AUTOMATED ASSET INVENTORY SYSTEM

Final Report 580

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16. Abstract

This report was prepared for the Arizona Department of Transportation (ADOT), to explore options for implementation of a barcode inventory system to track fixed assets on an organization-wide basis. ADOT currently has no department-wide automated fixed asset inventory process nor does it use barcode or other types of technology to track fixed assets. ADOT currently relies on manual inventory methods to maintain their fixed asset information in their fixed asset accounting software.

Information on label and ID technologies, bar code hardware and scanning technologies, software applications, and a Pilot implementation are discussed.

Since the Pilot Implementation showed that an automated asset inventory system can reduce the amount of time needed to perform a physical inventory as well as increase the accuracy of the results, it is recommended that ADOT further study the automated technology in conjunction with one of the three implementation strategies presented in this report.

It is the author's opinion that Strategy Three, the implementation of moderate barcode technology and web or network based data collection, would best suit ADOT's infrastructure. It offers the benefits of both Browser Access as well as barcode technology without committing to a dedicated centralized inventory staff. To recap, Browser Access can be advantageous under a number of situations previously discussed in this report.

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SI (MODERN METRIC) CONVERSION FACTORS*

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
	AREA			
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
	VOLUME			
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: Volumes greater than 1000L shall be shown in m^3.			
	MASS			
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000lb)	0.907	megagrams (or “metric ton”)	mg (or “t”)
	TEMPERATURE (exact)			
$^{\circ}F$	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	$^{\circ}C$
	ILLUMINATION			
fc	foot candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
	FORCE AND PRESSURE OR STRESS			
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
	AREA			
mm^2	Square millimeters	0.0016	square inches	in^2
m^2	Square meters	10.764	square feet	ft^2
m^2	Square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	Square kilometers	0.386	square miles	mi^2
	VOLUME			
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	Cubic meters	35.315	cubic feet	ft^3
m^3	Cubic meters	1.308	cubic yards	yd^3
	MASS			
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (or “metric ton”)	1.102	short tons (2000lb)	T
	TEMPERATURE (exact)			
$^{\circ}C$	Celsius temperature	1.8C + 32	Fahrenheit temperature	$^{\circ}F$
	ILLUMINATION			
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
	FORCE AND PRESSURE OR STRESS			
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

TABLE OF CONTENTS

EXECUTIVE SUMMARY 1
KEY FINDINGS 1
KEY RECOMMENDATIONS 1
INTRODUCTION 3
BACKGROUND 3
SCOPE 3
METHODOLOGY 3
OVERVIEW 3
CURRENT ADOT FIXED ASSET INVENTORY PROCESS 5
INTRODUCTION 5
ON SITE INVENTORY OBSERVATION 6
TECHNOLOGY AND LITERATURE REVIEW 9
INTRODUCTION 9
LABEL AND ID TECHNOLOGY 9
BAR CODE AND RELATED HARDWARE 12
Introduction 12
Hardware Portability 12
Hardware Durability 13
Scanning Technologies 13
Auxiliary Data Entry 14
Radio Frequency Identification 14
Wireless Local Area Network 15
Summary of Hardware Requirements for Asset Inventory 16
PRE-PACKAGED AND SEMI-CUSTOM APPLICATIONS 17
Case Studies 17
Vendor Search 18
Browser Based Data Access 20
PILOT IMPLEMENTATION 21
SELECTION OF STRATEGY 21
SELECTION OF TECHNOLOGY FOR PILOT 25
DEPARTMENTAL CANDIDATES 26
PILOT IMPLEMENTATION FINDINGS 27
SAMPLE RESULTS 27
Estimated Annual Cost Benefit 28
Estimated Acquisition Cost for Hardware and Software 28
Estimated Annual Maintenance Expense and Life Expectancy 29
CONCLUSIONS AND RECOMMENDATIONS 31
INTRODUCTION 31
CONCLUSIONS 32
RECOMMENDATIONS 32
APPENDIX A 33

LIST OF TABLES

Table 1. On Site Observation Sample..... 7
Table 2. Vendor / Product Matrix..... 19
Table 3. Pilot Implementation Sample. 27
Table 4. Implementation Cost..... 29

GLOSSARY OF ACRONYMS

ADOT	Arizona Department of Transportation
ASTM	American Society for Testing and Materials
ATRC	Arizona Transportation Research Center
AMS	Accounting Management System
DoD	United States Department of Defense
FAA	Federal Aviation Administration
GIAI	Global Individual Asset Identifier
GRAI	Global Returnable Asset Identification
ID	Identification
IEEE	Institute of Electrical and Electronics Engineers
IRL	Interactive Reader Language
IT	Information Technology
JFMIP	Joint Financial Management Program
OS	Operating System
RFI	Request for Information
RFID	Radio Frequency Identification
TSA	Transportation Safety Administration
UID	Unique Identification Initiative
USB	Universal Serial Bus
VIN	Vehicle Identification Number
WEP	Wired Equivalent Privacy
WiFi	Wireless Fidelity
WLAN	Wireless Local Area Network

EXECUTIVE SUMMARY

This report was prepared for the Arizona Department of Transportation (ADOT), to explore options for implementation of a barcode inventory system to track fixed assets on an organization-wide basis.

ADOT currently has no department-wide automated fixed asset inventory process nor does it use barcode or other types of technology to track fixed assets on an organization-wide basis. ADOT currently relies on manual inventory methods to maintain their fixed asset information in their fixed asset accounting software.

Information on label and identification (ID) technologies, bar code hardware and scanning technologies, software applications, and a Pilot implementation are discussed.

Sample inventory time data was collected using the current ADOT fixed asset inventory process. Then, asset inventory software and hardware from selected manufacturers were procured for a pilot implementation. Another inventory was performed using the software and hardware and time data was again collected. The results were compared.

Lastly, conclusions and recommendations are provided.

KEY FINDINGS

- The Pilot Implementation showed that an automated asset inventory system can reduce the amount of time needed to perform a physical inventory as well as increase the accuracy of the results. However, it cannot be concluded that a full scale implementation of the technology will result in a cost savings.

- Because of ADOT's infrastructure, three different statewide implementation strategies were detailed. Each strategy had distinct advantages and disadvantages.

- The lack of academic journal articles and publicly available data point to a lack of systematic analysis of fixed assets inventories. However, case studies justify the use of barcode technology and have shown reduction in the time taken to conduct periodic asset inventories.

- The primary benefit that bar code hardware brings to an asset inventory is its portability. Newer technology has made this process easier and faster. There were additional observed benefits of the automation. Finally, with automation, future inventories will be easier to perform since existing asset tags will contain bar codes.

KEY RECOMMENDATIONS

- The Pilot Implementation showed that an automated asset inventory system can reduce the amount of time needed to perform a physical inventory as well as increase the accuracy of the results. It is recommended that ADOT further study the automated technology in conjunction with one of the three implementation strategies presented in this report.

- It is the author's opinion that Strategy Three, the implementation of moderate barcode technology and web or network based data collection, would best suit ADOT's infrastructure.

- A larger study incorporating the Pilot Results with web or network based data collection would provide additional key information required to justify the statewide implementation of an automated Asset Inventory System.

INTRODUCTION

BACKGROUND

This report was prepared for the Arizona Department of Transportation (ADOT) to explore options for implementation of a barcode inventory system to track fixed assets on an organization-wide basis.

In reference to this study, we are using the term to denote an inventory of durable, moveable property referred to as "capital assets and non-capital assets." Capital Assets are also referred to as "Fixed Assets."

ADOT currently has no department-wide automated fixed asset inventory collection method nor does it use barcode or other types of technology to track fixed assets on an organization-wide basis. ADOT currently relies on manual inventory methods to maintain their fixed asset information in their accounting management system (AMS) Advantage Accounting System Fixed Asset module database www.ams.com.

SCOPE

Funding for this research project was $9,800. Reviews of academic, government, and industry literature as well as Internet based research were conducted. As a follow-up to this study, a Pilot implementation is suggested to validate the cost savings estimated in this study.

METHODOLOGY

The Project Manager was John Semmens of the ADOT Arizona Transportation Research Center (ATRC). The Project Researcher was Andreas Schiffer of Bar|Scan, Inc.

The literature review included business association and company websites, government reports, industry publications, and publicly available data. Principal sources of study data include the Arizona Department of Transportation's Financial Management Services Section of the Transportation Services Group's policies and procedures as well as first hand inventory observation.

Primary online Literature searches used Google (www.google.com).

OVERVIEW

This report has eight sections:

- Executive Summary
- Introduction
- Current ADOT Fixed Asset Inventory Process
- Technology and Literature Review
- Pilot Implementation
- Pilot Implementation Findings
- Conclusions and Recommendations
- Appendix A: Product and Vendor Information

The Technology and Literature review section contains the most in-depth discussions of issues, including:

- Label and Identification Technology
- Bar Code and Related Hardware
- Pre-Packaged and Semi-Custom Applications

The Conclusions and Recommendations section makes suggestions for consideration and briefly discusses their costs and benefits.

CURRENT ADOT FIXED ASSET INVENTORY PROCESS

INTRODUCTION

ADOT currently has no department-wide automated fixed asset inventory collection method nor does it use barcode or other types of technology to track fixed assets on an organization-wide basis. ADOT currently relies on manual inventory methods to maintain their fixed asset information in their AMS Advantage Accounting System Fixed Asset module database www.ams.com.

The manual inventory method relies on traditional checking of items with paper-based physical inventory reports and validation of human readable asset labels. The ADOT labels do not contain barcode or other advanced technology. The labels are foil with pressure sensitive adhesive. When a label is damaged, the asset number is replaced with a manually stamped foil label with the same number. Due to the lack of label placement guidelines, labels are applied in a somewhat random fashion.

The inventories are carried out on an annual basis by each Organization within ADOT during a two-week window prior to the end of the fiscal year on June 30. There are approximately four to five hundred organizations responsible for a total of approximately 3,900 vehicles, 2,400 federally funded items, and several hundred other capital assets. The lower threshold of capital assets currently is set at $5,000.

In addition to capital assets, ADOT tracks approximately 20,000 non-capital assets, which consist primarily of Personal Computers with a lower threshold value of $1,000.

The data elements relevant to performing the physical inventory at this time are:

- A unique human readable serialized ID Tag
- Serial Number or Vehicle Identification Number (VIN) (when applicable)
- Item Description, Make, and Model
- Location as of last inventory (e.g., Room Number, City, other Organization)
- Revised Location (if necessary)

Inventory reports containing the data elements are provided by the Fixed Asset Manager to each Organization. When the Organization has completed the inventory, the reports are signed and dated. Lost items are identified on the report. An Avery brand colored sticker is provided for confirmation and is placed on the physical item during the inventory to verify that the inventory information was captured. The color of the sticker is changed from year to year since it is not required that the previous year's sticker be removed.

Because of the possible movement of assets during the physical inventory, the total lost and found items cannot be determined until all inventory reports containing transfers are returned to the Fixed Asset Manager, all results verified, and changes are keyed into the Fixed Asset software.

ON SITE INVENTORY OBSERVATION

The author performed an on site observation of the physical inventory process during the annual update on February 28, 2005, meeting with Theresa Simms, ADOT Transportation Services Group - General Accounting Administrator and Tanya Shearrow at 206 South 17th Avenue, Phoenix, AZ. The author then observed them performing the inventory of assets for the Organizations within their responsibility. This inventory was completed the same day.

Prior to the actual physical inventory, the data collection forms need to be produced. The process begins with printing and collating the forms for all Organizations. This preparation takes three to four persons approximately three to four hours in total. The forms are then distributed.

Each Organization receives an Interoffice Memo "Annual Inventory of Fixed Assets" which contains specific instructions on how to complete inventory. Attached to this is a roll of colored Avery brand dots for application to the asset to denote that it was inventoried as well as three forms as follows:

- "Lost or Stolen Equipment Report"
- "Inventory Add-ons"
- A computer generated list of assets for the Org known as an "Annual Inventory Sheet"

Table 1 on the following page is a chart of the observation result. The inventory time includes travel time within the building as well as the time required to complete the forms.

Table 1. On Site Observation Sample.

	On site observation sample	
Org	Time	Number
Code	(minutes rounded up)	of Assets
1114	17	19
1030	6	14
1124	5	6
1125	7	6
1121	3	9
1110	2	3
1113	5	5
1111	4	7
1101	3	5
1112	5	13
1021	1	2
1023	10	6
	68	95
	assets/min/team = 1.39	
	assets/min/per person = .695	

While ADOT is geographically disbursed and the above sample is not meant to be representative of all Organizations, it can be used to extrapolate an estimate of the man-hours required to collect the annual inventory.

Assuming the collection time for all non-vehicle assets at .695 assets per minute per person and vehicles at .3475 assets per minute (200% of non-vehicle assets), the total time is approximately 765.5 hours (22,600 assets at .695 assets per minute = 32,518 minutes plus 3,900 vehicles at .3475 assets per minute = 11,223 minutes) plus an additional 5% for follow-up time for a grand total of 765.5 estimated man hours. Ninety to ninety-five percent of the 2004 inventory forms were returned within the inventory timeframe.

In summary, an estimated 765.5 hours are spent performing the direct task of the current ADOT annual fixed asset physical inventory. This estimate is not based on a representative sample and has no statistical significance. However, we will use it as a benchmark for comparison to an automated inventory as discussed in the Pilot Implementation section of this report.

Once the inventory data has been collected, it must be verified and entered into the AMS Advantage Accounting System. This time is in addition to the direct task of the annual physical inventory. Unless an automated interface is built, this time would be the same for both this and the Pilot Implementation and therefore, is not factored into the comparison.

TECHNOLOGY AND LITERATURE REVIEW

INTRODUCTION

The term "barcode inventory system" is generic and encompasses a variety of different applications and industries. The term is commonly used in warehousing, logistics, and distribution; it can also be used in retail point-of-sale, manufacturing, and various service sector implementations. In each case, at its core, a "barcode inventory system" includes a measurable list of items or quantities and utilizes barcode technology in some fashion.

Barcode technology is a means of interfacing humans to data processing equipment; therefore, barcode technology cannot be utilized independent of data processing equipment. Commonly, the data processing equipment stores the results of a "barcode inventory system" in electronic form.

In reference to this study, we are using the term to denote an inventory of durable, moveable property referred to as "capital assets and non-capital assets." Capital Assets are also referred to as "Fixed Assets." Although Fixed Assets can also include a larger set of items such as Real Estate and Infrastructure, these are not included in the scope of this report. For purposes of this report, we will refer to "capital assets and non-capital assets" simply as "Assets."

According to the American Society for Testing and Materials (ASTM), in their Report E 2132-01 titled "Standard Practice for Physical Inventory of Durable Moveable Property," the "primary product of a physical inventory is a report identifying, at a minimum, which items were located and which were not."[1] Therefore, any technology that assists in meeting this goal at less than its incremental cost of implementation should be considered viable.

The components that make up a "barcode inventory system" are discussed individually in the next sections. Other technologies are also discussed.

LABEL AND ID TECHNOLOGY

For Assets, barcode technology typically involves the application of some kind of identification or label. These labels can be applied at any time during the life cycle of the Asset, even during its manufacture. Labeling an asset with a unique ID has traditionally been used as a mechanism to both easily identify an Asset and, to a lesser extent, deter theft or misuse of the Asset.

All companies that the author has worked with during the course of implementing asset inventory systems (several hundred Fortune 500 and government entities) have utilized serial, non-smart numbering schemes.

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[1] "Standard Practice for Physical Inventory of Durable, Moveable Property" *ASTM International* Designation E 2132-*01* Published February 2001 downloaded September 29, 2004 from www.astm.org Telephone confirmation with ASTM to use copyrighted text on September 29, 2004

The implementation of a new label standard called EAN.UCC Global Individual Asset Identifier (GIAI) has been in process over the last several years. The United States Department of Defense (DoD) was an early adopter. Other parties who have expressed interest are the Transportation Safety Administration (TSA) and the Federal Aviation Administration (FAA).

The standard consists of a sequential asset number to which a prefix is added to identify the company and another prefix to identify the label as a fixed asset label. To properly use the standard, the company must register with the Uniform Code Council www.uc-council.org and obtain its own unique company code.

The GIAI standard would be of benefit for any company or government entity that requires a totally unique asset number, or whose assets are located at non-company facilities, e.g., Government furnished property at a defense contractor's site.

Under the Unique Identification (UID) Initiative, the DoD has asked suppliers to include a unique identification on products supplied to the government by 2005 if they meet certain criteria (acquisition cost over $5000, mission critical, repairable, etc.).[2] Most of the initiative applies to radio frequency identification (RFID) but it also includes the GIAI standard as this is a subset of the UID.[3]

According to the Office of the Under Secretary of Defense for Acquisition Technology and Logistics http://www.acq.osd.mil/dpap/UID/equivalents.html:

"The commercial unique identifiers meeting these criteria that the Department recognizes as DoD UID equivalents are the:

- EAN.UCC Global Individual Asset Identifier (GIAI) for serially-managed assets,
- EAN.UCC Global Returnable Asset Identifier (GRAI) for returnable assets, and
- ISO Vehicle Identification Number (VIN) for vehicles."[4]

The acronym "UID" is not to be confused with The Joint Financial Management Program's (JFMIP) term "UID or Unique Item Identifier." JFMIP is a government body formed to improve financial management in the Federal Government. See http://wwww.jfmip.gov for more information on this subject.

It is the author's opinion that at this point in time, the GIAI standard, as it applied to meeting the requirements of UID, is not relevant to the asset numbering scheme for ADOT. According to ADOT Policies and Procedures FIN-11.02, ADOT's Assets are being controlled solely for internal financial reporting and tracking purposes.

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[2] http://www.acq.osd.mil/dpap/UID/ Office of the Under Secretary of Defense for Acquisition Technology and Logistics Defense Procurement and Acquisition Policy Site, accessed October 7, 2004

[3] http://www.line56.com/articles/default.asp?NewsID=5535 "DoD's RFID Update" by Demir Barlas, April 9, 2004, accessed October 7, 2004

[4] http://www.acq.osd.mil/dpap/UID/equivalents.html Defense Procurement and Acquisition Policy "Unique Identification (UID) Equivalents," accessed October 7, 2004

There are several key considerations in the utilization of identification labels for Assets. These are discussed individually below.

A. Label size, material, and adhesion method

For asset purposes, there are two ways to produce a label. First, a computer and printer or specialized bar code printer (on-site) can be used or preprinted labels can be obtained from an outside source. An onsite printer can be either fixed at a station or portable. For most label applications such as warehouse distribution and retail environments, it is common to produce labels on-site. For asset tracking, preprinted labels can be less expensive under many circumstances since they do not require the purchase of equipment and the associated cost of implementation, training, production, and label stock.

"The central question in determining whether preprinted labels will be more cost effective is do you know the data you want to print in advance? In most bar code applications, the symbol is just a license plate. It need only encode a unique serial number, either unique to the individual item or to the product line. The detailed information is then stored in a database under the unique serial number. In such an application, preprinted bar code fits."[5]

B. Label size, material, and adhesion method

Both preprinted and on-site printed labels can be produced on a number of printing systems and with a wide variety of materials. Common printing systems are Film Master/Printing Plate, Ion-Deposition, and Photocomposition. Many printers are Thermal Transfer, "A method of printing by which heat from the printhead melts ink from the ribbon onto media. The ink adheres to the media as it cools."[6]

For most asset applications, materials typically include polyester, foil, aluminum, and others. The adhesion method can include any combination of adhesive glue, rivets, screws or other mechanical fasteners. For indoor application at normal ambient temperatures, adhesives are the most commonly used adhesion method.[7]

C. Bar Code Symbology, identification type, and sequence

"A Barcode Symbology defines the technical details of a particular type of barcode: the width of the bars, character set, method of encoding, checksum specifications, etc."[8] Basically, a barcode symbology is the language of the label.

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[5] Russ Adams, Adams Communications. http://www.barcode-1.net/pub/russadam/preprint.html, accessed September 14, 2004

[6] http://www.intermec.com/eprise/main/Intermec/Content/About/GlossarySubpages/Glossary_ST?section=About, accessed September 14, 2004

[7] Metalcraft, Inc., 149 4th St. SWMason City, IA 50401, http://www.idplate.com/products/fixed_asset_products/, accessed October 7, 2004

[8] http://www.mecsw.com/specs/speclist.html, accessed March 30, 2005

Code 39 or Code 3 of 9 symbology is widely used for asset tracking because its character set can include both numbers (0-9) and upper case letters (A-Z). Its printing tolerances are also not as rigid as some other symbologies and therefore, can be printed on a wide variety of printers. It has been adopted by all major equipment manufacturers as the symbology to encode serial numbers and other information on the manufacturer's product labels. As a single dimensional label, it can also be read by most bar code devices.

For smaller item tracking, a 2-d (two dimensional) barcode can contain more information in a smaller label. The downsides include a smaller adhesive surface and fewer bar code devices that can read the label.

D. Additional information displayed on or embedded in label

Typically, this can include the owner's name, corporate logo or other artwork, a human readable version of the asset number, and a specific color or color band. Bar codes need not be printed as black on white as long as there is sufficient contrast for the bar code device to read the label. Some bar codes employ ink coatings to visually "hide" the bar code for security reasons. These labels can be scanned by using lasers of different spectrums than visible light.

Also, an RFID tag (transponder) can be embedded in the bar code label providing the capability to track the asset using both technologies.

BAR CODE AND RELATED HARDWARE

Introduction

Bar code hardware represents only a small portion of the total worldwide automated ID marketplace. Major manufacturers of bar code hardware doing business in the United States include: Intermec, HHP, Symbol Technologies, PSC, Sato, NCR, Zebra Technologies, and Datamax. Distribution channels include direct sales, partners, and resellers. The technology gains in this industry over the last twenty years have mirrored many of the gains seen in the Personal Computer industry. They include more portability, wireless connectivity, faster processing and memory, as well as standardization of operating system (OS) and programming languages.

Hardware Portability

The primary benefit that bar code hardware brings to an asset inventory is its portability. Data entry that had occurred at the end of the inventory process can now be done at the collection site. Historically, portable hardware had been batched and offered little real-time validation. Batch connectivity was the primary method to connecting to Microsoft DOS based computers or to mainframes via emulation. In the last few years, newer technology such as the universal serial bus (USB) standard and RFID standards allowed more communication options.

Historically, the lack of validation was due to two factors. The first is that, until the last few years, sufficient memory (storage space) at an affordable cost was not available in the portable hardware to hold validation information. Secondly, until such operating systems such as Palm OS and Windows CE became available, much of the programming environment and program generators did not have the power to develop the sophisticated programs required for validation. As an example, the author's first experience with a programming language for portable hardware was Interactive Reader Language (IRL®), a proprietary language specific to Intermec hardware. In spite of being called a high level language, the programmer could only code at a relatively basic level and could not produce the types of sophisticated programs available today.

Hardware Durability

Bar code hardware is manufactured for almost every type of operating environment from extreme cold and wet to extreme hot and dry. In addition, it is manufactured to withstand different levels of physical use and shock. According to Intermec, "ruggedized mobile computers provide a total cost of ownership advantage over consumer-grade devices that offsets the implementation cost difference, according to VDC."[9]

However, due to its small size, Fixed Asset inventory was not a vertical market analyzed. The author has sold many different models of Bar Code Hardware and offers a range of hardware, both ruggedized and "consumer-grade."[10] It is the author's experience that fixed assets inventories in the traditional indoor environment (not warehouse) do not warrant the extra expense of ruggedized hardware. Some manufacturers offer leather or rubber coverings (or boots) over the non-ruggedized models that offer good protection for a smaller cost increment.

Scanning Technologies

There are two major types of scanning technology for bar code hardware that is suitable for most asset inventory systems. They are Linear Imagers and Laser Scanners. Either of these technologies can read the most common bar code symbologies and have some overlap in their capabilities.[11]

Linear Imagers are best suited for asset inventory systems since scanning distances are almost always less than 18 inches (45cm) and the scanner cost is typically lower than Laser Scanners. Additionally, they are solid state with no moving parts and tend to be more reliable.

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[9] Intermec quoted source: Venture Development Corporation www.vdc-corp.com/industrial/reports/03/br03-12.html also "It Pays To Understand The Total Cost of Ownership For Mobile Computers" published 08/13/2004 (no author)
http://epsfiles.intermec.com/eps_files/eps_wp/TCOMobileComputers_wp_web.pdf
Downloaded 10/13/2004

[10] http://www.bar-scan.com/website/html-products/products-hardware.html

[11] "Guide to Scanning Technologies" published 12/16/2003 (no author)
http://epsfiles.intermec.com/eps_files/eps_wp/GuideToScanningTech_wp_web.pdf
Downloaded 10/08/2004

Laser Scanners have some advantages in a warehousing environment of asset inventory systems because of their longer scanning distance and bright beam.

Auxiliary Data Entry

There are several forms of data entry commonly available on portable hardware beyond scanning technology. This is almost always a requirement for asset inventories since some detailed inventories involve the collection of ad-hoc information in the field, for example, the name of the current user of the asset. Additionally, the asset label may not always be in the line of sight of the scanner and the asset number may have to be entered manually. The most common forms of auxiliary data entry are:

- Keyboard - physical qwerty type or chording (characters are generated using different combinations of a few keys), touch screen, or both.
- Letter or handwriting recognition (graffiti tablet or block recognizer), typically with a stylus.

Speech recognition is not prevalent in the hardware, and computer mice are rare.

For asset inventories, the preference is typically to either utilize bar code menus whenever practical, or download information into the portable hardware to reduce the amount of unique auxiliary data entry. This has the combined advantage of both accuracy and speed. However, this does require knowing the data elements, or choices, prior to the inventory.

When the information is truly ad-hoc, a keyboard may be the best balance between accuracy and fast data entry.

Radio Frequency Identification

RFID is a major trend in the automated ID technology. However, its main application is in vertical markets that include Transportation and Logistics, Supply Chain (commercial and military), Industrial and Manufacturing, followed by the retail sector.[12]

At some future date, RFID may be a major trend in the inventory of fixed assets. However, "while the potential for viable RFID applications appears virtually limitless, few applications have translated into consistent and profitable opportunities, with price often being the decisive barrier."[13]

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[12] **Frontline Solutions** May 16, 2004 - "Label software vendors add RFID capabilities" by Brian Albright Quotes by Michael Liard, VDC's Senior AIDC/RFID Analyst *also* December 1, 2003 - "Ready or not, RFID's coming" - Quotes by Michael Liard, VDC's Senior AIDC/RFID Analyst *also* **Supply Chain Systems Magazine** December 2003, "Bar Code: 2003's Untold Success Story" - by Paul Quinn - Quotes by Taylor Smith, VDC's AIDC Analyst

[13] Global Markets and Applications for Radio Frequency Identification" David Krebs & Michael J. Liard, Venture Development Corporation, a white paper published 5/04 http://www.vdc-corp.com/white/index.html

Currently there is a substantial price difference between typically used Polyester labels and RFID labels. For example, a midwest supplier (www.idplate.com) retails 3,000 premium labels of a typical size used for asset labels at $509.10. The same supplier charges $4,220.10 for 3,000 combination RFID/barcode labels of 2" x 1.5" with a foam adhesive (required for mounting on metal assets).

On the portable hardware side, there is also a substantial premium for RFID capability. For example, the Symbol MC906R-G with RFID capability retails for $4,995.00 (www.symbol.com). A comparable scanner based Symbol MC9060-KH retails for $2,445.00.

Wireless Local Area Network

Wireless Local Area Network (WLAN) is often mentioned in the same sentence with bar coding. Many manufactures of bar code hardware are integrating this technology into their equipment. Basically, it refers to technology that enables the hardware to communicate to another computer (usually a host computer with a database depository) using standard network protocols, but without network cabling.

Since the emergence of cross-vendor industry standards such as The Institute of Electrical and Electronics Engineers (IEEE) 802.11 standard, manufacturers have produced a large number of different solutions. However, most of these solutions have focused in areas where there is either a high volume of transactions or a local area where the infrastructure can be easily installed, such as in warehousing or point-of-sale.

The most common form of WLAN today is wireless fidelity (WiFi). WiFi is the wireless way to handle networking. It is also known as 802.11 networking and wireless networking. Data throughput can be scaled to support transmission of up to 1500 feet (ft) outdoors and up to 295 ft indoors.

WiFi can be open or secure. If a hotspot is open, anyone with a WiFi card can access the hotspot. If it is secure, the user needs to know a Wired Equivalent Privacy (WEP) key to connect.

Just like the case with RFID technology, WLAN has little application for most fixed asset inventories. With the exception of warehouses, where the investment of access points can be justified, most organizations will not make the financial investment required solely for asset inventories.

The author has one international customer who is installing a WiFi network in one building for testing purposes. However, the justification includes access for a number of different uses including mobile email, work order processing, and to a lesser extent, information technology (IT) asset management. The customer stated that they could not justify a WiFi network based only on their need for asset management.[14]

[14] Confidential source pursuant to terms of non-disclosure agreement

The 802.11n standard is scheduled to begin appearing in products in 2005. Existing hardware is most likely not upgradeable. It will increase bandwidth and the range of wireless networks.[15]

Summary of Hardware Requirements for Asset Inventory

Most manufactures supply hardware which includes a wide range of features. The author's experience is that the key to an asset inventory is the need for Hardware Portability, including a relatively long battery life. Additional Hardware Durability is usually not warranted. The preferred scanning technology is linear imaging. A physical keyboard is advantageous for auxiliary data entry. RFID and WLAN are technologies yet to prove their additional expense.

[15] "The Future of Wireless Networking," Richard Baguley, *PC World Magazine*, November 2004 (pg. 106)

PRE-PACKAGED AND SEMI-CUSTOM APPLICATIONS

Case Studies

Numerous case studies justify the use of barcode technology. There are fewer case studies for asset management due to its more specialized application. The studies cited below were produced by the various vendors and all stated positive results when compared to the previous manual methods.

"Barcode auditing has also significantly reduced the time taken to conduct periodic asset audits by the Faculties. For example, one audit conducted that would normally have taken two days alone in sighting assets utilizing a spreadsheet generated printout … was completed in 6.5 hours…"[16]

"Despite the large number of assets to be collected, recorded and entered into the system, barcoding and actual data capture took only 11 days – this represented an average capture of more than 1000 items per day. The whole process took less time than previous audits and provided much more accurate and reliable information."[17]

"That's changing for the better with each annual inventory. 'The last one took three months, we hope to reduce it to two months this year and eventually even more,' says Bloodworth. Missing items figures decreased also. Two years ago, 2.36% of total inventory was not located during the annual inventory count. Under the new system last year, that was cut by more than half to 1.09%."[18]

"The second largest school district in Pennsylvania, Pittsburgh must inventory and track 21,000 fixed assets across 90 remote locations."

"For more than seven years, the District has continued to maximize its return on investment in FAS. The software has created a faster and more productive way of doing business by cutting actual inventory time by 30 to 40 percent."[19]

None of the studies cited cost justifications detailing actual costs and savings. In the author's own experience, where inventories are required, the savings in labor time has exceeded the purchase and implementation costs of the software and hardware on projects where the total number of assets exceeded 10,000 or the assets had to be counted on a regular basis of not less than annually.

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[16] "Case Study: Hardcat at Edith Cowan University" http://www.mindstreamit.com/AllCaseStudies.htm downloaded on 10/18/2004

[17] "Hardcat at ANZ Bank" http://www.mindstreamit.com/AllCaseStudies.htm Downloaded on 10/18/2004

[18] "Asset Tracking Program Gets A+ at Florida Community College," by Doris Kilbane http://www.dhsworldwide.com/Images/asset_art_fccj.pdf downloaded on 10/18/2004

[19] "FAS Suite Automates Fixed Asset Management for Pittsburgh Schools" http://www.bestsoftware.com/pdf/fas/ss/fas_pittsburghschools_ss.pdf downloaded on 10/18/2004

Vendor Search

An Internet search was made to identify a variety of vendors supplying "bar code inventory systems." Care was taken to select a broad variety of vendors that supply solutions from basic systems capable of inventorying a few thousand items, to enterprise-wide systems that both track as well as manage the life-cycle of hundreds of thousands of items.

Other sources which were used to compile the vendors were:

- "Frontline Solutions" Magazine "Buyers Guide 20904" www.frontlinetoday.com Advanstar Communications, Inc. 131 W First St., Duluth, MN 55802-2065
- "2004 Facilities Planning and Management Directory" published by Tradeline, Inc. 115 Orinda Way, Orinda, CA 94563 www.tradelineinc.com
- "American School & University" Magazine "Buyer's Guide & Industry Sourcebook" March 2003, Primed Business Magazines & Media, 9800 Metcalf Ave., Overland Park, KS 66212-2216 www.primediabusiness.com
- www.govtech.net by e.Republic, Inc., 100 Blue Ravine Rd, Folsom, CA 95630

While the list of vendors selected cannot represent the entire marketplace of applications, based on the author's 23 years of experience in this field, the author feels that it does provide a good cross-section representing various application features and price points.

It should be noted that at the enterprise level, most applications are customized to work within the IT infrastructure as well as the end-user operational guidelines. Some pre-packaged applications have features and/or modules that also allow some customization; for example "user defined fields" are typically available to some flexibility to the application so that it can meet unique needs of each customer.

The list of selected vendors is provided as Appendix A. From this list of Vendors the matrix on the following page was compiled.

Table 2. Vendor / Product Matrix.

Vendor/Product Name (alphabetical)	Available Server OS and Database	Est. Software Cost*	Bar Code Technology	Some Browser Functions
Asset Systems, Inc. AssetWin®	Microsoft Windows Microsoft Access Microsoft SQL Server Oracle 9i	$6,895 to $7,995	Yes	No
Bar|Scan, Inc. Bar|Scan®	Microsoft Windows Microsoft Visual FoxPro	$8,500	Yes	Yes
Best Software FAS Fixed Asset Management Solution	Microsoft SQL Server	$12,360	Yes	No
DataStream Systems, Inc. Datastream 7i™	Microsoft SQL Server Oracle 9i	$35,000	Yes	Yes
Hardcat Pty, Ltd. Hardcat™	Microsoft Windows Microsoft SQL Server Sybase SQL Anywhere IBM DB2	$10,000	Yes	Yes
Intellitrack, Inc. Fixed Assets	Microsoft Access	$2,495	Yes	No
PeopleSoft, Inc. Fixed Asset Accounting	Vendor unresponsive**	Estimated FA $85,000 module only	No information	No information
Peregrine Systems, Inc. AssetCenter®	Vendor unresponsive**	No information	No information	No information

* Basic Network version with barcode capability – 5 user license exclusive of training, support, server software, and PDA software

** Both Peoplesoft, Inc. and Peregrine Systems, Inc. were contacted via mail and email by John Semmens of ADOT with a Request for Information (RFI). Peregrine responded with only limited brochure information. There was no response from PeopleSoft.

Browser Based Data Access

Browser based assess to Fixed Asset databases is not common. This is due primarily to two factors. First, the information is often sensitive and is not shared among a large group; and second, the type of data presented does not process well in a Browser. For example, a Browser is not designed to manipulate thousands of records simultaneously, such as is done when depreciation is applied.

However, several of the Vendors do have a Browser Based Module that does allow access to some areas of functionality.

Brower Access can be advantageous under a number of situations including:

- When facilities are geographically remote and do not have sufficient IT infrastructure to allow access to a master asset database depository.
- When the number of assets at a facility does not warrant the bar code hardware, infrastructure, and training investment required for a physical inventory.
- When a large group requires limited access to the inventory.
- When persons outside the organization require access to the inventory.
- When the Personal Computer does not meet the minimum requirements to access the database directly (for example, Apple computers utilize Browsers but many Vendors do not provide their application for Apple OS).
- When the software pricing favors Browser Access.

PILOT IMPLEMENTATION

SELECTION OF STRATEGY

ADOT's Asset Inventory cannot be implemented in a traditional manner. The primary reasons are:

- Dozens of facilities are dispersed over a wide geographical area throughout the State.
- Most facilities have a relatively small number of inventoried items.
- Currently, a large number of Organizations are responsible for the inventory.
- No central location which facilitates initial tagging and subsequent data entry exists for the receiving or salvage of items.

Because of these reasons, three different Pilot implementation strategies are detailed below. In all implementations, inventory personnel will physically replace the current labels with bar code labels. Each strategy has distinct advantages and disadvantages**.** Finally, a Pilot implementation is suggested to validate the cost savings estimated in this study.

Strategy One - Implement robust barcode technology with dedicated physical inventory personnel

This scenario would move the responsibility of physical inventory from the Organizations to a centralized physical inventory staff. This would be the most radical departure from the current ADOT fixed asset inventory process.

Most larger entities have a specific department tasked with the maintenance of Fixed Assets which includes the process of physical inventory collection and audit. Sometimes this is an independent entity but most often it falls under the auspices of Facilities, Accounting, or Information Technology. In some cases, the personnel assigned are independent of any departments. However, it would be most feasible to place the Physical inventory personnel within the Fixed Assets department since ADOT already has a Fixed Asset Manager.

Since these personnel would be dedicating a relatively large portion of their time to physical inventory, they can be fully trained in the use of bar code technology. They can also be provided with more advanced technology since they would receive more personal training (than a larger group of Organization employees) and it is anticipated that they would have lower turnover.

The number of dedicated personnel required is a function of their inventory speed, number of items to be inventoried, routing schedule for the physical locations, and desired duration of the physical inventory window.

The inventory window would have the greatest effect on the number of personnel required to complete the inventory. In the author's experience, regulatory requirements are an important factor in determining the window. One California Agency requires an inventory every three years. In spite of being a very large and geographically diverse

entity, they only have to account for each new asset upon receipt, disposal and physical inventory once every three years; the large window means that they can employee only two persons for their physical inventory. On the other hand, it would be impractical to maintain the current two-week physical inventory as the staffing requirements would be prohibitive.

If a Cycle Count is acceptable to ADOT, performing the inventory over the course of one or two years would require the smallest number of dedicated personnel and would minimize the total cost of the strategy.

Advantages

- Minimal investment in barcode hardware while maximizing the hardware's usage.
- Reduced involvement of ADOT Organizations and associated annual disruption and the associated labor costs to the Organizations.
- Increased accuracy, speed, and consistency of the inventory due to specialized training of personnel and technology. For example, improved consistency of label placement and asset descriptions.
- Accountability independent of Organizations.
- 100% physical inventory – no delays or follow-up necessary with Organizations for data collection. Obviously some assets such as vehicles will require inventory schedule coordination.
- Fastest implementation track because this is the most centralized strategy.

Disadvantages

- Dedicated direct inventory labor and additional expenses such as transportation and lodging. These costs can be charged to the Organizations in proportion to the number of assets or other parametric.
- Increased duration of total physical inventory window due to sequential inventory collection methodology rather than parallel collection methodology.

Strategy Two - Implement minimal barcode technology with emphasis on web or network based data collection software

This scenario entails the implementation of software that replaces the current distribution of manual asset inventory information to the Organizations. Using either a web centric or server based database, push the inventory data to the appropriate Organization contact at each site. This scenario is the least radical solution but still adds automation to the current process.

The software should print data collection forms similar to forms currently being used. Organizations may use forms as they perform the physical inventory and manually mark as appropriate. Results are then keyed back into software at the Organization's site, eliminating the need for a paper-based response as software may provide immediate feedback. Optionally, Organizations can print a final hardcopy for their records. Authorizing Signature can be added manually or electronically.

Optionally, when adding barcode technology, you will need to procure one or two barcode hardware and train a very small number of personnel for independent auditing.

Advantages

- More accurate data entry than current manual method as Organizations can validate their own data entry and obtain immediate feedback.
- Minimized investment in bar code hardware and training.
- Minimal change created in current ADOT Fixed Asset Inventory Process of Organizations responsible for their own physical inventory.
- Current small physical inventory window of two weeks maintained.
- Less storage of paper records.

Disadvantages

- No independent accountability.
- Required follow-up of discrepancies required but this can be automated through technology such as automated email.
- Minimal increase in inventory accuracy due to lack of bar code technology implementation.

Strategy Three - Implement moderate barcode technology and web or network based data collection

This scenario is a blend of the previous two. In summary, allow the Organizations in the smaller locations to use the physical inventory methodology described in Strategy Two while implementing Strategy One with its bar code technology in the larger locations or all locations in a close geographical area.

Supply bar code hardware only to the larger sites such as Phoenix and Tucson. Train one person in barcode for audit purposes and two or three in barcode data collection for the larger locations.

A sample proposed grouping of locations to determine the feasibility of this option was developed to justify the procurement of four or five portable bar code readers and is included in Appendix Y.

Advantages

- Better than manual method.
- Minimal investment in barcode technology may be offset by investment in software.
- Some increase in inventory accuracy due to partial implementation of bar code technology implementation.
- Increased the current small physical inventory window by only a few weeks.
- More accurate data entry than current manual method as Organizations can validate their own data entry and obtain immediate feedback.
- Less storage of paper records.

Disadvantages

- Does not have independent accountability.
- Required follow-up of discrepancies at some locations, but this can be automated through technology such as automated email.

SELECTION OF TECHNOLOGY FOR PILOT

A selection was made for software and hardware for the barcode technology portion of the Pilot Implementation. Because the cost-benefit is not yet proven, it was decided to limit the choices to the lowest cost solution providers. Three vendors were suggested: Hardcat Pty, Ltd.; Bar|Scan, Inc.; and Intellitrack, Inc.

Of these, the Intellitrack Fixed Asset Software and Symbol PPT8800 were selected as this combination was the lowest cost and offered with additional discounts.

Richard Neshwat, the Fixed Asset Manager for Financial Management Services, installed and tested the Intellitrack Fixed Asset Software and Symbol PPT8800. Patches were required and were installed with assistance from the Vendor.

It was not possible to test an ideal implementation of one of the three strategies as installing and testing a web component would require additional unknown expenditures. However, cost savings can be extrapolated from a comparison physical inventory.

It is important to keep in mind that any hardware and software selected for the pilot may be replaced by a more robust selection at a later date.

Hardcat Pty, Ltd. and Bar|Scan, Inc. provide basic systems with bar code technology and some browser functionality. Intellitrack, Inc. offers the lowest cost solution but did not offer a browser function. The browser function is an important component of the implementation strategies previously mentioned. Estimated costs per vendor for a Single User version and one bar code reader were:

- Hardcat - User version with barcode capability – exclusive of training and support.
  Modules: Core, Barcoding plus Symbol PPT8800 $7,550.00.
  (Information on the Symbol PPT800 can also be found at www.symbol.com)
- Bar|Scan - Single User version with barcode capability – sold with 2 days training and 1 year support:
  Bar|Scan Asset Management plus Symbol SPT1550 $7,875.00.
  (Information on the Symbol SPT1550 can also be found at www.symbol.com)
- Intellitrack - Single User version with barcode capability but no browser capability– exclusive of training and support:
  Intellitrack Fixed Assets version 4.3 plus Symbol PPT8800 $3,580.00

Bar code labels to tag the individual assets were also required for any of the three above mentioned vendor candidates. The cost for 3,000 polyester asset labels was $480.00.

DEPARTMENTAL CANDIDATES

Several Departmental Candidates for Pilot Implementation were considered including Transportation Services, MVD, Equipment Services, and Administration.

It was decided to perform the implementation at the 206 S 17th Avenue site, primarily on the second floor. This was primarily due to the fact that the initial On Site Observation was also done at this location. Performing the Pilot Implementation within the same environment would present us with the most compatible data set for comparison.

PILOT IMPLEMENTATION FINDINGS

SAMPLE RESULTS

Richard Neshwat, the Fixed Asset Manager for Financial Management Services, performed the Pilot Implementation with the Single User Intellitrack Fixed Asset Software and one Symbol PPT8800.

Below is a chart of the observation result. The inventory time includes travel time within the building as well as the time required to complete the forms.

Table 3. Pilot Implementation Sample

	Pilot Implementation Sample	
Org	Time	Number
Code	(minutes rounded up)	of Assets
0020	4	6
1010	4	7
1021	1	2
1023	3	6
1030	7	12
1101	4	5
1110	3	4
1111	4	7
1112	4	14
1113	3	4
1114	7	16
1120	1	2
1121	4	9
1124	3	6
1125	3	4
	55	104
	assets/min/team = 1.89	
	assets/min/person = .945	

While ADOT is geographically disbursed and the above sample is not meant to be representative of all Organizations, it can be used to extrapolate an estimate of the man-hours required to collect the annual inventory with bar coding and automation.

Assuming the collection time for all non-vehicle assets at .945 assets per minutes per person and vehicles at .4725 assets per minute (200% of non-vehicle assets), the total time is approximately 563 hours (22,600 assets at .945 assets per minute = 23,915 minutes plus 3,900 vehicles at .4725 assets per minute = 8,254 minutes) plus an additional 5% for follow-up time for a grand total of 563 estimated man-hours.

Once the inventory data was collected, various reports, such as a missing asset report, were generated. Since this was only an experiment, the data was not entered into the AMS Advantage Accounting System.

In summary, an estimated 563 hours are spent performing the annual inventory. This estimate is not based on a representative sample and has no statistical significance.

Comparing the results of Table 1 and Table 3, the extrapolated reduction in man/hours for the physical inventory collection was 26% (765.5 man/hours reduced to 563 man/hours).

Estimated Annual Cost Benefit

For ADOT, the extrapolated reduction in man/hours translates to an annual benefit of $5,067.67. The cost is based on a $15.69 hourly rate plus benefits for ADOT administrative personnel.[20] Assuming an estimated six year operational life of the equipment and software, the total benefit would approximate $30,000.

Estimated Acquisition Cost for Hardware and Software

The total acquisition cost of hardware, software, and labels for the Pilot was $3,988.70. To implement Strategy Three, while retaining the abovementioned initial investment, the total additional implementation cost is estimated to be from $11,155.00 to $12,425.00.[21] This would be sufficient to implement bar code technology at the three largest facilities with the assumption that each facility requires one portable bar code device.

The Intellitrack network upgrade to allow up to five simultaneous users is $1,195.00. There are several different Symbol models that can run the Intellitrack software. The purchase of additional Symbol equipment that can run the Intellitrack software is from $1,410.00 to $2,045.00 each (including cradles and cables). Intellitrack software licenses for the Symbol hardware is $300.00 per unit.

Professional training in the use of the software and hardware would require additional expenditure for several days. The industry standard for training is from $1,000.00 to $1,500.00 per day.

The cost for 20,000 additional bar code asset labels of the same specification used in the Pilot is estimated to be $1,750.00. This is a sufficient quantity to label all inventoried assets. Depending on label placement, vehicles might require an ultra-violet resistant label.

An export from the Intellitrack to the AMS Advantage Accounting System Fixed Asset module should be reviewed. An electronic interface to update physical inventory information would eliminate data entry as well as improve accuracy.

[20] 202.5 hrs saved times ($15.69 hourly rate plus 59.5% payroll additive—estimate provided by Craig Rudolphy, Arizona Department of Transportation Comptroller)

[21] All upgrades at retail prices, discounts may apply.

Implementing software that replaces the current distribution of manual asset inventory information to the Organizations with a web centric or server based database to push the inventory data to the appropriate Organization contact at each site is more difficult to estimate and beyond the scope of this project.

In summary, the implementation cost, exclusive of a web component is:

Table 4. Implementation Cost

Item	Cost
Intellitrack 5 User upgrade	$1,195
2 units Symbol hardware that support Intellitrack with cradles[22]	$2,820 to $4,090
2 units Intellitrack Software License for hardware	$600
2 days of Intelltrack Training	$3,000
20,000 additional bar code asset labels	$1,750
First 2 years of Intellitrack Support	$1,790
Total Implementation Cost:	$11,155 to $12,425

Estimated Annual Maintenance Expense and Life Expectancy

There are many factors that can affect the life expectancy of hardware and software technology. Currently, there is rapid technological advancement in the hardware mentioned in this report, especially since the jump to Pocket PC technology. Assuming that the hardware would only be required for a short duration every year, it would be safe to estimate that the hardware would be technically obsolete before it is worn out from normal use. Expect to replace the hardware in about five to seven years. On the software side, Intellitrack provides an annual support plan for the five user license for $895.00.

Given the annual cost saving of $5,067, the annualized implementation expense of $1,965 and the annual $895 support plan for the software, the estimated benefit/cost ratio for implementing this bar scan solution would be approximately 1.77:1. That is, $1.77 would be saved for every one dollar spent on implementation. The time required to recoup the implementation investment above would be approximately 2.8 years.

Annual support for a web centric or server based database to push the inventory data to the appropriate Organization contact at each site is more difficult to estimate and beyond the scope of this project.

[22] Symbol MC50 or Symbol PPT8800

CONCLUSIONS AND RECOMMENDATIONS

INTRODUCTION

The Pilot Implementation showed that an automated asset inventory system can reduce the amount of time needed to perform a physical inventory as well as increase the accuracy of the results.

Comparing the Onsite Sample and Pilot Implementation showed a 26% reduction in man/hours for the physical inventory collection. However, based on this alone, it cannot necessarily be concluded that a full-scale implementation of the technology will result in a cost savings.

Because of the Study's budget, the Pilot Implementation represented only a very small sample of assets in a single building and was not representative of ADOT's infrastructure which has:

- Dozens of facilities dispersed over a wide geographical area throughout the State.
- Most facilities have a relatively small number of inventoried items.
- Currently, a large number of Organizations are responsible for the inventory.
- No central receiving or salvage of items location facilitating initial tagging and subsequent data entry.

Because of ADOT's infrastructure, three different statewide implementation strategies were detailed below. Each strategy had distinct advantages and disadvantages that were previously discussed.

Strategy One - Implement robust barcode technology with dedicated physical inventory personnel

This scenario would move the responsibility of physical inventory from the Organizations to a centralized physical inventory staff. This would be the most radical departure from the current ADOT fixed asset inventory collection process.

Strategy Two - Implement minimal barcode technology with emphasis on web or network based data collection software

This scenario entails the implementation of software that replaces the current distribution of manual asset inventory information to the Organizations. Using either a web centric or server based database, push the inventory data to the appropriate Organization contact at each site. This scenario is the least radical solution, but still adds automation to the current process.

Strategy Three - Implement moderate barcode technology and web or network based data collection

This scenario is a blend of the previous two. In summary, allow the Organizations in the smaller locations to use the physical inventory methodology described in Strategy Two

while implementing Strategy One with its bar code technology in the larger locations or all locations in a close geographical area. Supply bar code hardware only to the larger sites such as Phoenix and Tucson and train one person in barcode for audit purposes and two or three in barcode data collection for the larger locations.

Conclusions and recommendations are based on imperfect data. They are offered as suggestions for consideration. Also, review of ADOT operations is outside the scope of this report.

CONCLUSIONS

The lack of academic journal articles and publicly available data point to a lack of systematic analysis of fixed assets inventories. However, case studies justify the use of barcode technology and have shown reduction in the time taken to conduct periodic asset inventories. This was also validated in ADOT's Pilot Implementation.

The primary benefit that bar code hardware brings to an asset inventory is its portability. Data entry that had occurred at the end of the inventory process can now be done at the collection site. Newer technology has made this process easier and faster. Observed benefits of the automation were accuracy (transposition of numbers) and easy reporting. In addition, with automation, future inventories will be easier to perform since existing asset tags will contain bar codes.

RECOMMENDATIONS

Since the Pilot Implementation showed that an automated asset inventory system can reduce the amount of time needed to perform a physical inventory as well as increase the accuracy of the results, it is recommended that ADOT further study the automated technology in conjunction with one of the three implementation strategies presented in this report.

It is the author's opinion that Strategy Three, the implementation of moderate barcode technology and web or network based data collection would best suit ADOT's infrastructure. It offers the benefits of both Browser Access as well as barcode technology without committing to a dedicated centralized inventory staff. To recap, Brower Access can be advantageous under a number of situations previously discussed in this report.

A larger study incorporating the Pilot Results with Browser Access would provide additional key information required to justify the statewide implementation of an automated Asset Inventory System.

APPENDIX A

Product Name (alphabetical)	Vendor Information
AssetCenter®	Peregrine Systems, Inc. 3611 Valley Centre Drive San Diego, CA 92130 USA Telephone: 800.638.5231 web: http://www.peregrine.com
AssetWin®	Asset Systems, Inc. 618 B West 5th Avenue Naperville, IL 60563 Telephone: 1-877-955-4321 web: http://www.assetsystems.com/
Bar|Scan®	Bar|Scan, Inc. 31200 Via Colinas, Ste 202 Westlake Village, CA 91362-3939 Telephone: 1-818-991-7001 web: http://www.bar-scan.com
FAS Fixed Asset Management Solution	Best Software® Offices 2325 Dulles Corner Boulevard Herndon, Virginia 20171 Telephone: 1-800-368-2405 web: http://www.best-software.com/
Datastream 7i™	Datastream Systems Inc. 50 Datastream Plaza Greenville, SC 29605 Telephone: 800-955-6775 web: http://www.dstm.com
Hardcat™	Hardcat Pty, Ltd. GTC Systems, Inc. (Local US Distributor) 4631 Viewridge Avenue San Diego, CA 92123 Telephone: 858-560-5800 web: http://www.hardcat.com.au/
Fixed Assets	Intellitrack, Inc. 224 Schilling Circle, Suite 130 Hunt Valley, MD 21031 Telephone: 888-583-3008 web: http://www.intellitrack.net/
Fixed Asset Accounting	PeopleSoft Inc. 4460 Hacienda Drive Pleasanton, CA 94588-8618 Telephone: 800-380-7638 web: http://www.peoplesoft.com