THE APPLICATION OF RADIO FREQUENCY IDENTIFICATION TECHNOLOGY TO OVERCOME THREE COMMON AERIAL PORT CHALLENGES: A CONCEPT

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Stephen P. Ritter, Major, USAF

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DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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Stephen P. Ritter
Major, USAF

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Abstract

Operation DESERT STORM saw the logistical movement of the equivalent of the entire city of Oklahoma City, Oklahoma from the United States to Saudi Arabia. While impressive in scope, there were many inefficiencies and limitations highlighted during this operation. One of the foremost limitations was in the area of cargo management and identification. The United States Army, perhaps the Air Force's biggest customer, grew frustrated. It developed coping mechanisms to overcome these logistical challenges. Unfortunately, these coping mechanisms only added to the problem.

Air Force aerial ports still face some of these same challenges, especially exacerbated by the current Global War on Terrorism. The average port faces three common challenges: cargo yard and warehouse management, paperwork, and cargo processing. Ports currently use Automatic Identification Technology in the form of bar code and Radio Frequency Identification systems to help overcome these challenges. There are specific characteristics of each of these forms of technology and strengths and weaknesses that make one better than the other for overcoming these challenges.

Many civilian companies and other Department of Defense organizations have faced similar logistical challenges and have successfully applied Radio Frequency Identification technology towards solving these logistical challenges. The Air Force can learn from the success these organizations have earned from the effective implementation of Radio Frequency Identification technology.

THE APPLICATION OF RADIO FREQUENCY IDENTIFICATION TECHNOLOGY TO OVERCOME THREE COMMON AERIAL PORT CHALLENGES: A CONCEPT

I. Overview

Background

One of the chief concerns for the warfighter is that his troops have all of the necessary supplies before going into battle. Obviously, the warfighter places great value on knowing where these supplies are. Lives, and ultimately the battle, depend on this information. Because of this concern, one of the hottest issues at United States Transportation Command (TRANSCOM) is Intransit Visibility (ITV) for cargo moving through the military transportation system. TRANSCOM first began to look at ITV after the huge logistical challenge that was Operation DESERT STORM. Tremendous amounts of equipment, personnel and supplies were shipped from the United States to Kuwait during the buildup.

> At one point the build-up of forces was described as the equivalent of performing the Berlin Airlift every six weeks. The amount of personnel and equipment moved to the Gulf region would be the same as moving the entire population, cars, trucks, houses, food, and clothing of Oklahoma City. Farris and Welch, 1998:5-14.

Most military people are familiar with the logistics horror stories that came out of Operation DESERT STORM. Over 20,000 of the 40,000 cargo containers shipped to the Gulf had to be opened by port personnel to determine their contents, costing the Army about $2 billion (Department of Defense Logistics AIT Office, 1999:Ch 3, 23). Airlift control elements regularly misplaced items between cargo origin and final destination, clogging aerial ports until the cargo was discovered days or weeks later (Gross, 1995: Ch1, 1). When the cargo finally did arrive, usually much later than planned, it often did not have the required shipping documentation (Hewish and Pengelley, 1996:1).

Of all the services, the Army first began to realize the tremendous value in knowing where your cargo was in the supply chain. With the end of the Cold War and the draw downs of the early 1990's, it was transformed into a force projection Army in order to "quickly and efficiently project power from our shores" (Coburn, 1999:2). They realized the benefits of ITV and the critical role it could play in command and control and in making key strategic decisions, all while avoiding costly duplicate requisitions (Manzagol and Brown, 1996:10-11). Ultimately, the Army needed to quickly get the needed material in the hands of the war fighter when it was needed. They realized the benefits ITV brought to the table: a streamlining of logistics support provided to soldiers in the field, a seamless integration of the logistics transportation system, with the eventual end state of freeing commanders and their staffs to focus on the mission and their troops (United States Army Transportation School, 2003).

The military operations in the wake of the terrorist attacks on the World Trade Center in 2001 brought a new urgency to the logistics world. Operation ENDURING FREEDOM began in Afghanistan and the United States Central Command (CENTCOM) mandated the ITV concept through the use of radio frequency identification (RFID) tags on cargo bound for their theater (NAVTRANSSUPPCEN, 2002). They recognized the benefits ITV brought to command and control. CENTCOM put out similar guidance as Operation IRAQI FREEDOM (OIF) began to build up. A recent Government Account Office (GAO) report highlighted that, although many people have jumped on the ITV bandwagon and that ITV has been helpful, there is still a long way to go.

The GAO report told of hundreds of pallets and containers of war material backlogged at distribution points due to inadequate asset visibility (United States General Accounting Office, 2003:2). The report also found a $1.2 billion discrepancy between the amount of material shipped and the amount that was acknowledged as received in theater. There was also duplication of requisitions and circumvention of the supply system, all attributed to inadequate asset visibility (Ibid.:4). Although a policy message was issued requiring their use, assets were not shipped into the theater with the RFID tags on a consistent basis which severely hampered ITV. "The failure to effectively apply lessons learned from Operations DESERT SHIELD and DESERT STORM and other military operations may have contributed to the logistics support problems encountered during OIF" (Ibid.:4).

There are lessons to be learned not only from past military mistakes but also from some of the tremendous successes using RFID technology that have occurred in the civilian marketplace. Many successful companies have realized tremendous savings through effective ITV programs. These lessons hold promise for future military applications…specifically Air Force adoption of RFID technology in aerial ports.

Research Question

Although the benefit of RFID technology in logistics management has been clearly demonstrated in past military operations and exercises, the Air Force has been slow to exploit this rapidly expanding technology to its full potential. Are there new and better uses for RFID in the Air Force? Specifically, how can RFID technology be used to overcome three common challenges that the average Air Force aerial port faces?

This paper will attempt to answer this question by asking three investigative questions. First, what are some of the key aerial port processes that seem to sap manpower and draw away resources? The next question is what are the more common forms of AIT being used today by both military and civilian organizations for ITV? What are these respective technologies' characteristics, strengths, and weaknesses, with an eye on possible application in aerial port operations? The author will attempt to show that RFID technology offers much more promise for an organization than does bar code technology. Next, how have civilian companies and both foreign and DoD military units successfully applied RFID technology to streamline processes in their respective organizations?

Scope and Assumptions

The field of RFID and other Automatic Identification Technology (AIT) is growing rapidly as the world begins to realize its potential. As a result, this paper will only examine currently available technology, realizing that more capable systems using more advanced technology are more than likely under development.

This paper will attempt to analyze operations at an "average" aerial port. The author realizes that each aerial port is unique and has its own unique mission requirements and conditions in which it must operate. The basis for determining an "average" aerial port will be Air Mobility Command Instruction (AMCI) 24-101 Volume 11, dated 30 June 2001, the "Bible" for aerial port operations. The author applies the concepts in this paper to operations based on these Air Force Instructions. Individual aerial ports will more than likely have more specific local guidance. Because local procedure may only be more restrictive, not less, these Air Force Instructions paint a good overall look at aerial port operations.

While certainly not the biggest or busiest aerial port in Air Mobility Command, the author chose to use McGuire Air Force Base's aerial port as an example of a "typical" port. The assumption is made that McGuire's port is typical of the average sized aerial port operation.

This paper will also not attempt to further distinguish between "active" or "passive" RFID tags. Technology in this field continues to rapidly narrow the capability gap between these two types of RFID tags. The author has chosen to refer to RFID tags in a strictly general sense. Specific application of active or passive RFID to a given situation would require separate research.

Preview of Remaining Chapters

This paper follows the investigative questions with one chapter devoted to answering each of the questions. Chapter II will examine a "typical" Air Force aerial port according to AMCI 24-101 V11. Three specific challenges the average port faces will be identified and described. In some instances, McGuire AFB's aerial port will be used as an example. Chapter III looks at two of the most common forms of AIT used in Air Force aerial ports today: bar code and RFID systems. A description of the characteristics of each form will be advanced along with both benefits and weakness each offers. Chapter IV will examine successful adoptions of RFID technology throughout the private sector and in other branches of the military. Chapter V will tie together all of the information from the previous chapters to answer the research question and propose applications of RFID technology to overcome the key challenges most Air Force aerial ports face.

II. Challenges Facing Aerial ports

Introduction

The continuing war against terrorism, and more recently the war in Iraq, has highlighted the importance of Air Force aerial ports in the military's logistical supply chain. While stateside aerial ports do not operate under threat of direct enemy action, they still face the challenges of extreme weather conditions, patchy-at-best information flow, and often outdated equipment. It is under these conditions that aerial ports must try to operate to effectively and efficiently move cargo where it needs to go. There are other factors aerial ports face that are not so obvious which set the stage to create challenges that can severely hamper operations and drain valuable resources.

One of the factors that aerial ports must face is that ever-present nemesis to both the military and civilian companies alike, the clock. The main reason military organizations choose to send cargo by air is because they can get their cargo faster than shipping by any other means of transportation. These organizations spend the large amounts of money it takes to airlift cargo because the items sent are often keystones to their operations. Not only do these units want this essential cargo quickly, but often key decisions are made based on where that cargo is in the supply chain. For example, an Army division commander may choose to delay an attack if he knows his follow-on ammunition resupply will be log jammed in port for two weeks.

The importance of this supply chain information led to the development of the concept of In Transit Visibility (ITV). Recognizing advances many civilian companies were making in the field of Automatic Identification Technology (AIT), the Department of Defense (DoD) established an AIT task force to help develop a Concept of Operations

(CONOPS) for the use of this developing technology. This CONOPS would provide a framework for DoD-wide use of AIT within the logistics community (Department of Defense Logistics AIT Office, 2003:43).

One of the key goals this AIT task force established was that cargo tracking systems at military receiving activities (aerial ports for example) need to be capable of capturing departure and receiving information and then provide that information to key logistics decision-makers throughout the DoD. The proposed time criteria for the capture and posting of the information was set at 1 hour (Ibid.:43). One hour for aerial port personnel to download the cargo, transfer it to the warehouse, transfer the pallets off of the loaders, personnel to check in and verify all of the cargo on each individual pallet, and finally to enter the data into the cargo tracking system. This timeline is a challenging proposition even under the best of conditions. To add more confusion, the current Air Force Instruction dictates a processing time of 12 hours for priority cargo and 18 hours for other cargo (Department of the Air Force, 2001:17). Which time do aerial port personnel adhere to?

Another factor that sets the stage for aerial port challenges is the sheer volume of cargo that transitions through a typical facility. Even during peacetime most aerial ports struggle to keep up with the daily flow of cargo moving through Air Mobility Command's airlift system. During wartime what was barely manageable became pandemonium. During Operation DESERT STORM, aerial ports were overwhelmed with high priority assets to the point where logisticians lost almost complete visibility of cargo. This loss of visibility resulted in the opening of over half of the 40,000 containers shipped to Saudi Arabia merely to verify their content (Gross, 1995:Ch 2, 3). Aerial ports at Dover, McGuire, and Charleston Air Force Bases, were accumulating cargo faster than it could be forwarded. This accumulation along with the not-too-rare loss of accompanying paperwork resulted in a tremendous backlog of cargo waiting for air shipment (Moore and others, 1993:15). When aerial ports become overwhelmed, it is often the ITV systems that are the first thing neglected. Customers lose sight of their essential cargo which can severely affect their operations.

When customers ship high-value cargo and this cargo becomes lost, a general distrust of the overall system develops. "Mistakes in customer deliveries are expensive in terms of time and effort to fix them and in terms of damage to the customer relationship" (d' Hont, 2004:4). This damaged customer relationship between the Air Force and their military customers shipping cargo results in rational coping behaviors. These Army or Marine Corps units may overstock initial deployment packages or re-order more assets than actually required to ensure they can effectively operate (Gross, 1995:Ch 2, 6). This distrust and subsequent rationalization results in a less than optimal logistics system. A vicious cycle begins: "…system responsiveness further degrades, customer confidence continues to decline, and the final result is less system capability" (Moore, 1993:6).

All of these factors set the stage to make aerial port operations some of the most challenging in the Air Force. There are three specific challenges Air Force aerial ports face as a result of the demanding environment they must work in and the dynamic conditions to which they must constantly adapt.

The Challenge of Cargo Yard and Warehouse Management

When cargo pallets arrive for processing at an aerial port, one of three things can happen. The pallet can be loaded onto ground transportation and taken out of the aerial port yard. The pallet could be processed immediately and transloaded onto another aircraft for transport to another location. Or, what is often the case, the pallet is placed in the cargo yard where it awaits transportation at a later time. As mentioned before, when cargo begins to back up at an aerial port, cargo yard management can become a real challenge and effective visibility of cargo easily lost.

Air Mobility Command Instruction 24-101 Volume 11, the governing regulation for all AMC aerial ports, establishes the requirement for a storage system for pallets in a cargo yard. Assuming each and every pallet is in its proper place, finding the correct pallet could be a time consuming task. Workers using the current yard management system can get to the general area where a pallet is stored, but finding an exact pallet could be a real challenge if there are a large number of pallets in the area. On top of this challenge add a driving rain and a poorly marked pallet and you begin to understand the potential for misidentifying or losing a pallet.

Air Force Instructions also require aerial port personnel to inventory each and every pallet in the cargo yard "at least every other day" (Department of the Air Force, 2001:22). Personnel must walk up and physically check each and every pallet either through the use of a bar code scanner or from a paper inventory log. This physical inventory could expend large numbers of man hours in a large aerial port cargo yard. More personnel could be involved to help reduce the overall time, but with every extra person conducting the inventory the risk of introducing human error increases.

The Challenge of Paperwork

The current cargo movement system relies on paperwork to help ensure pallets arrive at their intended destinations. Each item to be shipped is assigned a Transportation Control Number (TCN) which is input into the aerial port's cargo tracking system, also called an Automatic Identification System (AIS). This cargo tracking system used by Air Force aerial ports is called the Global Air Transportation Execution System (GATES). A group of packages, each with their own TCNs, are placed onto a 463L cargo pallet. Items shipped on these pallets are dependent on a paperwork-intensive system to avoid delays, misrouting, or even worse, being lost. Each 463L pallet is weighed, inspected for airworthiness, and assigned a TCN as well (Rumplik, 2003). A Transportation Control Movement Document (TCMD) is printed and attached to the pallet. The paperwork load mounts when one adds to this TCMD both United States and foreign customs information, aircraft weight and balance information, airworthiness certification, destination information, plus any specific handling instructions. The more paperwork that travels with the pallet, the greater the chance that this crucial paperwork can be lost or damaged by the elements and made unreadable.

Lost paperwork has a tremendous impact on aerial port operations. During Operation DESERT STORM, approximately 62% of arriving containers did not have proper documentation. The manpower costs to open each of these problem containers, identify their contents, and determine the final destination was extensive (Gross, 1995:Ch 4, 14). In addition to the physical process of opening each of the offending containers, improper or missing documentation led to a further backlog of arriving cargo, multi-handling of containers to make room for new containers, and lost cargo due to lack of control (Estey, 1993:14). Cargo awaiting dispensation was put into a “frustrated cargo” area.

Lost paperwork also means that aerial port personnel have to manually enter the cargo data into the Automatic Identification System. This system of data input tends to introduce errors and is labor intensive (AIT Task Force, 1997:Ch 2, 7). Again, to bring the "human element" into the equation is to almost ask for errors. Redundant manual entries into the AIS system tend to degrade final information reliability (Gross, 1995:Ch 2, 5). During the DoD Logistics AIT Operational Prototype evaluation in 1998, inspectors noted that "various in-checkers were observed to make entry errors on manifests and listings and AIS keyboard entries leading to decisions that there were overages and shortages in the processed shipments" (Department of Defense Logistics AIT Office, 1999:A-95). Even if the errors are caught, ports must expend manpower to correct the errors.

In addition to the errors introduced by human intervention, some workers have natural biases toward any new initiatives in cargo tracking. During the 1998 AIT Operational Prototype evaluation, inspectors found that many personnel preferred "manual entry to the hassle of dealing with multiple scans for bar code reads…" (Ibid.:A-85). Other workers were observed manually inputting TCN numbers into the AIS system despite the presence of bar codes. This insistence on "doing things the way they have always been done before" can lead to higher data error rates.

The Challenge of Cargo Processing

Cargo pallets arriving at a base are downloaded and transported to the aerial port. These pallets are offloaded in the warehouse where personnel begin inprocessing them. For most aerial ports, workers inprocess the cargo using a bar code scanner to read the bar codes on each pallet. Data from these bar codes is input into GATES which feeds the information into the Global Transportation Network (GTN). GTN is the system that DoD uses to provide commanders ITV on their cargo (Rumplik, 2003).

If the entire pallet is moving on to another destination after inprocessing it will be placed into the appropriate area of the aerial port's cargo yard. Sometimes a pallet contains individual items going to several different locations. Workers must then break these pallets down, scan in each individual item's bar code, and build up separate pallets for each new location. The additional time to scan the individual items can start to add up for pallets with large numbers of smaller boxes. Each and every handling of the cargo increases the potential for these individual items to be misplaced or damaged.

As mentioned before, aerial ports have to deal with a myriad of potential problems while inprocessing cargo. Oftentimes the cargo that actually arrives does not match with the manifests attached to the cargo or the manifests that are downloaded from the GATES system. Shortages and overages occur on average "every flight" (Rumplik, 2003). Personnel must take the time to correct the error which takes time away from their other duties. Overages must be sent to the correct destination, incurring additional costs with the extra transportation. Shortages require coordination with previous aerial ports to ensure the item was really "shorted" and that the problem does not lie with a paperwork or a mishandling error on their end.

The Current AIT Environment in Aerial Ports

The current AIT systems used in aerial ports include bar code scanners, an RFID system, GATES, and GTN. Bar code scanners are used to process arriving and departing cargo. These scanners can be hand held and can download their data into GATES, the Air Force's cargo management system. GATES is a legacy system used only by the Air Force aerial ports and its data is cross loaded into GTN. GTN receives information from "feeder systems" like GATES and provides military customers with a way to track their cargo (Gilmore, 2002:20).

Some aerial ports have installed RFID systems. McGuire has a small system composed of an RFID interrogator along the access road to the warehouse to record inbound ground shipments, and an interrogator on the corner of the warehouse itself to record the arrival of airborne shipments (Cooper and Rigsbee, 2003). These interrogators are used to populate the GTN system with cargo information. This information from the RFID interrogators is not transferred to GATES, however (Rumplik, 2003). Aerial port personnel have no way of even knowing if RFID tag information has been successfully transferred to GTN. These personnel concentrate on the system they know and depend on to do their job…GATES. RFID in its current state offers them little benefit (Ibid.).

Conclusion

Air Force aerial ports face many challenges in order to effectively and efficiently move cargo throughout the military airlift system. Many factors exist that set the stage to make port operations some of the most demanding in the Air Force. Ports must deal with time constraints which often conflict with existing Air Force Instructions. The sheer volume of peacetime cargo movement is a daunting task. Today's current wartime operations tempo has created a virtual state of pandemonium. Past operations have shown that an increase in operations tempo often results in lost or mishandled paperwork, lost or misdirected cargo, and plenty of confusion. This is certainly not the well-oiled, streamlined logistics supply chain customers demand. The customer begins to mistrust the airlift system and develops coping mechanisms to attempt to get their crucial cargo when it is needed. Customers order extra, inflate priority systems, or overstock, all which work to burden an already overworked cargo movement system.

These factors aerial ports face all work to create three distinct challenges. Effective cargo yard management is difficult when pallets are moved in, shipped immediately out, transloaded onto another aircraft, or, as is often the case, stored for later shipment. Manual inventories of congested cargo yards can introduce errors that impact the efficiency and effectiveness of aerial port operations.

Paperwork requirements for each and every cargo pallet create the potential for error as well. Paperwork can be lost, damaged, or filled out in error. These paperwork errors have a tremendous impact on port operations. Personnel must take time away from other duties to correct the errors, further backing up cargo waiting for processing. Manual entry of cargo information into GATES also increases the chances for the introduction of human error, further compounding the problem.

Cargo processing was the last aerial port challenge discussed. The daunting task of breaking down a cargo pallet and scanning each and every item on the pallet takes time. The potential for misplacing or damaging this cargo increases with each and every handling. Human error rears its ugly head when port personnel must deal with overages and shortages on incoming cargo pallets. Again, time is required to correct the errors and money is spent to ship the misdirected cargo to the correct location.

The AIT task force established recommended processing times for populating AIS systems with inbound cargo information. Air Force Instruction 24-101 Volume 11 establishes the maximum processing time. Aerial ports use AIT to try to meet these timelines. A bar code system is used to input data into GATES, the Air Force's legacy cargo tracking system, which feeds the GTN system. This GTN system is used by the

Air Force's customers for cargo ITV. Although some aerial ports have RFID systems, these systems do not populate GATES.

The next chapter will examine two of the major forms of AIT used by the Air Force and civilian companies today, bar code and RFID systems. The characteristics, strengths, and weaknesses of each system will be examined with application towards potentially solving the three aerial port challenges.

III. Automatic Identification Technology in Use in Aerial Ports

Introduction

There are many different types of systems that fall into the realm of Automatic Identification Technology (AIT). Some of these systems include bar codes (both linear and 2D), Radio Frequency Identification (RFID), optical cards, and the so-called "Smart Card," just to name a few. All of these different technologies help achieve the fundamental principle of AIT which is "…to acquire data for use in computer based processing, in ways that are automatic, accurate, fast and flexible and involve a degree of identification, be it of items, data or people" (AIM Global, 2004:2).

What exactly does AIT do? What practical applications can it offer an organization like an Air Force aerial port? "AIT can improve DoD's logistics business processes and enhance war fighting capability by facilitating the collection of initial source data, reducing processing times, and improving data accuracy" (AIT Task Force, 1997:page iii). Some forms of AIT can also allow an organization to identify items at a distance, and it can help reduce the amount of paperwork through its automated data collection and portable databases (Air Force Materiel Command, 2004).

Clearly there is a benefit from adopting AIT in an organization. Back in 1997, the AIT Task Force recognized that the use of AIT is a key component in the DoD's efforts to achieve Total Asset Visibility over cargo moving through the logistics pipeline (AIT Task Force, 1997:page iii). In 2001, General Tommy Franks, Commander of United States Central Command, established a policy that all cargo moving into his command's theater of operations would be fitted with an RFID tag (Military Technology Online, 2003). General Franks and his logistics leaders clearly recognized the benefits of an effective AIT program.

This chapter will examine two forms of AIT technology used in aerial ports, the bar code and the Radio Frequency Identification (RFID) systems. First, the major characteristics of each technology will be examined. Then this paper will attempt to identify key strengths and weaknesses of each technology as they potentially apply to the three aerial port challenges examined in Chapter II.

General Characteristics of RFID

What is RFID? Simply put, RFID is "…an automatic way to collect product, place, time or transaction data quickly and easily without human intervention or error" (AIM Global, 2003b:2). The theory behind this technology is an interrogator and RFID tag use radio frequency energy to communicate with each other. The tag typically contains a battery to power its internal circuits, a tiny transmitter, and an antenna. The communication begins when an interrogator sends a radio frequency signal to the tag requesting information. The tag then transmits whatever data it is told to back to the interrogator. In some systems, the interrogators can actually write data to the tags. Typically, a system of interrogators are dispersed around an area and networked to a central Automatic Identification System (AIS). This AIS is essentially a central database containing information on the subject cargo fitted with carrying the RFID tag (AIT Task Force, 1997:Ch 2,6).

There are common attributes that further define RFID systems. One such attribute is whether the tag itself is "passive" or "active." A "passive" tag contains no battery and depends on transmitted energy from an interrogator to generate a signal and transmit it back. This tag, although cheaper than an active tag, requires an interrogator that generates a stronger radio frequency signal. This stronger signal can potentially interfere with other transmissions and are often require government licensing. Natural “bleed off” from the transmitted radio frequency also results in shorter read ranges. An “active” tag is powered by an internal battery. This internal battery allows a less powerful interrogator and longer read ranges (Under Secretary of Defense, 2003).

Another attribute of the RFID tag is the aforementioned “read range.” Read range is how far an RFID tag can be from an interrogator and still effectively pass along the information requested. Read range depends on many different factors like whether the tag is active or passive, the size of the tag’s antenna, and tag output power (AIM Global 2003b:2). These ranges vary from 6 inches for a low-power passive tag to over 200 feet for the higher powered active tag. Another factor affecting read range includes the absorption factor of the materials between the tag and the interrogator. Certain materials absorb radio frequency energy, robbing the RFID tag of enough signal to trigger the generation of a reply. Other factors include the actual size of the RFID tag and its internal antenna, the tag antenna position, and where the RFID tag is placed on the pallet itself (AIM Global, 2003a:15).

In order for communication to occur, a signal from the interrogator must reach the tag and vice versa (Air Force Materiel Command, 2003b:1). In an aerial port cargo yard with pallets blocking other pallets, this can often present a problem. “Line of sight” is the term that describes the degree to which the path from interrogator to RFID tag is obstructed. The less of a line of sight there is, the less likely a tag may receive the signal from the interrogator or that the return signal from the tag will make it back to the interrogator. The active tag has fewer line of sight problems due to its requirement for much less transmitted energy to be received in order for the tag to successfully respond to the interrogation (Air Force Materiel Command, 2003b:4).

Another attribute many RFID tags have is the “read/write” capability. A tag may have onboard memory that allows it to store information. Some tags even have internal memory storage that allows data to be written to them remotely using interrogators (Ibid.:4). Depending on the size of the individual tag’s memory, there are common bits of information which can be placed on an RFID tag. License Plate Data is summary information about the cargo to which the tag is affixed. This information serves as a “memory jogger” for the Automatic Identification System to pull up more detailed records. Other information that could be placed on an RFID tag include: TCMD data, stock number, routing information code, or commodity class. All or some of this information could be used to fulfill one of the principles of AIT: gather information from an aircraft pallet for a central computer system.

Read rate is another characteristic to consider when designing an RFID system. Read rate is the speed at which an interrogator can send out its signal and receive information back from the targeted RFID tag. Fast read rates are important to “EZ Pass” operations on some toll roads where data must be gathered from tags traveling by in excess of 35 miles per hour (AIM Global, 2003a:18). Conversely, a slower the read rate means a tag has to move by the interrogator more slowly in order to successfully transfer information. Typically, active tags have faster read rates than passive RFID tags.

In addition to the RFID tag, there are two other major components to an RFID system. One component is the AIS computer where RFID tag information is downloaded to and other information about the cargo is taken from. Another key part of the system is the RFID interrogators. These interrogators can be fixed in one position or can be portable (Intermec, 2003b:2 and AIM Global, 2003a:6). As mentioned before, the read ranges vary between different types of interrogators and tags and can be anywhere from a few inches to hundreds of feet (Intermec, 2003b:2).

An RFID system can best be described as a non contact, non line-of-sight data transfer system between an RFID tag and an AIS through a radio frequency interrogator ("Radio Frequency Identification: A Basic Primer," 2004). This data transfer is a wireless link used to uniquely identify whatever is tagged (d'Hont, 2004). All of the characteristics mentioned above come into play when designing an RFID system for an organization like an aerial port. The ability to transfer data rapidly to an AIS, portable database on tags with large memory storage, and standoff data collection capability are significant capabilities for military operations (Department of Defense Logistics AIT Office, 2000:Ch2, 7). These characteristics make RFID unique among the various forms of AIT and give it certain strengths that, if effectively implemented, would specifically benefit an aerial port operation.

Strengths of RFID Systems

A driving force in the decision whether or not to adopt new technology is often cost. There are inherent life-cycle asset management efficiencies with integrating an RFID system into an organization (Under Secretary of Defense, 2003:1). The price tag for RFID system equipment is dropping as the market expands (Gross, 1995:Ch 1, 4). As more and more organizations adopt RFID, manufacturers can begin passing along savings from economies of scale, driving costs down further for the user. Maintenance costs also fall into the total life cycle cost equation. Overall maintenance costs for RFID systems are less than those of bar code systems ("Radio Frequency Identification Tags for San

Francisco," 2001:13). The RFID tags themselves are currently more expensive than the bar codes in use today, but the prices are dropping. There are passive tags currently available for as little as 28 cents each; there are active, high performance tags available for as little as 20 dollars each (ZDNet UK, 2003:1). Also, the costs for the RFID interrogators are comparable to the bar code scanning equipment. The slightly higher cost for the RFID system is typically justified by the savings in maintenance costs and improved functionality (RFID Journal, 2004a:2). Again, between the economies of scale available from an expanding market and continued improvements in technology and maintenance, the cost for RFID systems should only continue to go down.

Another benefit from the use of an RFID system is the capabilities it brings to the area of paperwork management. Some of the tags on the market today can store large amounts of data on internal memory chips. This ability is of particular use when complete up-to-date information is required or when dealing with high-value inventory tracking (Intermec, 2003b:3). Data written on a tag from different interrogators can be used to create an audit trail showing when and through which logistics nodes a tagged cargo pallet had passed ("Keeping Tags," 2001:109). This audit trail helps increase accountability in the supply chain through better inventory management and increased reliability of an organization's inventory (AIM Global, 2003b).

Another paperwork management capability RFID technology offers is the ability to create electronic forms. Data from a tag can be downloaded to an AIS which can then create electronic forms for future shipment requirements or customs clearance. These forms would expedite the cargo's passage through customs or expedite scheduled cargo pickup (Patterson, 1999:42). Data on an RFID tag may be updated or erased at any time and the tag reused to identify some other pallet of cargo, eliminating the need for accompanying paperwork (Intermec, 2003b and Kren, 1999:62).

RFID systems also help organizations make better use of their time. The organizations that have adopted RFID systems find that workers are freed from manual input duties (Department of Defense Logistics AIT Office, 1999:Ch 3, 29, and AIM Global, 2004). Like bar code scanners, data from cargo is quickly input directly into the AIS. Warehouse managers have also found that these systems improve efficiency. Interrogators throughout a warehouse can read all of the tags in the area in a very short time, allowing quicker location of an individual pallet and minimizing lag time (Air Force Materiel Command, 2003a).

RFID tags have been shown to have better read rates than traditional bar code scanners. An RFID tag can go past its interrogator in any orientation, in any position on the pallet (Wilson, 2001:A7-A13). Automatic bar code scanners need exact orientation or else the code may not be read successfully. Bar code scanners in several airports have reported read accuracies in the mid-70s to mid-80s versus over 95% with RFID tags (Langnau, 2003:42). Hand-held bar code scanners may not be able to read damaged bar codes at all. With RFID, personnel do not have to directly handle cargo to ensure data collection, resulting in a tremendous manpower savings.

An RFID system's strength of faster cargo processing times can also make aerial port operations more efficient. It accomplishes this by automating the previous manual data entry or bar code systems (Ulfelder, 2003:73). Workers using bar code scanners have to individually scan each item, or worse, manually enter identification data using a keyboard into the AIS. RFID systems allow tags to be read from a distance with no requirement for human contact with the cargo. This allows all of the tagged items to be scanned at a much faster rate and in one only pass (Bednarz, 2003:1, 93). Because of the high data transfer rate offered by many RFID systems, loaders bringing pallets into a warehouse would not even have to stop for the tags to be read, much like an "EZ Pass" lane on a toll road (AIM Global, 2004 and d'Hont, 2004:9).

While there are many strengths of an RFID system that would benefit aerial port operations, there are also some system weaknesses.

Weaknesses of RFID Systems

The investment in installation and maintenance infrastructure for an RFID system is significant. Although there are big payoffs in the form of streamlining of and improvements in operations, there are significant costs associated with setting up an RFID system. During the Operational Prototype of the AIT Concept of Operations in 1998, evaluators found a direct correlation between the level of operational performance of the RFID system and the resources committed to its upkeep (Department of Defense Logistics AIT Office, 1999:Ch ES, 7). As the Prototype found, leadership must stay committed to the program and invest in the system's upkeep. There are other weaknesses as well.

The RFID tag itself can be a problem. The active tag commonly used by most military organizations is internally powered by a battery. This battery does wear out, with a resulting loss of all stored information. Battery life depends on many different things. Extreme temperatures and other environmental conditions can shorten battery life. Constant interrogations can drain the tag's battery as well (Department of Defense Logistics AIT Office, 1999: Ch 3, 28, and A79). An RFID schedule at a European shipyard was set up so that all the tags in the cargo yard were interrogated each minute and a report generated each hour if there was a change in a tag's position. Based on the information pulled from a sample RFID tag, inspectors surmise that the tags in the yard were interrogated approximately 6000 times while awaiting transport (Ibid.: A79-A80). There is currently no method for determining RFID tag battery strength. Some logistics nodes have established a policy of changing out all RFID tag batteries as they pass through, but there is no guarantee that all tags receive service (Rumplik, 2003).

Another problem an RFID tag has is that, although the tag's memory contains much more information than contained in a bar code, the memory does have a limit. This finite memory capacity can at times be exceeded. Once a tag's memory is full, it will not accept any further transmitted data. There presently is no indication to the user that the tag's memory is full (source 10, page 3-31).

Data accuracy can be a problem for an RFID system as well. A tag is only as good as the information on it. Outdated or incorrect information that is not cleared off of the RFID tag can lead to arrival delays, misdirected cargo, and confusion all along the supply chain. This problem happened to the Army during Operation JOINT ENDEAVOR. In Transit Visibility systems showed tagged cargo reaching the final destination and then, for some reason, turning around and returning to the original destination (Army Quartermaster Online, 2003). Army unit commanders were confounded about why their cargo was returning, necessitating phone calls to attempt to straighten out the situation. The error was traced to old data on the RFID tags that had not been erased at the final destination.

Another potential data accuracy problem occurs during the communication between the RFID tag and the interrogator. Current procedures at aerial ports do not call for confirmation of complete data transfer from the RFID tag to the AIS system.

Essentially, the aerial port personnel do not know if the tag information is passed along, if the cargo information on the tag is correct, or if the RFID tags even work at all(Rumplik, 2003). This occurred quite often during the Operational Prototype of the AIT CONOPS in 1998 at the various logistics nodes that were evaluated (Department of Defense Logistics AIT Office, 2000:Ch 2, 10). Poorly placed interrogators may also play a big role as well in whether or not an RFID tag is successfully read (Department of Defense Logistics AIT Office, 1999:Ch 3, 27). All of these problems could result in serious gaps in ITV for the Air Force's customers.

With all of its potential and demonstrated problems, the 1998 evaluation of the AIT Operational Prototype found that one of the key factors for the overall effectiveness for an RFID system is the enthusiasm of the workers performing the various tasks (Department of Defense Logistics AIT Office, 1999:Ch 3, 26). Workers who take the time to learn and develop experience using the system had a very large impact on the overall success of an RFID system. This factor obviously creates variations in the effectiveness of RFID systems from logistics node to logistics node. A chain is only as strong as its weakest link.

General Characteristics of Bar Code Systems

Bar codes are the most familiar form of Automatic Identification Technology (AIT) in use today (Patterson, 1999:32). The Department of Defense (DoD) has been using bar codes since the early 1980s in the form of the commercial Automatic Identification Manufacturer's BC-1 (Code 39) standard (Department of Defense Logistics AIT Office, 2000:Ch 2, 1).

The typical bar code is an array of narrow, parallel bars and spaces that represent a group of characters. A scanner reads these lines and spaces, decodes them, and transfers the translated data to a host computer (AIT Task Force, 1997:Ch 2, 2). These bar codes can be used to represent key data elements like a Transportation Control Number (TCN) for an aircraft pallet. The bar code scanner reads the bar code and links the resulting TCN number to its corresponding data on a central database (Department of Defense Logistics AIT Office, 1999:Ch 3, 2).

There are two types of bar codes in use today in military operations. The linear bar code, by far the most prevalent, has characters that typically represent TCNs or some other identification number used to link the cargo to more detailed cargo information on an AIS. The other type of bar code in use today is the Two-Dimensional (2D) bar code. This bar code system can hold almost a hundred times more data than a linear bar code, up to 1850 characters (Ibid.:Ch 3, 12, and AIT Task Force, 1997:Ch 2, 3).

During the 1998 evaluation of the AIT Operational Prototype, bar codes were found to "enhance or offer opportunities to enhance business processes when fully integrated with supporting logistics AISs" (Department of Defense Logistics AIT Office, 2000:Ch 2, 2). Linear bar codes are best used as an automated key to information prepositioned in a central database. 2D bar codes, due to their ability to store more information, can not only link to prepositioned data like the linear bar code, but can also be used to populate data into the AIS system itself (Department of Defense Logistics AIT Office, 2000:Ch 2, 1).

According to the Automatic Identification Technology (AIT) Concept of Operations, all logistics nodes should have the capability to read bar codes. The Operational Prototype conducted in 1998 validated the need for this requirement

(Ibid.:Ch 2, 3). However, this same evaluation also mentioned that bar code systems are only 80% of the AIT solution (Department of Defense Logistics AIT Office, 1999:Ch ES, 2).

Strengths of Bar Code Systems

Bar code systems are, for the most part, the cheapest AIT systems to purchase due to the fact that they are such an established system. The equipment used in the system is very portable and easy to use (Patterson, 1999:26). The bar codes themselves are simple and very inexpensive to produce. All a worker needs is the correct software and a printer to make a bar code.

When compared with the time to conduct manual data entry, bar code data entry systems save tremendous amounts of time. During the 1998 evaluation of the AIT Operational Prototype, inspectors found that workers typically took only 30 seconds to scan in a bar coded item, versus 80 seconds per item to manually enter the data into the AIS cargo tracking system. Where aerial port personnel had taken 10 to 15 minutes per pallet to inprocess cargo, that time was reduced to only 5 minutes per pallet using bar codes (Department of Defense Logistics AIT Office, 1999:Ch ES, 5). Bar codes eliminate the need for manual keystroke entry of cargo data into a central database. Again, removing the "human factor" from the equation more often than not means more data accuracy.

Bar code data entry is more accurate than manual data entry. The data entry is essentially error free, compared to the 1 in 300 keystroke error rate common in manual entry processes (source 10, ES page 5). Constant, repetitious entering of cargo data, transportation control numbers, and other identification data leads to errors being introduced into the cargo tracking system. "Accuracy beyond manual handling of data can usually be expected, particularly where lengthy, repetitious gathering of data is involved" (AIM Global, 2004). Bar code systems help prevent these errors by removing the human element of the data entry equation.

Weaknesses of Bar Code Systems

As with RFID systems, bar code systems do have weaknesses that can affect operations. The first drawback of bar code systems is that the readability of the bar code itself is affected by print quality. During the AIT Operational Prototype evaluation in 1998, bar codes at several major aerial ports were printed so dark that they could not be read by the bar code scanners (Department of Defense Logistics AIT Office, 1999:A10). Because any worker with the correct software and printer can create them, there is little control over the quality of the actual bar code being printed.

Another weakness is the lack of durability of the bar codes. Bar codes are printed on standard print paper and can be affixed to a box or pallet or placed in some watertight package like a standard commercial packing list. Bar codes do not read very well when they become worn or wet (Patterson, 1999:26). Workers sometimes unintentionally render bar codes unreadable by underscoring, circling, or marking on them (Department of Defense Logistics AIT Office, 2000:Ch 2, 5). Because of their susceptibility to damage from the elements, bar coded pallets are subject to the same disadvantages as hand written placards on pallets (Gross, 1995:Ch 2, 10). These damaged bar codes do not permit scanning, forcing personnel to take time to manually enter the cargo data. Damaged and unreadable bar codes "constrain business process improvement and the willingness of operators to use this technology" (Department of Defense Logistics AIT Office, 2000:Ch 2, 5).

The bar code readers can be a drawback at times as well. The readers are subject to high and low levels of light, making scans conducted outside a challenge (Patterson, 1999:26). An effective scan also requires fully operational equipment and an effective scanning technique from the worker (Department of Defense Logistics AIT Office, 2000:Ch 2, 5). Bar code scanners will sometimes not read effectively if the bar codes are placed too close together. Based on data gathered during the evaluation, the inspectors of the AIT Operational Prototype recommended at least 1 inch between bar codes to ensure successful scans (Department of Defense Logistics AIT Office, 1999:Ch 3, 16).

The difficulty in determining accuracy of identification data that are gathered from bar codes can also be a drawback to a bar code AIT system. Workers printing a 2D label cannot look at the label and verify any of the data on the bar code. Information printed onto a manifest can be read by any aerial port worker, but information coded on a 2D bar code is not intuitive and requires scanning to verify data. Linear bar codes will typically have alphanumeric characters printed near the bar code to allow some form of double-checking of the identification data (Department of Defense Logistics AIT Office, 1999:Ch 3, 15). Also, once a bar code is printed the data on the code cannot be updated. A new bar code must be printed out each and every time an update needs to be made to that particular cargo's information ("Keeping Tags," 2001:109).

The use of a bar code system usually does save more time than manual data entry. There are times, however, when bar code use is actually less time efficient. The AIT Operational Prototype evaluators found that an unreadable bar code is more time consuming than no bar code at all (Department of Defense Logistics AIT Office, 1999:Ch 3, 10). They observed aerial port personnel repeatedly running a scanner over bad bar codes, eventually having to manually enter the data anyway. This process obviously took more time than merely entering the data manually in the first place and was frustrating for the workers.

Airports using bar codes for luggage sorting have also discovered that the lower bar code read rates (70 to 80 percent) cost organizations time as well. Workers often have to manually route unscanned bags to the correct destination (Reed, 1999:65-66). A higher read rate would result in significant manpower savings.

Even when everything is working correctly and the bar codes are successfully read, aerial port personnel still have to scan each and every bar code on an aircraft pallet (Bednarz, 2003:1, 93). If a pallet contains many individual boxes, this scan could take a relatively long time. Bar codes do save time compared to manual entry. But even though a pallet may take only 5 minutes to process versus the 10 to 15 minutes to process using manual data entry, a typical Air Mobility strategic airlift aircraft can offload 18 to 36 pallets at one time. One person processing 20 pallets at 5 minutes a pallet means over an hour and a half to populate GATES with cargo information, easily eclipsing the 1 hour timeline established by the AIT task force CONOPS (Department of Defense Logistics AIT Office, 2003:Ch 1, 2).

Conclusion

Automatic Identification Technology systems provide inherent efficiencies for organizations that choose to implement them into their processes. Two of the most common systems on the market and in the DoD today are bar code and RFID systems.

RFID systems, while not as established as the bar code AIT systems, have many strengths that offer much promise in the area of automatic data gathering. Its stand off data capture ability, ease of tag reading, and more successful read rates has many organizations choosing to implement this system. Rapidly dropping costs for the tags and interrogators will make these systems even more attractive in the future. The dependency on user enthusiasm and resources can limit the capabilities of this system, however.

Bar code systems are by far the more prevalent of the two systems. Its tried-and-true system of bar codes and easy-to-use scanners has firmly established this AIT system in both the commercial and military world. While bar codes are the cheapest forms of AIT, at least for start-up costs, overall maintenance costs and wasted time overcoming logistical challenges from damaged bar codes help RFID tags to narrow this lead.

While bar code and RFID systems both offer the promise of streamlined operations and improved processes, it is the RFID system that many large, successful companies have chosen in recent years. Chapter IV will look at many companies that have implemented an effective RFID system into their operations. Some companies have even changed the way they do business altogether because of the efficiencies RFID systems have brought.

IV. RFID Success Stories

Introduction

Automatic Identification Technology (AIT) in the form of an RFID system offers many benefits to business processes. Air Force aerial ports have adopted the bar code system and use RFID in a limited way, but why should they change the way they do business and adopt a more extensive RFID system? Aerial ports have to overcome many challenges in order to be effective and efficient, but there is a certain comfort in maintaining the status quo, of doing things the way they have always been done. Why go through the pain of change? In a speech to the U.S. Army War College, Department of Defense Official Jacques Gansler said that "the DoD Logistics System must be dramatically transformed over the next few years. In very simple terms, it costs far too much, takes far too many people, and doesn't provide the desired performance—in terms of readiness, responsiveness, or sustainment" (Department of Defense Logistics AIT Office, 1999:Ch 5, 14). With ever-shrinking defense budgets and force draw downs, it is clear that the military logistics community, especially Air Force aerial ports, must change the way they do business. Bar code systems and the current level of RFID implementation is clearly not achieving the desired level of efficiency or performance.

What is the business of an Air Force aerial port? What is their core competency? The overall goal of the aerial ports and the air mobility community as a whole is to get the customer's cargo where the customer wants it, when he wants it. Arguably, the United States Army is the aerial port's biggest customer. So what does the Army want? The Army wants Total Asset Visibility (TAV) over their cargo moving through the Air Force logistical chain from "fort to foxhole." To achieve TAV, the Army realizes that

AIT is essential. They want a view of their cargo that all key leaders can see with minimal human intervention (Gonzalez and Hollister, 1999:103). The Army has embraced RFID as the preferred type of AIT with data-rich tags providing ITV to interrogators along various "choke points" throughout the supply chain. These "choke points," or bottle necks, are much like Air Force aerial ports.

The Army has taken the leap and invested heavily in RFID systems to improve deployment and redeployment processes, a level of investment the Air Force seems reluctant to make. Old Dominion Trucking Company Vice President Chip Overbey described money spent on customer support best when he said that it's spending that makes better, it's spending you can get a return of investment on. "We don't look at it [RFID] as an expense. We look at it as an investment. It is how you position yourself better with your customers" (Intermec, 2003a).

Civilian companies operate in a different environment than the military. These companies operate in a world where requirements and surges can be predicted relatively accurately. There is a stability which allows them to enter into long term contracts beneficial to both parties. And, obviously, they do not have to deliver their goods into the middle of a war zone (Department of Defense Logistics AIT Office, 1999:Ch 5, 14). The military has little stability, is forced to operate under the close scrutiny of Congress, and is highly constrained on its operating practices.

Because of this unique environment in which we operate, the argument is often made that things that work for civilian companies will not work for the military. In the past this was shown to be true. Civilian companies tended to concern themselves with tracking overall shipments while the military wanted visibility over the contents of the actual shipment. A recent shift in civilian business practices has seen these companies focus more on "lean logistics." As companies streamline their logistics, there is more and more need for information on what they will receive in a shipment, not just when they will receive it (Gilmore, 2002). Just like the military, they need to know where their shipments are because crucial plans are often made around when the shipments will arrive. This shift in business strategy makes the lessons learned from the study of these successful civilian companies more applicable to the Air Force than ever (Horsey, 2003:6).

Although the differences are clear, there are similarities between certain problems facing both civilian and military organizations. Many of the best and largest civilian companies have faced some of the same logistical problems and challenges seen today in Air Force aerial ports and have overcome many of these problems by combining RFID technology with organizational adjustments (Gross, 1995:Ch 2, 11). These adjustments and changes have catapulted these companies into the forefront in the implementation of AIT. Not only civilian companies, but other DoD services have adopted RFID technology as well to improve their operations. This chapter will examine some RFID success stories from the commercial and military world that have practical applications for an Air Force aerial port operation, specifically, the challenges these ports face.

Innovations in Cargo Yard and Warehouse Management

Aerial ports must have a place to temporarily store cargo pallets while awaiting further transportation to another destination. As discussed earlier in Chapter II, the aerial ports have some real challenges in managing these cargo yards.

Many other civilian companies have faced similar cargo storage challenges and have used RFID technology to solve many of these challenges. Perhaps the most innovative use of RFID comes from International Paper. International Paper is an industry-leading manufacturer of paper products. Their warehouses are full of gigantic rolls of paper that are stored until ready for shipment. The system the company had used previously to track the location of specific rolls of paper consisted of up to 3 bar codes per roll of paper and a manual tracking system requiring a worker to walk up and manually scan these bar codes for identification. These bar codes were easily damaged or dirtied, rendering them useless. Manhours were wasted while workers searched for the correct roll of paper. International Paper needed a more efficient way to track down its inventory in its large warehouse. The company developed an RFID Warehouse Tracking System (WTS) that has truly transformed the way that inventory is handled. The WTS system uses RFID with real-time location tracking to pinpoint a pallet or large roll of paper in the cavernous warehouse to within 6 inches (RFID Journal, 2004b:1). The company now uses an RFID tag on each and every roll of paper which is tracked by readers located on each of the warehouse forklifts. These readers are networked to a central computer database in the warehouse office and the decision about where a paper roll should be taken is transmitted to a monitor inside the forklift. The worker is directed to the correct paper roll and location every time, all without having to leave the forklift. International Paper's WTS is one of the most robust RFID warehouse systems on the market today and has often proven itself to be better than 99.7 percent accurate. "It will revolutionize the way companies benchmark operational efficiencies…the system will provide complete inventory visibility and compatibility throughout the supply chain" (RFID Journal, 2004b:2). Because this system works with pallets as well as paper rolls, there are obvious applications of this technology within Air Force aerial ports.

The U.S. Army began using RFID technology during Operation JOINT ENDEAVOR in Bosnia in 1996, the first time it had been used in a large-scale deployment. "This technology improved the information flow and visibility of unit equipment during deployment and of incoming supplies during sustainment" (Army Quartermaster Online, 2003:3). The Army established a central distribution hub in the European theater to efficiently consolidate and control the shipment of cargo, much like a gigantic warehouse. Shipments of cargo were tagged and readers at various "choke points" monitored the cargo's movement within the theater of operations. RFID technology was further used to classify and segregate cargo at several freight forwarding areas (Army Logistics, 2003:2).

Other countries' militaries have jumped on the RFID bandwagon as well. The British Army, using the same RFID technology the U.S. Army is using, realized huge cost savings during Operation IRAQI FREEDOM. There was an incident where a unit could not find a tank tread that had been ordered. Plans were in progress to order another tank tread when someone suggested using the RFID technology in place to try to find the misplaced item. Using RFID, it was found, saving the British Army $3 million in cost avoidance by not having to order and ship another tank tread. Just this one success nearly paid for the $5 million cost for installation of the British RFID system in theater (Military Technology Online, 2003:3).

The Europe Combined Terminals (ECT) in Rotterdam came up with an ingenious method for using RFID technology to manage their cargo yard. RFID tag interrogators were imbedded into the asphalt of the cargo yard and every container and vehicle entering the yard is fitted with an RFID tag. This system allows officials to track and locate both vehicles and containers as they move around the yard. Previously, ECT kept track of containers manually. This inefficient, manpower intensive system resulted in lost containers, confusion, and inconsistent performance (Texas Instruments, 2004d). The new RFID system uses the imbedded interrogators as "navigational beacons" to guide trucks and crane operators to the proper container, much like the system at International Paper's warehouse. An additional benefit of the interrogators is that they are programmable, allowing further organization of yard layout by specifying when to query RFID tags and what data to write to them. This innovative use of RFID technology has saved ECT hundreds of man hours and dramatically improved efficiency (Ibid.).

The massive Port of Singapore (PSA) tracks thousands of containers each day and manages the arrival and departure of up to 50 cargo ships per day. To help manage this chaos, PSA invested in RFID technology and installed interrogators in their cargo yard. These readers, like the ones at ECT, are imbedded into the asphalt in an X, Y, Z, coordinate system to read the RFID tags installed on each container. A centralized computer system manages the placement and location of each and every container in the cargo yard (d'Hont, 2004). These improvements have resulted in a reduction in delayed departures and incomplete shipments.

The Port of Charleston, South Carolina, is using RFID in their cargo yard management system. The efficiencies gained from this RFID technology have resulted in the dramatic 5% reduction in truck turn times (Knee, 2001:S3-S8).

RFID technology has not only been successfully adopted for use in the cargo yard and warehouse. Companies are also using this highly versatile AIT system to streamline and reduce paperwork, another serious challenge facing aerial ports.

Use of RFID Technology to Streamline and Reduce Paperwork

Old Dominion, a leading less-than-truckload interregional and multi-regional motor carrier, is using RFID technology on its warehouse dock doors to help streamline the paperwork in its operations. Before being loaded onto trucks, their cargo pallets are fitted with RFID tags. These tags are read by RFID interrogators located on the warehouse dock doors. Information on each tag, such as type of cargo and final destination, is downloaded to a central computer system where an electronic manifest is created. An RFID tag is affixed to the truck as well and the cargo list in the form of an electronic manifest is written onto it. This electronic manifest is also sent over the internet to the next destination. When the truck arrives at the next destination, RFID interrogators at the next warehouse download information from the tag on the truck and pull up the electronic manifest for the warehouse managers. Before this system was installed, arriving drivers had to park their trucks and take up valuable time to check into the receiving office while their trucks sat idle full of cargo. As the pallets of cargo are downloaded, RFID interrogators on the warehouse dock doors check in each pallet and compare it to the manifest on the central database. Old Dominion has seen improvements in productivity from the more efficient use of manpower and resources. With the old system, teams of workers would spot-check the trailers for load accuracy and supervisors would have to go over 4 copies of paperwork prior to releasing the truck. It now takes only 1 worker instead of 7 to check the loads at an entire warehouse. The new automated system allows automated, paperless data entry as well and has proven to be highly accurate (Intermec, 2003a).

Chevrolet's "Red Light, Green Light" system has also helped their warehouses reduce paperwork through the use of RFID technology. Crates and pallets are fitted with

RFID tags containing information on contents and final destination. As the pallet or crate is loaded onto a truck, an RFID interrogator mounted onto the warehouse door reads the tag. Information on the tag is matched with an electronic manifest and the date and time of shipment is electronically "stamped" on the central computer database. This RFID system replaces the obsolete manual system that was prone to human error. "The old system of floor plans and hand-held paper manifests proved to be time consuming and inefficient," according to the assistant plant manager (Texas Instruments, 2004a). Using this RFID system, Chevrolet has achieved greater precision and accuracy with filling shipping orders.

The U.S. Army, in conjunction with the Defense Logistics Agency, has learned from the commercial world and implemented a program of electronic manifesting and receipt of shipments. Using the Automated Manifest System, contents of a container are encoded electronically onto a plastic card. These cards are retrieved at the final destination and read into a computer system, providing an electronic manifest. This program has been verified to 98% accuracy and has reduced issue and receiving times to a matter of minutes. The previous paper-intensive method could take hours or even days to accomplish the same task (Coburn, 1999:3).

Many international ports are learning from the Port of Singapore's successes with their paperless customs system. Containers arriving in the port have RFID tags installed. The information on the content of the containers are read from the tags and downloaded to a central computer. This container information is forwarded to customs officials electronically (Patterson, 1999:42). This rapid information transfer allows customs officials to begin processing the paperwork, reducing idle time and getting the customer their cargo more quickly.

Use of RFID to Streamline the Processing of Cargo

Civilian companies operate in a different environment than the military, granted. But there are similarities. Like the Air Force, there are several civilian companies who ship large amounts of cargo by air. Caterpillar Corporation uses its electronic link of 256 dealers and 25 distribution centers to effectively ship parts and supplies to any of its dealers worldwide within 4 days. During Operation DESERT STORM, the DoD logistics system typically took 40 to 60 days to accomplish the same thing. Caterpillar's electronic cargo management system allows it to track shipments from request to receipt (Department of Defense Logistics AIT Office, 1999:Ch 5, 14). This system could be compared to GATES, currently used by aerial ports.

Fed Ex and UPS demonstrate their effective "management of chaos" as they oversee the shipment of millions of packages each and every night. In comparison, the military requisitions at the height of Operation DESERT STORM never reached more than 35,000 per day (Department of Defense Logistics AIT Office, 1999:Ch 5, 14). Now granted, these companies do not have to ship cargo into a combat zone like the Air Force. But these cargo carriers have set the bar very high for levels of effective and efficient cargo processing and delivery. There are lessons to be learned from other organizations.

The U.S. Army did learn some logistical lessons from Operation DESERT STORM. It used RFID technology during its deployment and sustainment of Operation JOINT ENDEAVOR in 1996 to improve the flow and visibility of this vital cargo and equipment (Army Quartermaster Online, 2003:3). Information stored on the RFID tags fed a central database that kept track of each individual tagged pallet as it moved throughout the theater. This RFID tag data provided handlers processing the cargo at each logistical node the information on final destination and any special handling that may have been required.

Old Dominion Freight Lines has dramatically improved its cargo processing operations through the use of RFID technology. RFID tags on each truck are interrogated by readers in the warehouse yard. Information from the tags is downloaded to a central database where, as mentioned in the previous section, an electronic manifest is brought up. Warehouse managers then look at the manifest, determine dispensation, and radio the truck driver to go to the appropriate bay for download (Intermec, 2003a:2). Cargo pallets offloaded from the truck are electronically "checked in" as well by RFID interrogators on the warehouse dock doors. These interrogators also help during the processing of cargo for shipment. The tags on outbound pallets are compared with the information on the manifests located in the central database. Alarms sound if the tagged cargo passing these interrogators does not match up with correct manifested cargo. "The system prevents misloads. If we've been surprised by anything with the whole project, it is the number of misloads that we catch. One shipment going cross country can cost a lot of money if you put it on the wrong trailer" (Ibid.). Finally, exiting trucks fitted with RFID tags are automatically identified and their departure time logged into the central database.

Xerox, the world's largest photocopier manufacturer, ships about 250,000 copiers per year from its manufacturing plant in England. This plant installed an RFID-based logistics tracking system similar to the one used at Old Dominion. RFID interrogators on the warehouse bay doors read tags affixed to outbound shipments. The interrogators compare data on the tags to a manifest located on a centralized database. An alarm sounds if a copier is loaded onto an incorrect truck. This system has improved shipping accuracy at the plant to 100%. "By accurately and reliably identifying and tracking goods throughout distribution, warehousing and shipping, companies such as Xerox can achieve major savings in costs and higher productivity through reduced shipping errors and more efficient handling" (Texas Instruments, 2004b).

Chevrolet's "Red Light, Green Light" RFID system uses the same RFID technology to improve its cargo processing operations as well. The RFID interrogators on each warehouse loading door help prevent shipping errors by flagging tagged pallets that may be loaded onto incorrect trucks. This system has given Chevrolet's warehouses greater precision in filling shipping orders and substantially reduced expenditures for emergency shipping charges (Texas Instruments, 2004a). Other benefits include the elimination of human error which was rife throughout the old manual tracking system, greater speed, efficiency, and better record keeping (d'Hont, 2004).

Unilever, the 25th largest company in the world and manufacturer of toothpaste and shampoo, uses RFID technology in a "smart pallet" system. This system is designed to revolutionize how customer products are moved, handled, and tracked throughout their warehouse system. Again, RFID interrogators on warehouse doors read tags affixed to outbound cargo. Data collected on the cargo is compared to information stored in the database such as the weight of the cargo, contents, and destination. The truck is weighed and the actual weight is compared to the database's record of weights. Any discrepancies are signaled to the warehouse managers. This system has increased warehouse productivity by raising the number of pallets handled daily and ensuring the validity of material movements (Texas Instruments, 2003a). Order fulfillment takes 20% less time and requires only one third the manpower of the previous system. Before this system was implemented, processing 200 pallets took 3 workers. Today, one warehouse employee can process 350 pallets per day (Texas Instruments, 2004c). This system also helps eliminate shipping mistakes and saves overall time by reducing the re-handling of pallets.

Motorola is one of the world's leading manufacturers of semiconductor chips. Because the chips must be kept antiseptically clean, an RFID system is ideal for the "hands off" data capture capability that this manufacturing system requires. The company uses the RFID system in its clean rooms to control movement of the valuable semiconductor chips through the manufacturing process, to improve overall system efficiency, and to promote effective equipment use. RFID tags installed on the racks carrying these semiconductor chips contain information on where the carriers have been and where they still need to go along the assembly line. Because semiconductor chips are so expensive, any problems with information accuracy during the manufacturing process can cost the company large amounts of money. The RFID tags have eliminated the need for workers to manually scan in items, thereby removing the human element, and have greatly improved data accuracy (d'Hont, 2004). As a side benefit, the RFID tags on the wafer carriers can also be used to identify overall manufacturing system inefficiencies and bottlenecks. Time and date stamps show where idle time occurred and what machines were not efficiently utilized.

During AGILE SWORD 1994, a Maritime Prepositioning Force offload exercise, the U.S. Marines conducted their first operational test of their new RFID system. The system, called Microcircuit Technology in Logistics Applications, helped the Marines realize a marked improvement in the speed of cargo data collection and a significant reduction in manpower needed to collect this data. Where before data collection at a cargo processing yard had required 30 marines to read bar coded cargo, only 9 marines were needed to collect data from RFID tagged cargo. While it only took a few seconds to scan in a bar coded item, the process had to be repeated for each individual item, sometimes consuming hours for large shipments of cargo. Conversely, all of the RFID tagged cargo was processed in a matter of minutes (Gross, 1995:Ch 4, 12). This test by the Marines found that data collection using bar codes could actually hinder offload operations, while the RFID system could instantly collect data as frequently as required (Ibid.).

Airlines and airports have recognized the benefits that RFID technology can bring to cargo processing. In their business world, passenger baggage is cargo. Airlines typically route over 3 million bags a year using a combination of bar codes and human intervention. Studies by airports have found that up to 40% of the bags processed must be manually routed because of unreadable bar codes ("Smart Tags for Bags," 1999:11). An airport's baggage sorting area is a noisy, chaotic place with bags moving to and fro on conveyer belts. Bar code tags must be in the proper orientation for the scanners to read them correctly. These tags are quite often not oriented correctly or are damaged and as a result the bags must be manually directed to the proper aircraft. RFID tags overcome this orientation problem in airports because of their ability to be read from as far away as 10 feet and in any position, allowing more precise tracking throughout the system (Brewin, 2003:7).

Airlines such as Delta and airports like San Francisco and Jacksonville International have begun replacing bar codes on bags with RFID tags. In San Francisco, the RFID tag system was certified by the FAA in June of 2001 and has seen a 99.98% read rate of baggage tags versus the 66%-85% read success rate using bar code systems. Because of the high read rates the tags bring, airports using the RFID system have seen speedier baggage processing, quicker aircraft loading, fewer lost bags, and fewer misrouted bags (Wilson, 2001:A7-A13).

Conclusion

Civilian companies have seen the benefits offered by RFID systems and have invested significant sums of money to develop and implement these systems. United Parcel Service (UPS) spent $11 billion over 10 years on Information Technologies like RFID. UPS has since realized a 10-fold return on investment. Fed Ex similarly invested heavily in this area and has enjoyed on 8-fold return (Melcer, 2003:B-1). Clearly, there are financial benefits in having an efficient cargo tracking system.

The U.S. Army realized that the benefits of RFID systems far outweigh the cost. They expended considerable resources setting up an RFID system in support of Operation JOINT ENDEAVOR. A conservative, independent cost benefit analysis by the Defense Logistics Agency Operations Support Office in April 1997 predicted a $21 million savings over a 5-year period using this RFID system. In fact, the cost from the investment in RFID hardware, travel, and associated support was realized within the first year of the operation (source 19, page 3). During Operation IRAQI FREEDOM, the British Army realized two-thirds of the cost of their RFID system investment with one transaction (Military Technology Online, 2003)!

It is clear that RFID systems typically enjoy large returns on investment. Improving business processes and streamlining operations using RFID can also have a tremendous effect on a company's bottom line. What other effects do RFID systems have? These companies that have implemented RFID systems have realized significant manpower savings. There were also reductions in the amount of physical paperwork generated and transferred from location to location. Less paperwork traveling with cargo means less paperwork that can be lost or damaged to the point of being unreadable. There were also cost savings and time savings from the elimination of misrouted cargo. Less time spent re-routing cargo meant more time working—production rates therefore went up. Workers spent less time being idle while management tried to figure out the proper destination and dispensation of the cargo.

Can the successes from implementing RFID systems these civilian companies experienced be applied to Air Force aerial port operations? Can aerial port operations be more streamlined? Can there be a manpower savings from more efficient work processes and less mishandling of cargo? Can paperwork loads be reduced? Chapter V will attempt to apply RFID technology discussed in Chapter III to the specific challenges aerial ports face discussed in Chapter II using the lessons learned from the study of civilian companies in this chapter as a model.

V. Discussion and Conclusion

Introduction

Today's warfighter demands information to help him win battles. Not only does he need information on enemy strength, troop concentrations, and tactics, the warfighter needs information on when his own army will be supplied. The fight cannot begin until the troops are trained, properly equipped and properly supplied. Critical battlefield decisions are often based on when and where these supplies arrive.

There were many lessons learned from past wars about the importance of logistics. Operation DESERT STORM showed that, for all intents and purposes, the logistical equivalent of Oklahoma City, Oklahoma could be airlifted lock, stock, and barrel to Saudi Arabia. Although this logistical movement was a truly monumental feat, it created huge "iron mountains" at the end of the supply chain (Farris and Welch, 1998:5-14). Supplies sat and waited for pickup and containers were opened to merely determine contents because paperwork had been lost. Frustrated by a seeming lack of responsiveness, it seemed to the United States Army that the only way to ensure the right supplies and equipment got to the right place was to order above and beyond what was really required, further increasing the burden on an already overstretched airlift system. Aerial ports quickly became inundated with supplies moving to the theater. Pallets awaiting shipment became "lost" as paperwork was misplaced.

United States Transportation Command realized that what the Army really needed was reassurance. The Army wanted to know where there "stuff" was at any point in time along the supply chain. The Army calls this information "Total Asset Visibility." Taking a page from successes in the civilian market, the TRASCOM began taking a look at the idea of Intransit Visibility using Radio Frequency Identification (RFID) tags. Experiments and trials on a larger scale began during Operation JOINT ENDEAVOR in 1996. Although there was room for improvement, leaders began to see the potential of Intransit Visibility using this new RFID technology.

This chapter will review each of the investigative questions discussed in the previous four chapters. This review will serve as a building block to answer the research question.

Review of Investigative Questions

What are some of the key processes of aerial ports that sap manpower and drain resources? To the warfighter, every piece of cargo shipped by air has the highest priority and needed to be there yesterday. Time is of the essence or else the warfighter would have sent the cargo by ship. The clock is one of the key factors aerial ports must deal with. Cargo must be processed, inspected, loaded, and documented quickly. Another factor ports must deal with is the sheer volume of cargo shipped through them. Surges and a wartime footing can create chaos at times. Pallets are lost, shipped incomplete, or are sent to the wrong destination. Worse yet, pallets begin piling up faster than they can be shipped out, further adding to the management nightmare. All of these factors take a toll on operations. The customers to develop “coping mechanisms” like over-ordering or inflating the priority system to deal with airlift shortcomings. This creates a downward spiral of inefficiency. In this demanding environment in which they operate, there are three specific processes that have considerable impact on aerial port operations.

The first process that challenges aerial ports is cargo yard and warehouse management. Arriving cargo pallets are immediately shipped out by truck or aircraft, picked up directly by the customer, or are stored in the aerial port warehouse or cargo yard. Air Mobility Command Instruction 24-101 Volume 11 establishes the requirement that all aerial ports must have some sort of system for orderly storage of these pallets. This system requires manpower to operate. When humans are involved in the process, efficiency of an inventory system is often lowered and the potential for error is increased. Port personnel are required by regulation to physically inventory pallets in the cargo yard and warehouse. This inventory can take a considerable amount of time and personnel to accomplish. It is relatively easy to misread an inventory sheet or a poorly marked cargo pallet which can lead to erroneous data being introduced into the cargo management computer system.

The "paperwork monster" is another process that creates challenges for aerial ports. Each individual piece of cargo is assigned a Transportation Control Number (TCN). A cargo pallet is built up from a group of these individual pieces of cargo and is itself assigned a TCN. In order to be transported from point A to point B, a cargo pallet requires airworthiness certificates, customs forms, and a whole host of other documentation as well. A tremendous amount of man hours are spent each year properly documenting all of the cargo moving through the airlift system. The challenge arises when this paperwork is filled out incorrectly or, even worse, is lost in transit.

Aerial ports must expend huge amounts of man hours overcoming the hassle of lost paperwork. Personnel must contact the previous station, if that station even has an aerial port, to gather the required information. While this backtracking occurs, the subject pallet is placed in a "frustrated cargo" area. Assuming the correct information on the cargo pallet can be gathered, aerial port personnel must then manually enter the information into the cargo tracking computer system, increasing the chance for the introduction of further errors. Strangely enough, attempts at improving paperwork processes through the introduction of Automatic Identification Technology (AIT) like bar codes have, in the not-to-distant past, met with resistance. Natural biases toward new processes have resulted in "doing things the way they have always been done."

The last key process discussed in this paper is the actual act of cargo processing. Some improvements have been made using bar code technology. If every item on a cargo pallet is continuing on to the same destination, the worker merely has to scan the pallet's bar code into the cargo tracking computer system. The problem is when this same pallet has to be broken down and individual items checked in and processed and sent to separate destinations. Although workers do not have to manually enter each and every item coming off of the pallet, there is still a requirement to physically handle each item to scan it into the cargo tracking computer system. The bar code system has allowed ports to achieve check in times of roughly 5 minutes per pallet versus the 10 to 15 minutes per pallet using the previous manual check in system. A large, strategic airlift aircraft can carry over 20 of these pallets, quickly swamping a single person attempting to process all of the cargo. To further add to the workload, actual loads often do not match the cargo manifest. Personnel have to take time tracking down "short shipments" or determining dispensation for "overages."

What are the more common forms of AIT being used today by both military and civilian organizations for ITV? There are many different technology systems on the market today used by organizations to gain visibility all along the supply chain. Two of the most prominent are bar code and RFID systems.

The bar code has been around longer and is by far the more familiar and established of the two technologies. It is composed of an array of narrow parallel bars and spaces that represent alphanumeric characters. The bar code is read by a scanner and translated into data. In a typical system in most aerial ports, a bar code represents a Transportation Control Number (TCN). When a bar code from a piece of cargo is scanned, the TCN is compared to the matching TCN in a central database and further information on the cargo is pulled up for the worker to see. The 1998 evaluation of the Automatic Identification Technology (AIT) Operational Prototype found that bar codes "enhance or offer opportunities to enhance business processes when fully integrated with supporting logistics Automatic Identification Systems" (Department of Defense Logistics AIT Office, 2000:Ch 2, 2).

The bar code is by far the more familiar of the two Automatic Identification Technologies discussed in this paper. They are cheap and simple to make. All an aerial port needs are computer stations with the correct software and printers that can produce them and a bar code can be generated for any piece of cargo being processed. The equipment used in the system is very portable and relatively easy to use. When compared with manual data entry, the bar code system saves significant amounts of processing time and reduces the errors that are common during manual data entry.

Bar codes do have weaknesses that make their use in aerial port operations less optimal than other AIT systems. Much of the effectiveness of the bar code itself depends on printer quality. Any aerial port can make these bar codes, and each port has their own type of printer which makes it tough to standardize print quality.

The bar codes are printed on regular printer paper and are therefore not very durable. Smudges and blurring of the bar codes can easily affect readability. Cargo pallets stored outside are typically covered with plastic to protect them from the elements and the bar codes are stored in plastic pouches, but they sometimes still get wet. Workers can affect readability as well by marking or making notes over the bar code sheet during normal processing. The scanner itself is subject to high and low levels of light or may not read a bar code if it is too close to another bar code. A drawback from a bar code that cannot be read is that the productivity of the worker trying to scan in the bad code is reduced. This worker will attempt to scan in the item several times, perhaps thinking that it is his scanning technique. After several failed attempts at scanning, the worker eventually has to type in the data manually anyway. Where is the time savings?

Radio Frequency Identification (RFID) systems have found a significant niche in business processes over the past 10 years. Simply put, RFID is an automatic way to collect data on an item or group of items without human intervention or error (AIM Global, 2003b:2). The typical system consists of an RFID tag which contains a power source (active tag), a transmitter, an antenna, and some sort of internal memory. Tag interrogators send out radio signals that are received by the RFID tags. The signal triggers a response from the tag in the form of a return radio signal containing tag identification data. A group of interrogators may be networked to a central database where more detailed information on the tagged cargo is contained.

An RFID system offers inherent life-cycle asset management efficiencies for an organization that adopts its technology (Under Secretary of Defense, 2003:1). These efficiencies often outweigh the costs of implementing this new technology. As more and more organizations switch to RFID systems the cost for the systems should continue to decrease. RFID systems bring other capabilities as well. Internal memory storage on an RFID tag can reduce the need for accompanying paperwork. Data can be downloaded from the tags and transferred onto electronic forms, further streamlining cargo processing. RFID interrogators can be networked to help locate and keep track of tagged pallets in a warehouse. RFID systems allow quicker processing as well. The contents of tagged pallets are automatically scanned into the organization's cargo tracking system, allowing "hand-free" operations. RFID tags do not have to be oriented in a particular direction in order to be read, unlike bar codes. This characteristic allows greater than 95% read rates versus the 60-70% read rates from automatic bar code systems.

RFID systems do have some drawbacks, however. The initial start up cost for implementing this system can be daunting for some organizations. Although RFID systems have consistently demonstrated their ability to recoup their costs from savings in a very short amount of time, some organizations are unable, or unwilling, to expend the funds or move away from older, more established systems. The RFID tags themselves can present some problems. Active RFID tags depend on batteries to recognize and respond to interrogator signals. Studies have shown that a large number of interrogations can easily drain a tag's battery. Data on a tag must be kept updated. Old data that is not cleared off often creates confusion among logistical supply chain managers. The success of RFID systems ultimately depends on the enthusiasm of the workers in accepting and applying the system. Poor attitudes and unwillingness to learn the nuances of the system lead to system ineffectiveness.

Based on a comparison of the characteristics, strengths, and weaknesses between the bar code system and the RFID system, the RFID system is offers by far the most potential for solving the three most common aerial port challenges.

How have civilian and both foreign and DoD military units successfully applied RFID technology to streamline processes in their respective organizations? The current ITV system used by Air Force aerial ports does not meet the customer's needs. The system costs too much, is inefficient, and does not produce the desired performance. The United States Army, by far the aerial port's largest customer, wants "factory to foxhole" visibility over its cargo. They have taken great strides in developing RFID systems to provide this visibility. Civilian companies have also recognized the great potential RFID systems offer to streamline operations and improve efficiency. Although there are many, many differences between civilian and military logistical operations and the environments that they operate in, there are enough similarities that lessons can be learned from the successful companies who have implemented effective RFID systems. Chapter IV examined innovations using RFID technology in three specific areas that aerial ports face challenges: cargo yard and warehouse management, paperwork, and cargo processing.

Many civilian companies and military organizations have successfully used RFID technology to improve cargo yard and warehouse management. Perhaps the most innovative is International Paper. Their Warehouse Tracking System uses RFID tags to pinpoint the location of an individual roll of paper in their huge warehouse. RFID interrogators communicate with the tags and transmit the exact location to the worker on a forklift. The United States Army used RFID tags to manage cargo moving through logistical nodes on the way to support Operation JOINT ENDEAVOR. The British military's RFID system found a lost tank tread, avoiding over $3 million in costs. The Port of Singapore and the European Combined Terminal in Rotterdam have successfully implemented RFID systems to manage their cargo yards. Efficiencies these systems develop have resulted in improved throughput and increased production rates.

Many civilian companies who ship a great deal of cargo recognized the potential time and cost savings RFID systems bring in paperwork reduction. Old Dominion Truck Lines installed RFID interrogators on the doors of their warehouses. These interrogators compare information from passing tagged cargo with an electronic manifest for the truck being loaded. Loading errors are quickly identified and prevented and the electronic manifest is forwarded to the next warehouse via internet. This paperless manifest system has improved loading accuracy and reduced the number of workers required to double check loaded trucks before their departure. Chevrolet's Red Light, Green Light system electronically stamps departure time and shipping information on outbound tagged items. The United States Army has achieved a 98% accuracy rate and significantly reduced issue and receiving times from its Automated Manifest System. Many seaports have used their RFID systems to generate electronic customs forms from data read from individual tags, shortening processing times and increasing yard throughput.

Civilian companies and military organizations have realized tremendous improvements in cargo processing efficiency by using RFID systems. Companies like Caterpillar and Old Dominion have had significant reductions in cargo processing times because of RFID system efficiencies. Xerox and Chevrolet used RFID systems to improve shipping accuracy, saving their respective companies money through elimination of reshipping costs and lost time from straightening out shipping errors. Unilever increased warehouse productivity by implementing an RFID system. Cargo processing time was reduced 20% with a 66% reduction in the manpower requirement. Motorola's system put RFID tags on their semiconductor chip carriers to allow "hands free" tracking throughout the manufacturing process. As a side benefit, this system allows the company to identify bottlenecks and inefficient use of equipment. Finally, airports have begun using RFID tags to route passenger baggage. Their RFID systems dramatically improved read rates from the previous automatic bar code readers, significantly reducing the lost baggage rate and the requirement for manually routing baggage.

Answering the Research Question

This section will attempt to answer the research question posed in Chapter I. The author will apply proven RFID system strengths and anecdotal success stories from the civilian world and other areas of the DoD to propose solutions for the three common challenges that the average aerial port faces.

Overcoming cargo yard and warehouse management challenges

There are two specific ways RFID technology can help aerial ports overcome the challenge of cargo yard and warehouse management. The first way is by reducing the time and effort expended in finding a specific cargo pallet in the cargo yard or warehouse. Each cargo pallet in an aerial port's yard should be fitted with an RFID tag containing identification information. Drawing from the demonstrated successes of both the European Combined Terminal and the Port of Singapore, RFID interrogators should be distributed in a grid pattern throughout the cargo yard and warehouse. This distribution will form a natural grid using an X, Y coordinate system, meeting the AMCI 24-101 Volume 11 requirement for the establishment of a cargo storage system. The RFID interrogators can be networked together and tied to a central computer database.

Directing port personnel to the correct pallet can be as simple as a radio call from the warehouse manager who could pass along the X, Y coordinates of the correct pallet. The Air Force should investigate the feasibility of a wireless system much like the RFID system at International Paper. This wireless system would allow the port workers to query specific pallet locations right from their forklifts and receive precise directions to the subject cargo pallet.

RFID technology can also provide solutions for the elimination of the need for manual cargo pallet inventories. The same network of RFID interrogators used to locate a pallet can allow yard and warehouse managers to query tagged pallets in the entire area. This technique of electronic inventory would provide the manager with real-time inventory information on every tagged item in a matter of mere seconds. This is a clear time saver when compared to the several man hours required to inventory large cargo yards. The electronic inventory also eliminates the possibility of human error from the misreading of pallet information. One consideration, however, is that too many interrogations reduce the life of the RFID tag's internal battery. Procedures would have to be developed to optimize the collection of yard inventory information while minimizing the battery drain from excessive interrogations.

A future consideration for study would be to determine the feasibility of affixing passive tags to individual cargo items on each pallet while applying active tags to the pallet itself. Technology is available today that would overcome clogging the computer system from the mass of data collected from an interrogation of thousands of passive RFID tags in a cargo yard. This use of RFID technology would provide the customer with cargo movement information down to the item level. Obviously, this combination RFID system holds much promise for future logistics supply chain management.

Overcoming Paperwork Challenges

There are three ways which RFID technology can help aerial ports overcome paperwork challenges. This first way is through an almost total elimination of the need for accompanying paperwork on each cargo pallet. RFID tags have an internal memory storage capacity that makes them ideal for cargo data storage. Data such as Transportation Control Numbers, special handling instructions, destination information, customer information, and a log of passage through specific logistic nodes, can be written onto the tags by the customer, the aerial ports, or RFID interrogators. There would still be a need in the near future to print this cargo paperwork out when the final destination is an austere airfield with no RFID capability. Also, bar codes should continue to be used as a backup until the RFID system throughout the Air Force as a whole is more robust. As RFID systems are more fully developed and their capabilities more fully exploited, there may come a day when there will be global RFID coverage with the customer having total asset visibility of his cargo.

With the elimination of the need for accompanying paperwork on cargo pallets comes the side benefit of the elimination of the problem of lost paperwork. Cargo pallets entering an aerial port will have their RFID tags interrogated and their data downloaded to the cargo tracking computer system. There will be no more need for port personnel to inspect a cargo pallet's paperwork. Better yet, there will be no need for these personnel to expend valuable time tracking down cargo information on a pallet with lost or unreadable paperwork. Again, the inherent internal memory capabilities of RFID tags would help overcome these paperwork challenges.

Another way RFID technology can help overcome paperwork challenges is in the area of electronic forms. Much like the RFID system at the Port of Singapore, aerial ports can download required information from specific cargo pallets. This information can be automatically transferred to a wide range of electronic forms. This use of RFID technology can be used to significantly streamline the processing time for customs and other required paperwork, allowing faster cargo processing times and eliminating the potential for human error during paperwork generation. A revision of business processes is the next logical step with the eventual elimination of the requirement for paper copies of required forms being the goal.

RFID technology could also be used to generate electronic manifests for outbound aircraft. Like the RFID system at Old Dominion, electronic manifests could be created as cargo pallets pass interrogators while departing the yard for aircraft loading. This electronic manifest, once verified by warehouse managers, could then be sent via the Global Air Transportation Execution System (GATES) to the next destination. At the next aerial port, this electronic manifest would then be compared to the RFID interrogations of the cargo actually being downloaded. This use of RFID technology would eliminate paper manifests and the need for multiple workers to compare manifests with the actual cargo load.

Overcoming Cargo Processing Challenges

The last aerial port challenge RFID technology can help overcome is cargo processing. RFID can help eliminate the need for an aerial port worker to scan in each individual item on a cargo pallet during processing. Although bar code systems have shortened the average processing time to only 5 minutes per pallet, this time can quickly add up when large numbers of cargo pallets are delivered at once. The stand-off, automatic identification ability of RFID tags makes their use in cargo processing ideal. Cargo pallets can be taken by an RFID interrogator on the way in from the flightline and each pallet's tag can be quickly read and their data inputted into GATES. Old Dominion's RFID system has shown how effective a system like this can be. By the time the aircraft loader carrying the pallets reaches the aerial port building, warehouse managers can already have dispensation information for each and every pallet available to the workers. Pallets requiring break down can be quickly identified and workers assigned to the task immediately. Cargo pallets going out into the yard for future shipment can have forklifts standing by to take them immediately away. The RFID grid system that helps with pallet inventory would guide the forklift to a specific location for each pallet. This RFID system would significantly increase the amount of cargo throughput in a typical aerial port.

Another area where RFID technology could improve cargo processing is in cargo load accuracy. Patterned after the RFID systems used at Xerox and the Red Light, Green Light system at Chevrolet, aerial ports would install interrogators onto the loading dock doors. Data from RFID tags on each pallet going out the door would be compared with electronic manifests. An alarm would sound if an incorrect pallet passes by alerting nearby workers. The benefit of this application of RFID technology is a reduction in the requirement for human load verification. Another benefit is the elimination of "short" shipments and "over" shipments. Aerial ports could avoid costly special shipments to get cargo to their correct destinations.

Like the experience Motorola had with their system, the use of an effective RFID system in cargo processing could help Air Force leadership identify bottlenecks and choke points all along the logistics supply chain. By analyzing RFID tag information, it would be fairly obvious to supply chain managers to determine where a cargo pallet spent an excessive amount of time during its travel to the theater. If data from other tags corroborates this finding, more resources could be devoted to the bottleneck to improve cargo throughput rates.

Conclusion

Based on the author's analysis of the strengths and weaknesses of RFID technology as compared to bar code technology, and the success stories of both civilian and military organizations, it is obvious that it is RFID technology that holds the most promise for overcoming the common challenges facing Air Force aerial ports. Based on the successes of organizations that have adopted and used a robust RFID system, the benefits outweigh the costs. From Fed Ex's 10-fold return on its Information Technology investment to the British military's recovery of more than half of the system cost with one transaction, the Air Force should invest in a robust and well-integrated RFID system for all of its aerial ports.

As future study, there should be an investigation into the possibility of a combination active/passive RFID tag system. Perhaps passive RFID tags could be affixed to individual items. These tags would contain only Transportation Control Numbers, with the cargo pallet receiving an active tag containing more detailed information. This set up would resemble the current bar code system, the difference being the elimination of the need for individual scanning for each item. The different applications and possibilities are almost endless. As RFID tag technology develops, the advantage active tags enjoy over passive tag narrows. In the future it may be more advantageous and cheaper to go with a strictly passive RFID tag system.

Lastly, as with any significant investment in a new system, an organization should look first at its business processes. During the evaluation of the Logistics Automatic Identification Technology (AIT) Operational Prototype, inspectors noted that new systems were most effective when applied to reengineered processes (Department of Defense Logistics AIT Office, 1999:A79). Otherwise, an organization merely "paves over a cow path." Before the Air Force invests in an integrated, robust RFID system for its aerial ports, it should examine and redefine the business processes of these aerial ports. This process evaluation will ensure the most effective use of this highly promising technology…Radio Frequency Identification.

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Vita

Major Stephen P. Ritter was born in Newport News, Virginia. After graduating in the top 10 percent of his high school class, he attended The Citadel in Charleston, South Carolina. He graduated with departmental honors with a Bachelor of Science in Biology and as an Air Force ROTC Distinguished Graduate. On May 15, 1990, he was commissioned as a Second Lieutenant in the United States Air Force.

In his first assignment, he served as an Aircraft Maintenance and Munitions Officer at Altus AFB, Oklahoma. In 1994, he entered Specialized Undergraduate Pilot Training at Laughlin AFB, Texas. After graduation, he attended C-17 copilot initial qualification training at Altus AFB, Oklahoma, and was assigned to Charleston AFB, South Carolina. After upgrading to Instructor Pilot, Major Ritter was assigned as an instructor at the C-17 Combat Crew Training School at Altus AFB, Oklahoma in 1999.

Major Ritter was selected for the AFIT-sponsored Advanced Study of Air Mobility class of 2004. Upon graduation, he will be assigned to Headquarters United States Air Forces in Europe at Ramstein Air Base, Germany.

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14. ABSTRACT
Air Force aerial ports face three common challenges during these days of high operations tempo: cargo yard and warehouse management, paperwork, and cargo processing. To attempt to do these effectively and efficiently is, in the least, manpower intensive and very difficult with existing systems.

Radio frequency identification and bar code technology have many characteristics that could help streamline operations in an aerial port. Each have strengths and weaknesses, but it is Radio Frequency Identification Technology that offers the most to aerial port operations and, specifically, the three specific challenges discussed in this paper.

This case study examines specific Radio Frequency Identification technology success stories in the civilian world and attempts to apply these basic concepts to propose possible solutions to the common aerial port challenges.

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