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Esser, Lee E. ***Bar Code Technologies' Time Saving Effect on Company Inventories***

Abstract

This research paper examines the use of bar code scanners to manage and track equipment to the company level in the U.S. Army. Time to inventory equipment each month needs to be reduced by at least 50%. Several tests were performed in this study to assess time advantage of using barcodes. It is concluded that the research results show that bar code scanners are 68% more efficient and over three times faster than the current methods used to inventory a company. The results confirm that efficient and accurate means are currently available to help reduce the monthly burden a company commander experiences during inventories. Implementation of the bar code scanners to the company level would be a great asset, and provide commanders with more time needed for training.

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To my wife and our three beautiful children, your career and time sacrifices the last three years have not gone unnoticed. I cannot thank you enough!

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Chapter I: Introduction

Over the past several years, the Army has struggled to find innovative and efficient ways to manage and track equipment. Recently, the Army has been able to take advantage of some of the advances that the commercial sector has made in database and Web-based applications. As the Army moves towards a paperless organization, new technologies will allow the Army to become more effective and efficient in its supply inventory methods (Office of the Assistant Secretary of the Army for Installations and Environment [ASA (I&E)], 2009).

In 2001, a new software package called Property Book Unit Supply Enhanced (PBUSE) was introduced and ready for Army-wide operation. The PBUSE software was designed specifically to replace the Standard Property Book System-Redesign (SPBS–R) in garrison and tactical environments. PBUSE uses a centralized Web and database server to securely share and store its logistic information.

Each month, every unit in the United States Army, whether deployed or in garrison, is required to perform a 10% inventory of its total equipment. In addition to this 10% inventory, all units must perform a 100% sensitive item and Controlled Cryptographic Item (CCI) inventory of equipment in their units. The PBUSE software, along with the unit supply sergeant, will print off a paper checklist of all items to be inventoried each month. That information is then handed off to the company commander for action and signature no later than the end of each month. In addition, a company change of command requires a 100% inventory of the company by both the out-going and in-coming commanders.

Inventories are a difficult and time consuming process each month. Personnel can spend hours searching for equipment that had been turned in for maintenance, or broken electronic cards that had been swapped out for working ones with different serial numbers. Unit training and combat missions can come to a screeching halt when sensitive items like a weapon or crypto

device are missing or unable to be tracked via a hand receipt. Valuable training time is taken away from the commanders and their soldiers each month so that these inventories can be completed. Some units, such as a Signal Company, may have over 300 or more items to inventory each month as a result of the Sensitive and CCI inventory requirements the Army requires each month.

Figure 1. PBUSE Sensitive Items Screen Shot. Reprinted from Sensitive Item Inventory Listing. From PBUSE, n.d., Retrieved May 1, 2012, from https://pbuse.lee.army.mil. Courtesy of U.S. Army PBUSE.

Technology has improved over the last decade, and numerous advances have been made in logistic tracking that would allow this process to become much more efficient and less time. Technologies that worked in the past may not be effective and efficient enough for today's Army needs. As the technology has improved and the implementation has become more common place, overall cost for these technologies has reduced as well. The time and cost savings now make bar code technology a viable solution to equipment tracking down to the company level in the Army. The advancement in bar code technology alone offers a venue for great improvement

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Technology has improved over the last decade, and numerous advances have been made in logistic tracking that would allow this process to become much more efficient and less time. Technologies that worked in the past may not be effective and efficient enough for today's Army needs. As the technology has improved and the implementation has become more common place, overall cost for these technologies has reduced as well. The time and cost savings now make bar code technology a viable solution to equipment tracking down to the company level in the Army. The advancement in bar code technology alone offers a venue for great improvement

in time and effort needed to track equipment that is spread over an organization with 1.3 million plus employees in over 148 countries worldwide (Department of Defense [DoD], 2010).

Implementing bar code software and trackers into a companies' sensitive and CCI equipment could help drastically improve the total time needed for a company to inventory its equipment each month, leading to more overall time for training and more accurate accountability down to the lowest levels.

Statement of the Problem

Current technology used to inventory equipment in a U.S. Army Company requires an average of four days for company soldiers to perform and is not 100% accurate. Time to inventory equipment each month needs to be reduced by at least 50%.

Purpose of the Study

This study reviews current automatic identification technologies (AITs) available, specifically bar code scanning, to inventory equipment at the company level of the United States Army. Implementing bar code technology into United States Army company inventories would allow more time each month for additional training and more accurate overall accountability during physical inventories and audits. Bar code scanning provides an accurate, hands-free data capture that helps support today's warfighter. The goal of this study is to demonstrate the efficiency of bar code scanning, show how the initial startup/investment cost would be beneficial to the company's time and determine a potential increase percentage in time efficiency using the new method. The study also shows the accuracy of the bar code technology available.

Assumptions of the Study

The assumptions of this study are:

1. The U.S. Army will continue to use the current supply inventory requirements for the duration of the project.

2. Methods used to perform monthly inventories are similar for all United States Army companies.
3. Company commanders are not satisfied with the current time requirements and accuracy of monthly inventories.
4. Bar code technology meets the current automation security requirements set forth by the Department of Defense (DoD) and the United States Army.

Definition of Terms

Barcode. An optical machine-readable representation of data, which shows certain data on certain products. Originally, barcodes represented data in the width (lines) and the spacing of parallel lines, and may be referred to as linear or one dimensional barcodes or symbologies.

Communications Security (COMSEC) equipment. COMSEC equipment, including CCI, which is designed to provide security for telecommunications by converting information to a form unintelligible to unauthorized elements and by reconverting such information to its original form for authorized recipients. This includes equipment designed to aid in, or which is essential part of the conversion process. (AR 25-12; 14 Aug 1992, pg 9.)

Controlled Cryptographic Item (CCI). An unclassified COMSEC equipment, assembly or component which embodies classified cryptographic logic and is approved by NSA for safeguarding classified information or authenticating identification friend or foe signals. (DA Pam 25-380-2; 10 Jan 1991, pg 9.)

Property Book Unit Supply Enhanced (PBUSE). An Enterprise Data system registered in APMS with a criticality assignment of "mission essential" owned by PMLIS. Users perform transactions via a web browser on the PBUSE system to access one of several Army servers to perform supply, logistics, and property book actions.

Sensitive item. Those items identified on the FEDLOG with a controlled inventory item code of 1 through 6, 8, 9, $, N, P, Q, R, or Y.

Takt time. The maximum time per unit allowed to produce a product in order to meet demand.

U.S. Army company. Typically the smallest Army element to be given a designation and affiliation with higher headquarters at battalion and brigade level. (Retrieved on 26 June 2010 from www.usmilitary.about.com/od/army)

Limitations of the Study

The limitations of this study are:

1. Research is limited to National Guard combat arms companies located in Northwestern Wisconsin and active duty companies located in Fort Leavenworth, Kansas.
2. Testing will be done only on 10% and sensitive items inventories at the company level, not an entire command inventory.
3. Limited funds will determine what equipment and software can be used for bar code scanning research.
4. Size of the test is limited to a company element. Nothing smaller (platoon) or larger (battalion) will be tested.

Chapter II: Literature Review

The following literature discusses some lean principles used to inventory effectively and efficiently, current methods used to inventory large companies, and bar code scanning and its current uses.

Look at the current methods used for supply inventory in any successful company in today's society and some common trends start to emerge. Successful companies now tend to perform business on a global level; with buildings, equipment and personnel all over the world. To effectively and efficiently manage these corporations, command and control of their inventories must be accurately maintained and updated in real-time twenty four hours a day, seven days a week.

Today's companies are using technology and lean practices to constantly look for more efficient methods to manage their products (Deiters, 2007). When companies need to manage millions of pieces of equipment they look for methods that are both timely and accurate. Company operations and productions cannot afford to wait hours or days for updated inventory of their equipment. Currently, one of those preferred methods is bar code scanning. Why are these current methods used? What lean principles can help? And, most importantly, how can bar code scanning make these companies more successful?

Lean Principles

There are several lean tools and methods used to help companies work effectively and efficiently. Lean tools like takt time, value stream mapping, 5 S's (Sort, Set in Order, Shine, Standardize, and Sustain) and the 7 Types of Waste can help companies locate inefficiencies and develop methods for improvement. The overall goal of applying lean principles to any organization would be to streamline work effectively and efficiently with whatever resources you have at your current disposal (Strouse, 2008). "It's a proven fact that lean manufacturing

principles can be applied to transactional or administrative processes" (Deiters, 2007, p. 42). Taking those concepts and applying them to the inventory process will help improve system performance (Gibson, 2007). Lean principles can be applied to a plethora of areas in most companies. Methods to reduce movement of inventory, organize parts storage, quicken assembly times, reduce unnecessary steps in assembly or decrease error proficiency are all areas where lean principles can be applied. The bottom line is that lean processes can help reduce (errors, time, inventory, and steps) and increase (assembly, production, profit, and accuracy). An example of a lean principle at a company could be as simple as moving bins of parts off the ground to waist level to reduce the movement of workers assembling parts on an assembly line. Lean is a process that aims to transform a company, unit or culture into one that seeks to reduce waste in all operations (Deiters, 2007). When companies apply lean principles to supply fundamentals they can be used to "simplify processes, eliminate waste, and improve overall effectiveness" (Gibson, 2007, p. 48).

7 Types of waste. The 7 Types of Waste that are crucial in the manufacturing process are overproduction, correction, movement of material, motion, waiting, inventory and processing (Liker, 2004). When companies look to improve their bottom line, they look to reduce their waste. Waste can do more than hurting a company financially. Waste reduces the overall supply chain performance (Gibson, 2007). Inventory and correction are the key elements of waste that effect inventory efficiency. Poor visibility of inventory throughout the system and incorrect equipment locations and statuses are common wastes in the inventory process. The benefits of reliable inventory information "enables managers to monitor the status and availability of inbound replenishment items accurately" (Gibson, 2007, p. 45).

Current Methods of Inventory

Searching the web provides numerous methods and software programs on the market today that companies can use to track their inventory. Three of the most common methods are bar code scanning, radio frequency identification (RFID), and global positioning systems (GPS). The Warehouse Management System (WMS) at Radiator Specialty Company uses bar code scanning to reduce their inventory, be more accurate in shipments and be more productive with its people (Knill, 1996). These methods have proven their value over the years by timely and accurate maintenance of inventories. Bar code scanning is still the preferred method of tracking grocery store inventory and pricing. Several successful large corporations, like Wal-Mart, are using a combination of bar codes, RFID tags, and GPS's to manage their inventories today. By using a combination of methods the corporations can track inventory from initial assembly through the shipping process and final delivery.

Current AITs that are implemented today in the Department of Defense combine software with web-based applications to provide tracking reports and maps. The ability to achieve "real time asset visibility" is the goal of the United States Transportation Command, the lead proponent for AIT technology in the DoD. RFTrack software and Radio Frequency In-Transit Visibility (RF-ITV) provide that combination of tracking and global positioning to maintain accurate accountability. The integration of these initiatives into the Army Battle Command Systems (ABCS) provides the link between commercial off the shelf (COTS) products used for tracking and DoD systems such as the Army's Battle Command Sustainment Support System (BCS3).

Bar Code Scanning

Universal Product Code (UPC) is the most recognizable use of bar code scanning throughout the world. UPC is used in a majority of all retail company sales. Anyone who has been to a grocery store checkout knows the value in using UPC bar code scanning (see Figure 2).

Figure 2. Bar Code 39 used in the United States Military. Reprinted from Bar Code 39, In Nationwide Bar Code, n.d., Retrieved May 1, 2012, from http://www.nationwidebarcode.com/?s=code+39. Reprinted with permission.

Bar code scanning is a relatively simple concept. Wray (2006) states the "visual Morse code" (p. 58) is simply made up of bars and spaces with two widths – wide and narrow.

Current uses. Some of the latest bar code technology involves embedding scanning devices into wireless equipment. This allows any mobile device such as a cell phone, PDA or pager to perform bar code scanning (Demers, 2000). New technology will allow miniature bar codes "Web codes" to be used to inform consumers about the product through a web server database. This will allow anyone with a mobile device with web access to lookup specific data about a product right there in the store or warehouse (see Figure 3).

Figure 3. Quick Response (QR) Bar Code. Courtesy of Lee Esser.

The combination of wireless bar code scanning equipment with radio frequency data transmission is an application started in the late 1990's and still currently used in BMW's

manufacturing plants (Harris, 1999). Even the latest bar code technologies are still very affordable; currently costing $.05 (U.S.) a piece to implement a barcode (Boeck, 2007). The explosion of individuals with smart phones today also allows an organization to implement bar codes into their inventory process without additional startup costs for code readers or software.

Reliability. One of the great features of bar code scanning in the industry is its reliability. "Bar code scanning has eliminated picking errors due to mis-keying" (Knill, 1996, p. 8). According to an article in EBSCOhost, bar codes are virtually error-free. A manually entered item takes 4 to 6 seconds to enter and has 1 error per 300 characters while bar code scanning takes 1 to 2 seconds to enter and has 1 error per 10 million characters (Wray, 2006). Processing and implementation of bar code scanning allows two things – lightning-fast data collection and nearly zero errors (Wray, 2006). Early 1970 and 1980 issues with durability and quality have all been fixed, making the application viable in almost any environment the Army occupies today.

Speed comparison. Bar code scanning is a fast and accurate method available to transform any complex inventory into a manageable level. The University of Arkansas transformed its library of over 50,000 volumes to bar code in ten days (Lennertz & Conway, 1997). According to Jim Rubendall, Vice President of Management Information Services, "Our people used to spend as much as 20 percent to 25 percent of their time looking for a product; that problem has virtually gone away (Knill, 2006, p. 67). Enabling a company to manage thousands of items of inventory in a timely manner allows for more efficient and reliable data analysis at the managerial level.

These can be summarized as follows: Inventory methods in global companies have continued to improve with advancements in technology. Bar code scanning has been used for over 30 years and has proven its sustainability, reliability and accuracy during that time. These three characteristics make implementation of bar code scanning into the Army inventory system

a potentially huge gain. These technologies, along with lean principles, provide the tools needed for any company to manage and maintain efficient inventories of equipment anywhere their business takes them.

Chapter III: Methodology

Current technology used to inventory equipment in a U.S. Army Company requires an average of four days for company soldiers to perform and is not 100% accurate. Bar code technology could help improve the time and accuracy of physical inventories done each month at the company level. This chapter discusses the subject selection and description, the data required, methods used to collect that data and data analysis.

Subject Selection and Description

The sample for this research was taken from two National Guard companies in northwestern Wisconsin and one company in Fort Leavenworth, Kansas. Both National Guard and active duty companies were selected for this project because of their unique inventory schedules to meet their monthly requirements. These company locations allowed for direct observation and hands on evaluations. Each company has one commander who conducts his or her inventories each month, but the process involves the whole company which is 100+ soldiers. In addition to these three companies, research was done using 12 future Army second lieutenants at the University of Wisconsin – Stout. These cadets were selected because they are currently enrolled in the military science department at the university and are preparing to sign for their first equipment inventory after graduation. Cadets were observed in a classroom environment using lean principles and scanning techniques for comparison analysis versus current methods used to inventory equipment at the company level.

Data Required

Using qualitative data from similar research on bar code scanning and quantitative data from the companies and 12 cadets, data analysis was performed. Research on the three companies determined the current time needed to conduct a monthly 10% and CCI inventory along with the accuracy of the reports. Over a two month timeframe, the company commanders

were observed as they performed their monthly inventories. The total time needed to complete the inventories, to include follow up adjustment paperwork for any errors in the inventory report, were calculated and averaged among the three units. This provided a baseline for a mean time and accuracy percentage for the monthly inventories. The future second lieutenants were given a variety of hands on performance tests to calculate time and accuracy data for inventorying. The cadets validated or confirmed hypothesis that related to inventory success or failure with respect to time and accuracy. All performance tests were given twice to insure validity of the data.

Data Collection Methods

Unobtrusive measures were used to gather data from the three companies. Company commanders performed their normal inventory procedures while data was collected on their methods (such as time of day inventories were conducted), organization (were items prepared ahead of time and laid out in sequential order) and procedures followed (did the company commanders look at each items serial number or have someone call off the numbers). A total time for inventory was determined based on the day the inventory process started until the day it was completed. After this observation period, the data was analyzed to determine any similar techniques or procedures that were either more or less effective between the three companies or single acts there were more or less effective than others.

The purpose for conducting experimental research with the cadets at UW-Stout was to determine time and accuracy data needed for comparison. Cadets were given three tests using the 5s (sort, set in order, shine, standardize and sustain) method of lean manufacturing. Cadets were given 49 numbers to find in correct sequence on an 8 ½ in. by 11 in. paper. Each time the test was given, a stopwatch was used to record the total time needed for the cadet to find all 49 numbers. The first test was given with no sorting, order or standardization to the 49 numbers. The numbers were placed randomly over the sheet of paper in any order, organization or axis.

The second test had the numbers sorted and the third test had the numbers sorted and standardized. Total times were then averaged and compared using descriptive statistics to confirm the lean techniques used to inventory (numbers in this case) were more efficient than current techniques used to inventory companies today.

Once the three tests were complete, the subjects were asked to inventory 49 items with six digit serial numbers in the same fashion as the first three tests. The cadets were then given a task of inventorying 50 items with a six digit serial number using only pen and paper. A list of the 50 items serial numbers were printed in ascending order on three sheets of paper. The cadet was given the three sheets and told to inventory the items as fast as he or she could. The total time needed was recorded with a stopwatch. The cadet was then told to perform the same inventory as quickly and as accurately as possible and the total time was recorded. The last test the cadets were given was to complete the same steps as above but with a bar code scanner (see Figure 4).

Figure 4. Datalogic Power Scan used in research experiments. Reprinted from Datalogic Power Scanner. From Google, n.d., Retrieved May 1, 2012, from http://www.adc.datalogic.com/en/bar-code/industrial-handhelds/powerscan-pd8300_psc_prd184_1.html. Reprinted with permission.

The total time was calculated for this using a stopwatch as well. This data allowed for a comparison between current methods used to inventory versus bar code scanner methods.

Based on the research and data collected from the first three tests, the subjects were then given the freedom to move, change or rearrange the 50 items to perform the inventory as fast and

accurately as possible. The cadets were observed in this stage and data was collected from the observations. Data in this step was focused on lean methods and techniques used to make the bar code scanning inventory the most efficient and accurate.

Data analysis. Several methods of data analysis were used during this project. Descriptive statistics were used to compare mean and range data for hand versus bar code scanning inventories. Standard deviation was determined for both groups and overall efficiency percentages calculated comparing the two methods. Analysis was done with a focus on time and accuracy, while trying to eliminate effects of all outside variables as possible using experimental design and observation.

Limitations

The study is based on data from a small population overall for testing with only three units and twelve cadets. It is also limited to one scanner and 50 items maximum per scanning sequence.

Data was compared using the two different methods (paper versus bar code scanner) for overall efficiency and accuracy. Based on the research results, recommendations were made to the three companies that detailed more efficient methods, organization techniques and procedures to implement for the most efficient and accurate use of inventory time each month. The 7 types of waste were discussed with emphasis on an efficient inventory procedure. The 5 S's were also discussed with focus on the use of sorting and setting in order. Recommendations on how to layout the inventory efficiently such as placing items in serial number order and flipping all items so that the bar code scanner was on top. Commanders and cadets were able to experience the time savings from the scanner when implemented properly into the inventory.

Chapter IV: Results

Bar code scanning is an efficient means to inventory equipment at the company level of the United States Army. Implementing bar code technology into United States Army company inventories would allow more time for additional training and more accurate overall accountability during physical inventories and audits. The goal of this study is to demonstrate how efficient and beneficial bar code scanning can be for inventorying at the company level. Results after the inventory observations and scanning tests show an average time and efficiency increase gained by using the scanners. This chapter will focus on the data results from observations and experiments done with and without bar code scanners. The numbers gained in the test will lead to the "so what" explanations and hypotheses for using the scanners.

Item Analysis

The first test results found during the 5 S's experiment are shown in Table 1. The test was designed to determine how sorting, setting in order and standardization all help increase the efficiency of inventorying. The tests performed were organized in the following manner:

- 1st Test: No organization, sorting or standardization was given to any of the numbers on the sheet
- 2nd Test: Numbers were placed numerically into groups, but not organized or standardized within the groups
- 3rd Test: Numbers were sorted, organized, and standardized within each group

The cadets showed great overall improvement from the 1st Test to the 3rd Test.

Table 1

Cadet 5 S's Test Results

	1st Test	2nd Test	3rd Test
1	480	184	63
2	380	128	42
3	307	125	41
4	723	276	67
5	441	151	48
6	343	132	40
7	382	124	51
8	291	115	37
9	358	138	42
10	408	193	53
11	572	219	62
12	424	143	55

All times are in seconds

By using the 5 S's the cadets were able to improve their inventory of the 49 numbers from an initial mean of 7 minutes and 6 seconds down to 50 seconds by the 3rd Test. Table 2 shows how ordering and sorting the numbers not only reduced the overall time to inventory, but also the standard deviation for the entire group as well. This helped demonstrate how implementation of some lean principles into the inventory directly led to time savings.

Table 2

Cadet Summary of Results

	1st Test	2nd Test	3rd Test
Mean	426	161	50
Range	432	161	30
Fastest	291	115	37
Slowest	723	276	67
SD	121	48	10

The second test was designed to provide comparative data for inventorying with and without the bar code scanner. Lessons learned from the 5 S's test made the inventory with paper and pencil as efficient as possible, yet the average time to inventory all 50 items was 5 minutes

and 12 seconds. This compared to the average time of 1 minute and 39 seconds for the same 50 items with the bar code scanner shows how efficient the scanner can be when used to inventory. The scanner was 68% more efficient and over three times faster than the current method used to inventory a company in today's Army. The scanning was extremely reliable, with no errors in any of the tests completed. The data above helps validate the original theory that bar code scanners could greatly reduce the time a company commander spends each month conducting inventories. With a system over 50% faster than the current methods, the gains in a company commanders training schedule are exceptional. With an average of four days a month cut down to two days a month, a company commander could gain 24 days (1 month) of additional training in a year by implementing bar code scanning into monthly CCI and 10% inventories. With some companies in the Army having over 500 sensitive items, these could lead to days of extra training each month for soldiers and commanders once caught up in the process each month.

Chapter V: Discussion

Implementing bar code software and trackers into a companies' sensitive and CCI equipment could help drastically improve the total time needed for a company to inventory its equipment each month, leading to more overall time for training and more accurate accountability down to the lowest levels. The bottom line up front is that current technology used to inventory equipment in a U.S. Army Company is too long and not 100% accurate. Bar code scanners will reduce inventory time more than 50%. The process used to get to this outcome, conclusions from the research and data, along with current recommendations and future recommendations are provided in this chapter.

Limitations

Research was limited to only three companies and 12 future second lieutenants. Testing was only related to the monthly 10% and sensitive items inventories at the company level, not an entire command inventory. In addition, only one type of bar code scanner was used in the testing (Datalogic Power Scan).

Conclusions

Using bar code scanners at the company level could help alleviate some of the time constraints a company commander encounters each month during 10% and CCI inventories. Research data supports the feasibility of the bar code scanner to reduce the inventory time by over 50%. Testing showed that the bar code scanner was 68% more efficient and over three times faster than the current methods used to inventory a company. The scanning was extremely reliable, with no errors in any of the tests completed. The research supports the possibility of a better means to track equipment at the company level. A possibility to gain over a month of training time back each year for any company implementing bar code scanning make this an extremely promising option. Bar code scanners can become the gap filler needed to provide a

means of timely and accurate inventories to company commanders. Using lean principles and new technology could help solve the age old problem of too much training to accomplish and not enough time to get it done.

Recommendations

It is recommended that current leadership in the Army be aware of the time and cost benefit advantage to switching to bar code scanning for inventories at the company level. Smart phones and software applications can be used to test these results inexpensively until a permanent solution is implemented. The time savings of using lean principles and bar code technology during a commander's inventory can become very advantageous. It is recommended to the cadets the need to use all their time effectively and allow technology to help you in the process.

Recommendations for Future Research

It is recommended that the future research involves a much bigger test sample than this paper used. Future research needs to involve the Army logistics corps and its supply personnel. Research into different scanners and their durability, along with a means to attach a durable bar code onto military equipment is needed. Since starting this research, the United States Army has implemented a Command Maintenance Evaluation Training Team (COMET) to introduce AIT to the company level for supply. The COMET has started fielding bar code scanners that work in conjunction with the PBUSE system to units in Fort Campbell, Kentucky starting in February, 2012 (Vowell, 2011).

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