per year. The volume alone creates a significant amount of tracking which would score greater advantages than we gave in our overall assessment.

C. OTHER USES

1. DoD RFID Mandate

This infrastructure provided with the Tobyhanna pilot program supplements the infrastructure required for compliance with the DoD RFID mandates. These mandates require RFID on shipments of certain commodities arriving at Tobyhanna beginning in January 2006. As soon as this is implemented, Tobyhanna will no longer require manpower to accept this material into inventory because this process will be automated through RFID. The Tobyhanna Army Depot RFID pilot program is focused on improving internal overhaul processes and can be used in many other aspects of operations.

2. Asset Management of Forklifts

RFID can be used for real-time tracking of forklifts to evaluate if they are being utilized most efficiently. Managers can review the daily use of the forklifts to reveal if there is significant down-time or if there is excess use of specific equipment. RFID can be used to evaluate the paths of forklift operation throughout the shops for most efficient use of the equipment available. One problem that was noted in an interview with personnel in the AN/TRC-170 shop was that it takes too much time to call the dispatch center in order to get a forklift programmed for a pickup or delivery. One solution with RFID is to establish a call button that can activate a forklift to go to a specific pickup point for pickup or delivery. The button could activate the appropriate forklift and eliminate a need to call dispatch. There are 25 employees that work first shift in forklift operations, and this solution could reduce the number of employees needed to manage forklift operations.

3. Maintenance Management

RFID can provide telemetry data of forklifts or other equipment that managers can use to ensure that the equipment is maintained and always ready for operation at critical times. Furthermore, the history of service parts can be stored and used to perform maintenance on a predictive basis rather than on a recurring schedule reducing maintenance actions and total life cycle costs.[70] Forklift maintenance is scheduled on a periodic basis and breakdowns are rare. This may be an indication that there is some opportunity for savings in forklift maintenance. There are 24 forklifts in operation and maintenance is scheduled once per month and takes an average of one hour per forklift. This totals 288 hours (12 hours per forklift x 24 forklifts) of forklift maintenance a year. There are additional annual and biannual maintenance requirements that require another 5 hours per forklift each year which totals to another 120 hours a year for maintenance. Total forklift maintenance requires about 400 hours per year for 24 forklifts.

Maintenance could be scheduled on an as-required basis instead of monthly. A standard manufacturer recommendation for gas and diesel lifts is to perform maintenance after 250 hours of operation which generally equates to monthly maintenance.[71] RFID can monitor forklift operations to keep track of exact hours of operation and overall maintenance could be reduced depending on the utilization of the forklifts. Assuming just one maintenance action is eliminated per forklift each year equates to a reduction of 24 hours of yearly maintenance time assuming no reduction of annual and biannual requirements. If the wage rate for a forklift mechanic is $30 per hour, the total additional productivity for other work is $720. Given that the infrastructure is already in place, the only incremental cost is to place RFID tags on each forklift to monitor operations. The

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70 Daniel W Engels, Robin Koh, Elaine M. Lai, and Edmund W. Schuster. *Improving Visibility in the DOD Supply Chain.* Army Logistician. June 2004. http://www.almc.army.mil/alog/issues/MayJun04/alog_supple%20chain.htm. Accessed May 2005.

71 Hyster New England Website, http://www.hysterneweng.com/faq.html. Accessed June 2005.

cost for tags would be $480 (24 forklifts x $20/tag) and payback for this investment would be less than a year.

4. Management of Hazardous Materials

RFID provides a system to track Hazardous Material (HAZMAT) throughout the facility. The system can notify managers when HAZMAT arrives within the boundaries of the facility and track materials and post alerts if it travels outside of designated areas or comes within a designated range of an unwanted area. Alerts can also notify managers if hazardous material shipping containers are opened without authorization.

Currently Tobyhanna tracks about 60,000 containers of HAZMAT each year and maintains about 5,000 Material Safety Data Sheets (MSDS) using barcodes. They have a conforming storage facility that serves as their HAZMAT warehouse and 14 forward distribution centers that stock smaller quantities of HAZMAT for distribution to individuals as needed. HAZMAT compatibility is an issue and must be monitored closely to ensure incompatible materials do not come into contact.

Tobyhanna is a partner in the *ChemSecure* project with NASA, Oracle, Intel, Lucent/Bell and others to develop active RFID technology for HAZMAT tracking and distribution. The project provides automatic alerts and notifications to Security, Safety, Health and Environmental professionals in the event of HAZMAT requirement violations. Environmental conditions for HAZMAT storage are important to prolong the life and it is estimated that "for every $1 spent on HAZMAT, another $10 is spent to dispose of it."[72] Furthermore, the program will provide detailed information from MSDS to handheld computers to assist with required corrective actions if there is an incident.

The benefits of RFID for hazmat management are expected to positively impact financial, risk management, operational and logistical considerations. Better inventory control will provide cost savings and make operations more efficient by reducing waste. RFID will allow better management of inventories and reduce HAZMAT acquisition costs. The most significant benefit is in the alert system that will help to identify safety

[72] Jonathan Collins. *NASA Tries RFID for HAZMAT*. Environmax Press Release, December 14, 2004. http://www.environmax.com/vmax2.nsf/0/27a5740d328e798387256dc7006a14c9?OpenDocument. Accessed June 2005.

issues before they become problematic as well as prevent violations of HAZMAT regulations.

5. System Arrivals to Tobyhanna

One problem that was identified for the overall operations at Tobyhanna was the difficulty in tracking system arrivals to Tobyhanna from DLA. Systems could be tagged from DLA and RFID could provide notification of arrival to Tobyhanna to ensure that systems are processed efficiently. In the same manner, RFID would provide notification to DLA when the maintenance process is complete and the system is ready for return to the war fighter in the field. This information would provide visibility to help eliminate idle time generated in the transition between DLA and Tobyhanna to ensure the systems are processed as quickly as possible for the customer.

Table 15 shows time periods for transferring systems between DLA and Tobyhanna for the AN/TPS-75 and AN/TRC-170 systems.

DLA ACTION TO:	**PROCESS TIME FOR EACH SYSTEM**	
	AN/TPS-75	AN/TRC-170
Initially Transfer to Tobyhanna		
Average	1-2 days	1-2 days
Accept Delivery From Tobyhanna		
Best	1-2 days	1-2 days
Average	3-5 days	3-5 days
Worst	5-7 days	5-7 days
Ship to Customer		
Best	2-3 days	2-3 days
Worst	2-3 days	30-45 days

Table 17. Times to Transfer Systems To and From Tobyhanna

VII. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The cost-benefit analysis of the Tobyhanna Army Depot RFID pilot project indicates a ROI of less than one year. This result supports other research conducted on RFID as an asset management tool, and indicates that Tobyhanna's investment in advancing technology essentially paid for itself within one year when measured in labor cost savings. More importantly, the technology yields an annual savings of 837 RCT days. Although we could theoretically assign a monetary value to the RCT savings, we believe the statistic adequately reflects the savings to the field.

The RFID Balanced Scorecard presented in this study provides an additional leadership tool for use in determining future applications of RFID within Tobyhanna Army Depot. The scorecard provides an initial indication of whether or not further study should be undertaken to validate potential ROI from incremental investment. Since the primary infrastructure for RFID is already funded and fully operational, the payoff period on incremental investment is likely to be much shorter.

B. RECOMMENDATIONS

Based on our findings, Tobyhanna Army Depot should consider the RFID pilot study a total success, especially since the payback period nearly coincides with the end of the one-year pilot study. To leverage the investment already made in the RFID infrastructure, Tobyhanna should seek to implement the RFID asset management tool for other systems within the Depot. As the technology develops, the RFID solution can be fully integrated into the existing Enterprise Resource Planning (ERP) software used at Tobyhanna to gain further efficiencies within the management process.

Since data collected for this study was limited to the first five months of the pilot program, we recommend that a follow-on study takes place to validate our findings. The mature data set derived over a longer period of time will more accurately reflect the long-term implications of using RFID as an asset management tool. A study initiated in April 2006 would provide one year's worth of follow-on data for the two systems involved in this study, and nearly nine months of data to support an initial cost-benefit analysis of the incremental investment made on the Firefinder system. Additionally, the larger data set would support application of learning curve theory to determine the learning rate associated with the overhaul process.

APPENDIX A. WHERENET WHITE PAPER: "ENABLING LEAN BUILDING BLOCKS"

CONFIDENTIAL- FOR INTERNAL AND CLIENT USE ONLY

WhereNet

Enabling Lean Building Blocks

November 24, 2004
Revision 1

PRESENTED TO:

Ronald Rains, Sr. - Tobyhanna Army Depot

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David Phillips - WhereNet

DAVE PHILLIPS PAGE 1 6/5/2005 WhereNet

Overview

Tobyhanna Army Depot has deployed WhereNet's Real Time Location System (RTLS) within the Depot to achieve complete visibility of all components associated to two of the three RADAR systems that are currently repaired and refurbished at the Depot. The intent of the system is to provide the operational management the ability to instantly understand where a system component is located, both physically and logically within the process. This will enable the measurement of process performance through capture of area dwell time and process cycle time.

The ability to measure performance is a fundamental requirement for improvement. Without measurement, the impact of initiatives or ideas cannot be quantified and, therefore, cannot be fully realized. Tobyhanna is currently at this first critical step, the first steps to implementation of Lean Operation Principles.

Current State

Operational Management is acutely aware of the many challenges facing operational efficiency today. Multiple organizations within the facility identified the following issues (waste) including:

Overproduction - Tobyhanna manufactures and refurbishes by classic push processing. Inventory is placed in front of work cells with no visibility to priority of orders, consuming capacity that could be utilized for current demand. 5 days of buffer stock between processes is common.

Waiting – Critical production items, both Purchased Parts and Refurbished Components are placed on order ***during and after*** the system is received and disassembled. This variability in cycle time for procurement is introduced directly into the production critical path. In addition, the wait time for critical production information was measured in days, not seconds.

Transportation – All material, purchased components and components in inventory to repair are held in central warehouses. Movement of material from process to process is based upon manual communication paths between drivers and work cells, causing delay of product delivery to the down-line production process. Point of Use storage is not utilized.

Non-Value Added Processing – Just locating the next item to work on takes hours if not days. Total cycle time to process components in work centers is exponentially larger then touch time to repair / refurbish of those same components.

Excess Inventory – This is related to the overproduction issues in conjunction with the procurement process. Every nook and cranny is filled with WIP.

Defects – Rushing to meet the cyclical ship requirements for end of year creates a process in which work is rushed. Level Scheduling is not present.

Excess Motion – Poor layout and undocumented processes create excess movement of both material and resources. On the surface, excess inventory and overproduction contribute to this waste.

Underutilized People – When asked, the average worker / lead cannot identify how they are measured. Very few people feel empowered in the process or feel they can impact change.

Moving Toward Lean Operations

Fortunately, Tobyhanna management is aware of the waste in the operation and is actively implementing Lean initiatives to address known issues. Three fundamental Lean Building Blocks, Workplace Organization Work Cells, and Visual Controls are apparent in the TPS-75 Area. The Tobyhanna Lean Group is in discussions on Market Areas and supporting Min/Max authorizations for both Purchased and Refurbished Components, essential for removing cycle time variability from the Manufacturing Process.

WhereNet offers many solutions to facilitate the implementation of Lean Building Blocks. Building upon the basic visibility initiative launched at Tobyhanna to support Workplace Organization and Visual Controls, the following Lean Building Blocks are supported:

Pull Processing – All WhereNet solutions support the implementation and philosophy of Pull. Visibility is given to the operation to ensure the correct item is worked on next.

Kanban – WhereNet provides the event trigger for material replenishment at a work cell or line side location. Ford and GM both use WhereNet for line side replenishment. Ford went so far as to remove their Toyota Production System influenced Kanban card process and replaced it with the WhereNet Wireless Kanban system.

Total Productive Maintenance (TPM) and Total Quality Management (TQM) – WhereNet Solutions capture cycle time and units produced which is a fundamental requirement to improving Quality and Maintenance processes and procedures.

Point of Use Storage- Using location information, WhereNet can ensure that product is always delivered to point of use. The system can even alert when product is delivered to the wrong location.

Batch Size Reduction and Quick Change Over – WhereNet has provided visibility to the location of critical to load tools and dies to facilitate Quick Change Over initiatives. The Directed Processing feature of many WhereNet solutions allows the processing of product in batch sizes of one.

Workplace Organization – Complete visibility to the location of all assets and resources for a particular process, viewed graphically, allows management and workers the ability to instantly know if those assets and resources are available and in place.

Visual Controls - WhereNet solutions allow the operation to graphically view the key indicators of the operations such as production levels, inventory, quality issues, and schedule.

As presented, WhereNet has been successful at facilitating the implementation of Lean initiatives in numerous organizations including Ford, General Motors, Honda and BMW. The solutions facilitate the implementation of repeatable and scalable processes that reduce direct and indirect labor costs, reduce inventory, reduce quality concerns, and increases facility throughput and utilization.

APPENDIX B. N/TPS-75 DATA

SN	ACTUAL DIR HOURS	ACT LABOR COST ($)	ACT MAT'L COST ($)	TOTAL ACT COST($)	Repair Cycle Time (RCT)	RFID Utilization (% of RCT)
1050A	13,832	$956,895	$236,200	$1,193,095	414	0.00%
1046A	15,661	$769,884	$809,197	$1,579,081	326	0.00%
1043A	11,691	$976,814	$437,680	$1,414,495	348	0.00%
1027A	10,592	$964,077	$341,366	$1,305,443	334	0.00%
1036A	13,615	$756,028	$627,772	$1,383,800	445	0.00%
1042A	12,698	$772,581	$409,386	$1,181,967	347	0.00%
1003A	11,532	$890,597	$282,685	$1,173,282	245	0.00%
1029A	11,163	$871,301	$594,707	$1,466,088	260	0.00%
Total	**100,784**	**$6,958,177**	**$3,738,993**	**$10,259,175**	**2,719.00**	
Avg	**12,598**	**$869,772**	**$467,374**	**$1,282,397**	**340**	
1056A	11,683	$907,264	$552,308	$1,182,823	324	13.00%
1031A	11,289	$884,859	$228,289	$1,113,146	244	17.00%
1024A	11,877	$941,793	$479,788	$1,421,581	266	38.00%
1016A	8,392	$655,742	$503,676	$1,159,418	147	71.00%
1052A WIP*	9,174	$659,060	$468,372	$1,127,432	198	78.00%
1017A WIP*	10,513	$755,253	$850,440	$1,605,693	165	100.00%
1049A WIP*	11,094	$796,992	$438,285	$1,235,277	209	100.00%
Total	**74,022**	**5,600,962**	**3,521,159**	**8,509,768**	**1,553**	
Avg	**10,575**	**800,137**	**503,023**	**1,215,681**	**222**	

*Shaded Area Denotes Estimated Completion Figures

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APPENDIX C. AN/TRC-170 DATA

W/O Number	ACTUAL DIRECT LABOR (HRS)	ACTUAL LABOR COST ($)	ACTUAL MATERIAL COST ($)	TOTAL ACTUAL COST ($)	REPAIR CYCLE TIME (DAYS)	RFID UTILIZATION (% of RCT)
6806	2,607	$199,178	$59,604	$263,852	72	0.00%
6805	2,345	$185,855	$56,101	$241,956	72	0.00%
7183	2,461	$150,158	$67,654	$217,812	64	0.00%
7182	2,607	$202,758	$47,290	$250,048	64	0.00%
7181	2,502	$165,405	$54,419	$219,824	64	0.00%
7143	2,623	$178,940	$60,609	$239,549	64	0.00%
5965	2,459	$146,551	$37,620	$184,171	67	0.00%
7402	2,671	$194,377	$39,789	$234,166	86	0.00%
7637	2,654	$201,692	$31,495	$233,187	55	0.00%
7636	2,530	$194,287	$53,168	$247,455	55	0.00%
7634	2,635	$200,569	$57,872	$258,441	55	0.00%
Total	**28,094**	**2,019,770**	**565,621**	**2,590,461**	**718**	
Avg	**2,554**	**183,615**	**51,420**	**235,496**	**65**	
7588	2,519	$144,202	$60,900	$205,102	110	40.00%
7635	2,532	$197,290	$52,990	$250,280	108	41.00%
7431	2,373	$182,041	$45,205	$227,246	132	42.00%
7587	2,545	$146,567	$101,280	$247,847	123	44.00%
7631	2,446	$188,317	$40,544	$228,861	115	47.00%
7632	2,490	$186,747	$97,863	$284,610	115	47.00%
7633	2,364	$180,033	$75,656	$255,689	115	47.00%
8001	2,563	$127,183	$118,203	$245,386	110	55.00%
7165	2,581	$185,820	$38,171	$223,991	156	57.00%
7613	2,475	$191,363	$37,551	$228,914	108	60.00%
8140	2,522	$152,279	$131,047	$283,326	110	60.00%
8160	2,397	$148,686	$36,868	$185,554	110	60.00%
8261	2,616	$157,492	$160,538	$318,030	110	60.00%
Total	**32,423**	**$2,188,020**	**$996,816**	**$3,184,836**	**1,522**	
Avg	**2,494**	**$168,309**	**$76,678**	**$244,987**	**117**	
8019	2,635	$154,024	$154,581	$308,605	115	62.00%
8141	2,545	$125,783	$146,673	$272,456	115	62.00%
8263	2,585	$194,356	$154,328	$348,684	104	63.00%
8262	2,422	$148,433	$161,338	$309,771	115	67.00%
7919	2,465	$151,965	$153,064	$305,029	88	69.00%
8257	2,579	$164,272	$45,998	$210,270	99	72.00%
8258	2,487	$189,918	$35,774	$225,692	99	72.00%
8255	2,523	$189,820	$36,352	$226,172	121	73.00%
8256	2,470	$157,935	$30,930	$188,865	121	73.00%
8259	2,575	$158,847	$53,229	$212,076	121	73.00%
8252	2,590	$157,946	$45,296	$203,242	104	74.00%
8253	2,450	$154,677	$36,187	$190,864	104	74.00%
8254	2,544	$157,314	$161,652	$318,966	104	74.00%
8264	2,314	$174,151	$53,163	$227,314	94	82.00%
Total	**35,184**	**$2,279,441**	**$1,268,565**	**$3,548,006**	**1,504**	
Avg	**2,513**	**$162,817**	**$90,612**	**$253,429**	**107**	

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APPENDIX D. T TEST FOR RCT AND LABOR COST DATA

2 Sample T Test for Repair Cycle Time

AN/TPS-75 No RFID	
Mean	339.875
Standard Error	24.00553
Median	340.5
Mode	#N/A
Standard Deviation	67.8979
Sample Variance	4610.125
Kurtosis	-0.47834
Skewness	0.123815
Range	200
Minimum	245
Maximum	445
Sum	2719
Count	8

AN/TPS-75 RFID	
Mean	221.8571429
Standard Error	23.1160927
Median	209
Mode	#N/A
Standard Deviation	61.15943256
Sample Variance	3740.47619
Kurtosis	-0.22705464
Skewness	0.554423249
Range	177
Minimum	147
Maximum	324
Sum	1553
Count	7

Results
u1>u2
t=3.538
p=.00182
df=12.979

AN/TRC-170 <=60% RFID	
Mean	117.0769
Standard Error	3.756126
Median	110
Mode	110
Standard Deviation	13.5429
Sample Variance	183.4103
Kurtosis	5.795927
Skewness	2.347432
Range	48
Minimum	108
Maximum	156
Sum	1522
Count	13

AN/TRC-170 >60% RFID	
Mean	107.4285714
Standard Error	2.843373414
Median	104
Mode	104
Standard Deviation	10.63892914
Sample Variance	113.1868132
Kurtosis	-1.00121444
Skewness	-0.17237482
Range	33
Minimum	88
Maximum	121
Sum	1504
Count	14

Results
u1>u2
t=2.048
p=.02611
df=22.7855

2 Sample T Test for Labor Cost

AN/TPS-75 No RFID	
Mean	869772.1263
Standard Error	32933.72367
Median	880949.045
Mode	#N/A
Standard Deviation	93150.63734
Sample Variance	8677041237
Kurtosis	-2.056875658
Skewness	-0.153369217
Range	220785.86
Minimum	756028.14
Maximum	976814
Sum	6958177.01
Count	8

AN/TPS-75 RFID	
Mean	800137.3786
Standard Error	44050.09114
Median	796992
Mode	#N/A
Standard Deviation	116545.5864
Sample Variance	13582873706
Kurtosis	-1.806242307
Skewness	-0.18114802
Range	286050.58
Minimum	655741.99
Maximum	941792.57
Sum	5600961.65
Count	7

Results
u1>u2
t=1.266
p=.1153
df=11.50

AN/TRC-170 <=60% RFID	
Mean	168309.2308
Standard Error	6328.892191
Median	180033
Mode	#N/A
Standard Deviation	22819.14531
Sample Variance	520713392.7
Kurtosis	-1.353143135
Skewness	-0.384158255
Range	70107
Minimum	127183
Maximum	197290
Sum	2188020
Count	13

AN/TRC-170 >60% RFID	
Mean	162817.2143
Standard Error	4984.743069
Median	157940.5
Mode	#N/A
Standard Deviation	18651.20073
Sample Variance	347867288.5
Kurtosis	0.232005581
Skewness	0.217097393
Range	68573
Minimum	125783
Maximum	194356
Sum	2279441
Count	14

Results
u1>u2
t=.6817
p=.2510
df=23.247

APPENDIX E. RFID PILOT PROGRAM CONTRACT MODIFICATION

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. CONTRACT ID CODE: J

PAGE 1 OF 2 PAGES

2. AMENDMENT/MODIFICATION NO.: P00002

3. EFFECTIVE DATE: 07-Feb-2005

4. REQUISITION/PURCHASE REQ. NO.: W25G1V408301EY

5. PROJECT NO.(If applicable)

6. ISSUED BY — CODE W25G1V

TOBYHANNA ARMY DEPOT
TOBYHANNA DEPOT CONT OFC
ATTN AMSEL-TY-KO
11 HAP ARNOLD BLVD
TOBYHANNA PA 18466-5100

7. ADMINISTERED BY (If other than item 6) — CODE W25G1V

TOBYHANNA ARMY DEPOT
CHERYL SAYLOCK 5708957056
11 HAP ARNOLD BLVD
FAX 570-895-6794
TOBYHANNA PA 18466-5100

8. NAME AND ADDRESS OF CONTRACTOR (No., Street, County, State and Zip Code)

SYS-TEC CORPORATION
CYNDI MESZAROS
6911 SUMMERFIELD ROAD
PETERSBURG MI 49270

CODE 04ZA9 — FACILITY CODE 04ZA9

9A. AMENDMENT OF SOLICITATION NO.

9B. DATED (SEE ITEM 11)

X 10A. MOD. OF CONTRACT/ORDER NO. W25G1V-04-F-0417

X 10B. DATED (SEE ITEM 13) 07-Jun-2004

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

☐ The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offer ☐ is extended, ☐ is not extended.

Offer must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended by one of the following methods: (a) By completing Items 8 and 15, and returning ______ copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. ACCOUNTING AND APPROPRIATION DATA (If required)

See Schedule

13. THIS ITEM APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS. IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.

A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.

B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation date, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(B).

C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF:

X D. OTHER (Specify type of modification and authority)
dfar 13.302-3(c)

E. IMPORTANT: Contractor ☒ is not, ☐ is required to sign this document and return ______ copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF section headings, including solicitation/contract subject matter where feasible.)

Total consideration is increased by $37331.20 from $396629.06 to $433960.26.

g, annual

Line Item 0001: W25G1V408301EY, 1 each @$433960.26

Block 25: $433960.26

All other terms and conditions remain unchanged.

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

15A. NAME AND TITLE OF SIGNER (Type or print)

16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print)
MOZALESKI JOSEPH P / CHIEF, PURCHASING DIVISION
TEL: 570-895-7579 EMAIL: Joseph.Mozaleski@tobyhanna.army.mil

15B. CONTRACTOR/OFFEROR
____
(Signature of person authorized to sign)

15C. DATE SIGNED

16B. UNITED STATES OF AMERICA
BY [signature]
(Signature of Contracting Officer)

16C. DATE SIGNED: 07-Feb-2005

EXCEPTION TO SF 30
APPROVED BY OIRM 11-84

30-105-04

STANDARD FORM 30 (Rev. 10-83)
Prescribed by GSA
FAR (48 CFR) 53.243

SECTION SF 30 BLOCK 14 CONTINUATION PAGE

SUMMARY OF CHANGES

SECTION B - SUPPLIES OR SERVICES AND PRICES

The total cost of this contract increased by $37,331.20 from $396,629.06 to $433,960.26.

CLIN 0001

The unit price amount has increased by $37,331.20 from $396,629.06 to $433,960.26.

The total cost of this line item has increased by $37,331.20 from $396,629.06 to $433,960.26.

SECTION G - CONTRACT ADMINISTRATION DATA

Accounting and Appropriation

Summary for the Payment Office

As a result of this modification, the total funded amount for this document was increased by $37,331.20 from $396,629.06 to $433,960.26.

(End of Summary of Changes)

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