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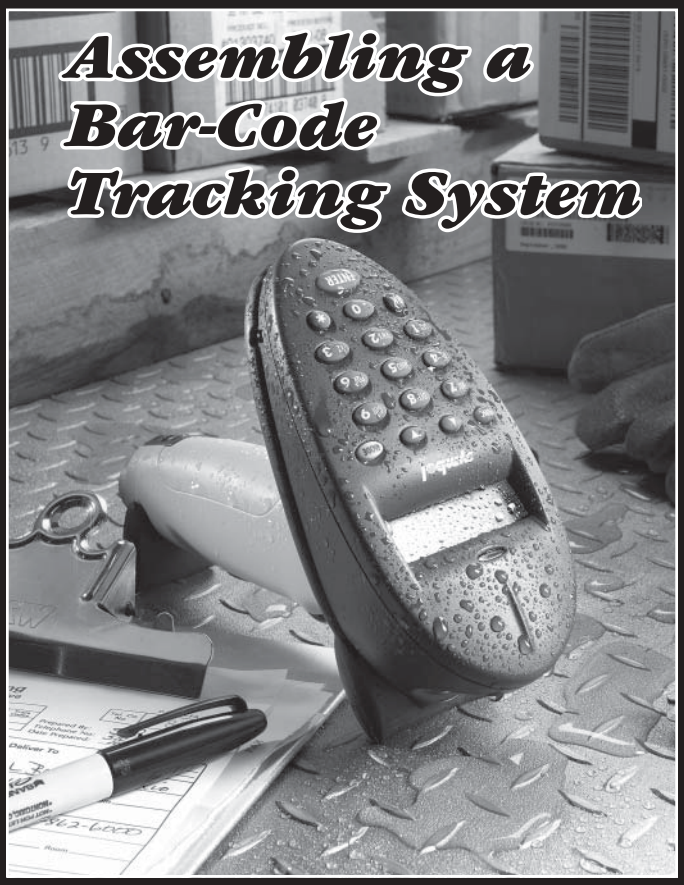
Assembling a Bar-Code Tracking System



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Introduction

Personal digital assistant configured for bar-code scanning with the docking terminal and cable system.

This report provides the information you will need to assemble your own bar-code tracking system. It includes descriptions of bar-coding equipment, data collection and storage software, methods for setting up and running your own system, sources of equipment, tips for using a bar-code system, and other useful information. If you want general information about how a bar-code system works, please read this report's companion publication, *Bar-Code Tracking System Overview* (0271–2333–MTDC). Information on obtaining the *Bar-Code Tracking System Overview* Tech Tip is included at the end of this report.

Making It Work

The importance of making the system easy to use cannot be overstated. Bar-code systems will not perform to expectations without staff commitment. Personnel must be trained to use the system and work leaders must ensure that the system is used consistently and properly. Routine maintenance must be performed to ensure that the system is running properly and that the data are up to date. Organizations that use a bar-code-based inventory system agree that the number-one requirement for success is having someone with the authority to enforce the rules for using and maintaining the system. A system manager should be appointed and given the authority and resources to assure that the system is used and maintained properly.

Designing and Implementing an Inventory-Tracking System

Designing an inventory-tracking system based on bar codes requires planning. The basic design and setup are the same whether you need to track chemicals, material safety data sheets, office supplies, pesticides, furniture, documents, or fire equipment:

- Determine what you want the system to do.
- Detail the system's operation and procedures.
- Determine the information you want to store.
- Purchase equipment.
- Enter initial information into the system.

The first three steps provide the data you need to choose the appropriate system components.

Determining What You Want the System to Do

The initial step is deciding what you want the system to do. Some commonly requested features are included in the following list. From it, choose the features you will need. Also note anything you want the system to do that isn't on the list.

Inventory-Tracking System Features

Ease of Use
- Graphical (Windows) or text-based user interface.
- Easily accessible by everyone.
- New items, users, and descriptions can be added easily.

Labels
- Bar-code labels for primary containers.
- Bar-code labels for secondary containers.
- Hazard communication labels (health, flammability, reactivity).
- Connections to a material safety data sheet (MSDS) database (scan the bar code and print or display the appropriate MSDS).
- Provisions for adding MSDS to the system from scanners, the Internet, manual input, or other sources.

Bar-Code Readers
- Stationary—Attaches to a workstation.
- Portable—Batch system (information that is stored remotely on the reader is moved to a computer by a cable).
- Portable—Remote radio-frequency access (information can be exchanged between the bar-code reader and computer in real time when the reader is used at a remote location).

Chemical Tracking
- Tracking use.
- User checkout system.
- Tracking by project.
- Tracking purchases.
- Tracking by location.

Record Keeping
- User checkout system (pharmacy system).
- Purchase, consumption, and disposal records.
- Report generation abilities (automatic and query based).
- Missing material/inventory.

Computer System
- Workstation based (system is loaded on specific machines).
- Server based (access from any network workstation).

Regulation Compliance
(Program contains built-in regulation compliance warnings).
- Storage threshold limits.
- Incompatible chemical storage.
- Transportation rules.
- Disposal regulations.

Detailing the System's Operation and Procedures

Decide how you want the system to operate. Identify how the bar codes will be scanned, who will scan the codes, who will enter purchase, consumption, and disposal data, how users will interact with the software, where the bar code and report printers will be located, who will label the containers, and so forth.

Determining the Information You Want to Store

Decide what information needs to be stored and whether you will store it in a database you design or in a commercially purchased program. The reports you will be able to generate depend on the data that are stored in the software program. Keep possible future uses, requirements, and upgrades in mind.

Purchasing Equipment

It will be relatively easy for you to decide what equipment you need to purchase if you have done a good job of determining what you want the system to do, detailing the system's operation and procedures, and determining the information that you want to store. Use the information you have gathered to evaluate the equipment and systems on the market. The section in this report entitled *The Components of a Bar-Code Tracking System* will help you understand the parts of a bar-code system and how they interact. The components must work with your computer's hardware, operating system, and other software. Purchase compatible equipment. Bar-coding systems and equipment are no more standardized than other computer systems. Do not attempt to assemble a system from "parts" unless you understand the connections. For many users, it will be more practical to work with a vendor or system designer than to assemble a system from individual components.

Entering Initial Information into the System

Entering information is the last significant step in setting up the system. This step requires impeccable accuracy. For large operations, entering the information may take a considerable amount of time. All inventoried items are entered into the database by hand or imported from an existing file, spreadsheet, or database. A bar code is assigned to each item and each item is labeled with its corresponding bar code. If you have successfully completed these steps, your system is ready to run.

The Components of a Bar-Code Tracking System

An inventory-tracking system based on bar codes has three basic parts:

- The bar-code label
- A suitable data-storage software program
- Bar-code readers

Anyone is capable of designing and purchasing a basic system. Designing more elaborate systems requires more knowledge of computers and bar-code systems. The following component information will help you assemble your own system or provide enough information so you can discuss your needs with a system designer.

Labels

You can purchase a supply of preprinted bar-code labels or generate your own using label supplies and a printer.

If you purchase preprinted bar-code labels, you must specify exactly what you need. Include the range of ID numbers to be encoded, the bar-code symbology that your software will understand, the label's dimensions, the material it is to be printed on, and any information that belongs on the label besides the bar code.

Generating your own labels is easy and provides more flexibility, because labels can be made whenever you need them. You will need a printer, bar-code labeling software, and a supply of blank labels.

The readable lifetime of a label depends on the label material and its environment. Paper labels are the cheapest and most common, but they are not very durable.

Sometimes labels are printed on vinyl, polyolefin, polypropylene, or polyester. Polyester labels are considered the most durable. These synthetics resist heat, cold, smearing, humidity, abrasion, and chemicals better than paper labels. Consider using synthetic labels when they will be subjected to harsh conditions or when the surface of the item being bar coded is curved or flexible. Ensure that the label material is compatible with your printer.

Bar-Code Labeling Software

If you do not buy preprinted labels, you will need labeling software and a printer. Because a bar code is a special type of character font based on graphics instead of letters, printing a bar-code label requires software that can translate data from numbers and letters into a bar-code symbology.

Printers designed to print bar-code labels (thermal printers) often contain bar-code fonts allowing you to print bar codes without software upgrades. When you want to print characters as a bar code, you encode the characters by including a special symbol that tells the printer that the text is to be bar coded. A macro (small program) can be created to automate the process. Check the manual or contact the printer vendor for information on your printer's capabilities.

If you will be using a DOS- or text-based computer, such as the old Data General machines, consider purchasing a bar-code printer module. The module plugs into the printer, and the printer cable from the computer plugs into the module. The module contains software that will make your printer work much like a thermal printer when you use the special character that activates the text to bar-code conversion.

Your inventory program may contain bar-code-labeling software modules, or you may be able to purchase labeling modules. Some modules are basic, but others are as powerful as stand-alone labeling software programs.

You can purchase a stand-alone program that allows you to create and print bar codes. Most labeling programs contain features like:

- Scalable text and bar-code fonts
- Support for most bar-code symbologies
- Ways to import image and data files
- Software interfaces for popular database programs
- Uncomplicated user interface

They allow you to easily create custom labels with lots of information such as the label shown in figure 1. This label includes bar-code identification numbers, text labels, a graphic, and health and flammability warnings. It can be printed in several sizes.

You can purchase a bar-code font or bar-code program to load into your computer. Bar-code fonts allow existing Macintosh or Windows programs, such as Word or WordPerfect, to convert text into a bar code and print labels. Bar-code fonts are an excellent choice if you want to print simple bar-code labels and your inventory system is based on a standard spreadsheet or database program, such as Excel, Lotus, or Access. Word-processing software and bar-code fonts allow you to create elaborate labels with little additional cost.

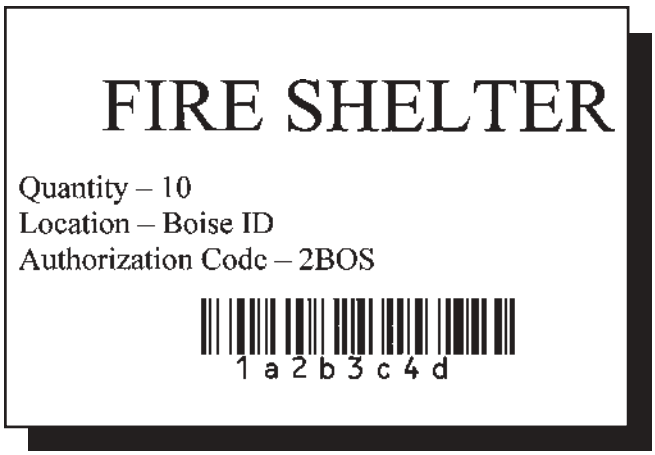

Figure 1—Labeling software allows you to create custom labels to fit almost any need.

Programmers can obtain bar-code DLL (direct link library) modules, allowing bar-code labels to be composed and printed from custom applications. This is a good option when creating systems inhouse. Many sample bar-code font and DLL programs are available for downloading from the Internet.

Bar-Code Printers

A bar-code-based inventory system requires a printer capable of printing bar codes or a supply of preprinted labels. Purchase a thermal printer or use a common dot matrix, inkjet, or laser printer.

Newer standard office printers (dot matrix, inkjet, and laser) can print bar codes if the correct software is installed. For an older printer, you may need to update the printer driver or purchase a bar-code printer module.

Dot matrix printers can produce low- and medium-density paper bar-code labels. They can print one label at a time, but can't print on synthetic materials. Some scanners will have trouble reading a bar-code label printed with a dot matrix printer. Dot matrix printers are a good choice for low-cost operations with no need to use tough label materials. Change the ribbon often.

Laser printers work well as bar-code printers. They work with almost any type of labeling paper, have excellent resolution, and produce clear and long-lasting high-density bar codes. Laser printers can print on durable synthetic materials if the blank labels are made specifically for a laser printer.

Adhesive-backed labels for laser and inkjet printers are available on standard letter-size sheets. A sheet may contain any number of labels depending on their dimensions. A label sheet is fed through an inkjet or laser printer just like normal printer paper, but it must be fed with the correct side up.

Inkjet and laser printers work similarly for bar-code label printing. However, because most inkjet printer ink is water soluble, it is not suitable for use in wet or high-humidity areas. Do not use an inkjet printer if the label will be subjected to any kind of abuse. The interaction between inkjet printer ink and most synthetic labels creates a slippery mess that is highly sensitive to abrasion (figure 2). If you use an inkjet printer, be sure to use label stock made for inkjet printers. If labels need to be readable for several years, they should not be printed with an inkjet printer.

Figure 2—This label was created using an inkjet printer on paper meant for laser printers. Light rubbing produced the smear, which will prevent the bar code from being read.

Thermal printers are used specifically for printing bar-code labels. They require specialized ribbons and label supplies. When you need only one label at a time, thermal printers are a good choice. There are two types of thermal printers: direct thermal and thermal transfer.

Thermal printers often contain text and bar-code fonts controlled by special codes directing the printer to print a bar code from alphanumeric characters. An experienced programmer can often add bar-code printing capabilities to other programs. You can purchase labeling software compatible with your thermal printer.

Direct thermal printers, sometimes called thermal autochrome printers, use heat-sensitive paper to create the image. The hot print head causes the paper to turn black, creating the desired image. Exposure to sunlight and heat will turn the label entirely black, making the label unreadable (figure 3). A direct thermal printer is not recommended except for indoor short-term applications.

Figure 3—These labels turned black after an hour of exposure to direct sunlight. A fresh label (right) is shown for comparison.

Thermal transfer printers use heat to transfer ink from a ribbon to the label. They use a special ribbon with a wax, wax-resin mix, or a resin-based ink. Thermal transfer inks containing more resin are more expensive, but last longer. Polyester-based or other synthetic labels are required if you use high-resin ink. Thermal transfer printers provide more label stock options than other printers. Suppliers carry types and sizes for any imaginable application.

Data Storage Software

Data storage software is the heart of any inventory tracking program. You can purchase a software package or design your own system using a spreadsheet or database program.

Users with few reporting requirements or small inventories may be able to use a spreadsheet-based program. An "add-in" software package for your existing spreadsheet program may approach the power of a database.

Users with significant reporting requirements or large inventories of many different items may need a database. While databases generally take longer to set up, they provide immense data-handling capabilities and can generate reports easily. Microsoft Access and other database programs allow you to create your own inventory program (figure 4). To test the feasibility of constructing your own database, you may wish to experiment with your current software or with databases that are available for a free trial period. You may be able to use the template "wizards" in database programs. Wizards ask the designer questions about operation and data storage requirements, then automatically create a customized program, which can be modified.

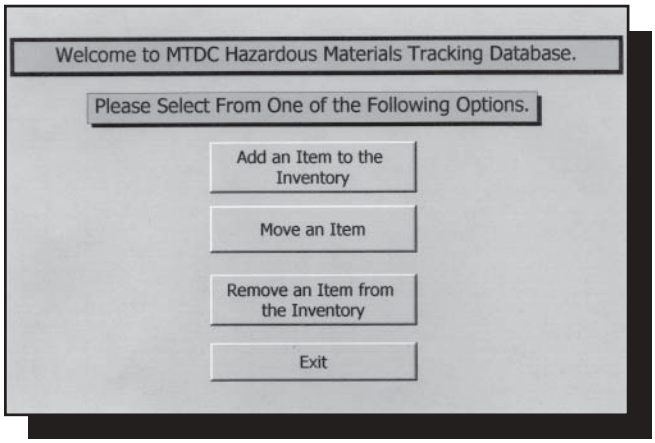

Figure 4—A screen shot taken from a sample database created using Microsoft Access.

Finally, you can purchase a stand-alone inventory and tracking software program. These programs are recommended for those who do not want to create their own inventory systems or who have complex operations. Prices range from $200 to $5,000, depending on the features and the number of users and workstations. The simpler and more economical software

programs don't require extensive computer skills to set up. Some of the more powerful and expensive systems offer features for specialized operations such as managing chemical storage and checkout areas, tracking hazardous materials, and inventorying real property. Most of the programs are available for free trial periods so you can determine whether they meet your needs.

Reports

Reports provide a fast and easy way of accessing and sorting through a large amount of data. If you are fluent in structured query language (SQL), you can generate reports that will tell you almost anything you want to know about the stored data. Many standard bar-code-based programs offer built-in reports. Select the desired report from a menu and print it. Some programs offer reports tailored for specific regulation reporting requirements, such as the Emergency Planning and Community Right to Know Act (EPCRA).

Some of the more common built-in reports include:

- **List by location**—Lists materials at chosen locations
- **List by ID number**—Lists the quantity and location of items by their identification number
- **List by low limit**—Lists items in stock quantities below their designated minimum stocking quantity
- **List by high limit**—Lists items in stock quantities above their designated maximum storage quantity
- **Shelf life**—Produces a list of items that have expired or will soon expire
- **List by material type**—Lists items of each type and their quantities
- **List by person, work group**—Lists name and quantity of items each person or work group has used within a specified time period
- **List by chemical**—Lists the amount used or quantity on hand of each chemical
- **Delinquent container**—Lists containers that have not been returned to storage
- **Returned containers**—Lists all returned containers grouped by person, time, and/or chemical
- **Incompatible material guide**—Contains guidelines based on codes and laws showing which items cannot be stored together and any required spacing and barrier separations

If you design and program your own inventory and reporting system, include features that allow users to access the reports by selecting them from a menu. Deciding the types of reports to build is a basic step in the initial design phase and often guides decisions about the type of data that will be stored in the database.

Bar-Code Readers

Choose a bar code reader that matches your needs from the many different types that are available (figure 5). You can choose from wands, charge-coupled devices (CCD), lasers, portable data terminals (PDT), and readers based on a personal digital assistant (PDA). You may need to balance convenience with your budget in determining which types of readers to include in your system and how many you will need.

Figure 5—You can use many different types of equipment to scan bar codes.

Decoding—Decoding readers translate the symbology of the bar code into decipherable data before sending it to the workstation. Nondecoding readers simply capture the code and forward it to the processor. A system using a nondecoding reader must have a separate hardware or software decoder.

Most hardware decoders are the keyboard wedge type, which allow the processor to accept scanned data as keyboard input. Figure 6 shows an ordinary hardware decoder. Both the scanner and the keyboard plug into the decoder. The decoder plugs into the keyboard port on a workstation. Some decoders are RS232 (serial) models that translate undecoded signals into ASCII format (letters, numbers, punctuation symbols, and other symbols) and send it to the workstation's serial port.

Figure 6—The keyboard decoder shown here allows RS232 devices to be used without additional hardware or software configuration.

If your system includes several portable readers, you could save $100 to $200 per reader by buying nondecoding readers and a separate decoder for the computer or docking station.

Connection Types—Fixed readers use a variety of cable connections, some of which are shown in figure 7. Cable connections are not interchangeable among most bar-code readers. Readers are programmed at the factory to work with a specific cable connection. Some readers can use multiple connection cable methods, but must be reconfigured whenever the connection method is changed. If a reader is to be used with different workstations or in the field, a programmable scanner may be an option.

Figure 7—These two readers are the same model, but use different methods of connecting to a computer.

The simplest method of connecting a scanner to a computer is through the keyboard port. This method is often called a wedge connector, because the reader is "wedged" between the computer and the keyboard as shown in figure 8. The keyboard and scanner each plug into an arm of the "Y" cable, and the base of the Y plugs into the keyboard port on the host computer. This connection method will work with any program that reads keyboard entries. A decoding scanner or a separate hardware decoder must be used with a wedge connector.

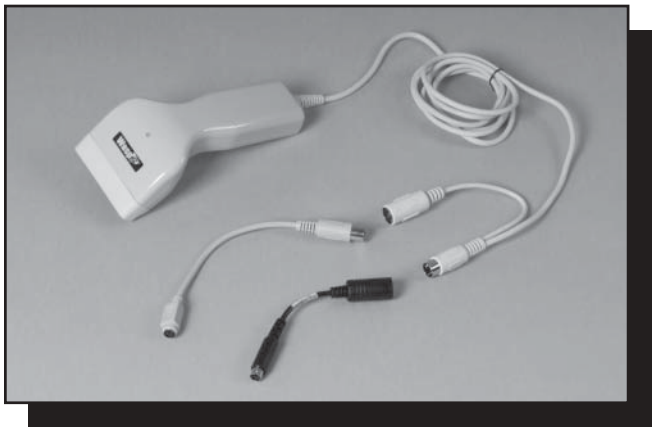

Figure 8—This CCD (charge-coupled device) bar-code reader uses a keyboard "wedge" cable configuration.

Universal serial bus (USB) connections for fixed readers also use Y cable adapters. However, the scanner's cable is attached to a USB adapter (figure 9). The USB adapter plugs into the USB port on the back of the workstation. The keyboard remains plugged into the computer's keyboard port and the third arm of the Y remains unused. This connection method is common with laptop-based systems. Data flowing through a USB connection are read as keystroke entries.

Personal computers, laptops, UNIX terminals, and many other electronic computing devices contain RS232 (serial) ports. The small D-shaped port with nine pins on the back of a standard personal computer is an RS232 port. Connections made using these ports are commonly called serial port connections or DB9 connections. When the bar code reader is used with UNIX or another operating system that supports more than one terminal, the bar-code reader acts like a second keyboard.

Figure 9—A laser bar-code reader with a USB adapter.

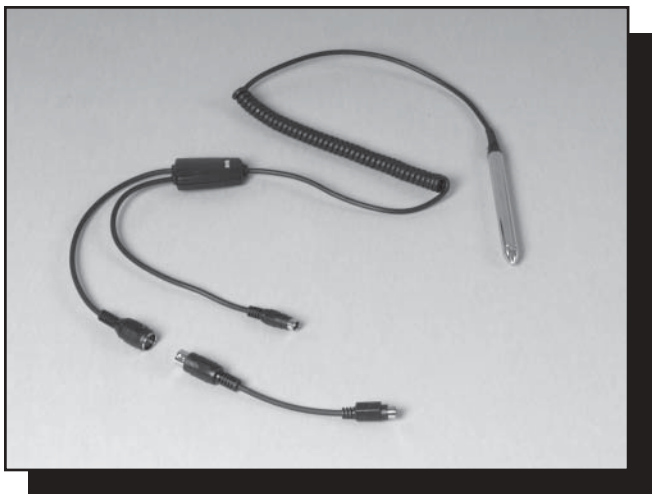

Figure 10—This wand reader uses a keyboard wedge cable. The separate cable is an adapter for older IBM-compatible models.

An RS232 wedge cable connects the scanner to the system. Scanned data will appear as characters on the terminal's screen, just as if a user had typed them in.

On DOS- and Windows-based systems, the computer will ignore the signals though an RS232 serial port unless a communication protocol has been set up. The easiest method of establishing a communication protocol is to purchase a software program. Some program suppliers are listed in the *Additional Information* section of this report. These programs convert scanned data so they emulate keyboard input to the computer. Another method is to write your own data conversion program with a programming language such as C++. A third option is to use a basic serial communications program to save scanned data in a text file that can be imported into the inventory program.

You may need to configure the RS232 ports on both the computer and the reader so they have the same settings. The manual with the reader will contain instructions on configuring its RS232 settings. You can find the current serial setting on Windows computers by clicking on the *System* icon in the *Control Panel* window, selecting the *Hardware*, *Device Manager*, and *View Devices by Connection* options, highlighting the correct COM communications port and displaying its properties.

Fixed Readers—Fixed readers physically attach to a workstation or network through a cable. Wands, charge-coupled devices, and laser scanners all come in fixed-reader versions. Corded models limit mobility to the length of the cord.

Wands are contact readers. Figure 10 shows one of the many types of wand readers. To read a bar code, the wand must be smoothly brushed across the label perpendicular to the lines. These pen-shaped devices are the least expensive scanning option and are available in most connection types. Using a wand to consistently read bar codes requires practice. Extended use can cause fatigue. Some wands will not read high-density bar codes and have trouble with damaged labels and uneven surfaces. Wands are not recommended for intensive bar-code scanning applications.

Like wands, charge-coupled devices (CCD) require physical contact to scan a bar code but they use a point-and-shoot method similar to a laser scanner. Figure 11 shows one type of CCD. CCDs are available for most types of connections. CCD readers are intermediate in cost between wands and lasers. CCD devices use less power than lasers, so they may be a good choice when used with a laptop or portable data terminal.

Figure 11—A CCD reader is a good choice when you don't need to scan from a distance.

Laser bar-code readers do not have to contact the bar code. Figure 12 shows a very futuristic-looking laser scanner. If you aim the reader and pull the trigger, the device will read the bar code. Ranges vary from 3 inches to 30 feet, depending on the bar code's density and the range of the laser. Advantages include the ability to read uneven surfaces and poorly printed bar-code labels, and better durability in some models. Lasers seem to be the most ergonomically comfortable scanners, but they require more power than CCD devices and deplete batteries more quickly. Laser bar-code readers cost about twice as much as a CCD bar-code reader.

Figure 12—Laser bar-code readers are a popular option because they can scan from a distance.

Cordless Readers and Adapters—Cordless laser readers are the most common type of cordless bar-code label reader. Laser readers use a base station that connects to the workstation like a comparable corded model. The base station uses radio frequency (RF) signals to communicate with its remote scanner. Cordless scanners are significantly more expensive than wired scanners, but are useful in situations where bulky items cannot easily be brought to the scanner. The range of cordless scanners depends on the model and the operating environment. Interference may occur from multiple RF scanners operating at one time, microwave ovens, cell phones, and other radio sources. Some models have features to correct these problems. RF communications are one way or two way, depending on the model. In one-way setups, the base station will beep when data is received, so the user must stay within earshot to confirm successful transmission. In two-way setups, the base station will return a signal to the scanner confirming that the data was received.

Adapters are also available that will turn some corded scanners into cordless scanners. These adapters are costly. Adapters work only with certain bar-code readers and connections, so you will need to check to make sure that a particular adapter will work with your system.

Portable Readers (Batch Readers)—Portable data terminals and personal digital assistants can be configured for bar-code tracking. They are powered by batteries and used for collecting and storing information at locations remote from the processor. The data are uploaded as a "batch" when the portable reader is connected to the processor.

Portable data terminals (PDT) have a keypad, screen, onboard memory, operating system, and communication ports. Some contain a built-in laser scanner, others include a connection port for a laser, CCD, or wand reader. Figure 13 shows a PDT with a separate laser reader. Most PDT software is easy to understand, taking only a few minutes to an hour to fully learn. You can expect to pay at least $1,000 for a basic PDT. More complex models have correspondingly higher prices.

Figure 13—This portable data terminal uses an RS232 connection to a laser bar-code reader.

Basic PDT models store scanned items in sequence. More complex models allow the user to define input variables. Deluxe PDTs contain sophisticated programming capabilities and extended memory storage. They allow the user to build custom programs that can respond to keyed or scanned inputs, download inventory files, and manage the main database from the PDT. Most PDTs with advanced programming capabilities come with a program generator so that a personal computer can be used to set up the data collection program. Once the collection program is complete, the program is loaded onto the PDT.

Each PDT uses an RS232 serial cable connection and communications program to connect directly to its host terminal or to establish a connection through its docking station. The PDT manual will contain instructions for configuring RS232 ports on the computer and scanner. You can find the current serial setting on Windows computers by clicking on the *System* icon in the *Control Panel* window, selecting the *Hardware*, *Device Manager*, and *View Devices by Connection* options, highlighting the correct COM port, and displaying its properties.

Most PDTs transfer data to their hosts using text files. The user must open the text file and the database or spreadsheet and copy individual values from the text files into the database or spreadsheet. Specialized inventory software can directly communicate with some PDTs, so the scanned data goes directly into the spreadsheet or database. Packaged systems containing compatible PDTs and software are available.

Figure 14—The Symbol SPT 15xx model series are popular entry-level personal digital assistants with an integrated laser bar-code reader.

Bar-code readers for personal digital assistants (PDA) use a laser. You may be able to purchase a bar-code reader expansion pack for your existing PDA. New PDAs can be ordered with built-in bar-code readers (figure 14), or with a bar-code expansion pack. The laser reader on your PDA will not work without a well-charged battery.

Unless PDAs are configured for wireless communication, they use the batch method to transfer stored data. PDAs use a cradle connection through a USB or serial cable. Some operating systems on newer PDAs require the Windows 98 or newer Windows operating systems.

Bar-code expansion packs for PDAs and PDAs with built-in readers contain system files to decode bar codes and send the data to the appropriate data storage software program. Data is normally routed to the program that is currently running, but some models allow the user to configure the PDA to launch the proper program automatically when scanning begins.

Some PDAs include software that can be used to store data, or you can purchase separate software. The software stores data in text files that are “hot synced” into the workstation when the PDA is connected to the processor. Text-based storage software works with almost all inventory programs, but some systems will not import or update data automatically.

Some PDA database programs can be customized to mimic the main database on the workstation. This feature can be helpful when you need to check information at a remote location, but it uses a lot of memory and slows the operation. Each time the PDA is hot synced, the main database tables are automatically updated.

Certain computer-based inventory software programs include partner programs that allow data to be transferred easily between the PDA and the main database. They function like the more elaborate database programs described above.

Wireless Data Collection Systems

Wireless systems allow portable terminals to transmit and receive information instantaneously from a remote workstation or server. They allow mobility and continuous access to information. Data are always up-to-date, accessible, and can be managed by any user within radio frequency range.

Wireless systems can be simple or complex, depending on the size of the coverage area, the RF environment, the complexity of the bar-code system itself, and the existing computer network. Implementing a wireless system requires a strong knowledge of computer networking protocols, a working understanding of Visual Basic or C++, and knowledge of RF communications. If you don't have access to programmers and radio technicians inhouse, but absolutely need a wireless system, you will need to hire those experts. Wireless systems are far more expensive than connected or batch systems.

Wireless Integration

Wireless equipment uses radio waves to communicate with the network. Providing dependable RF system connectivity is not easy in large and complex areas, such as an entire ranger station or a large office building located in an urban setting. When designing a wireless data collection system, you need to address the size of the coverage area, the RF environment, data collection equipment, communication protocols, and integration of the networking components with the bar-code software.

A site survey is usually necessary to determine RF coverage. Many wireless bar-code readers contain a signal-strength utility. You can perform your own site survey by moving throughout the desired coverage area and testing the signal strength.

More access point antennas will be needed to maintain connection to the network for large coverage areas, areas with interfering radio waves, and offices and buildings with numerous interior walls. The range of antennas varies from brand to brand. You may need to place access point antennas in different locations to see which combination of locations provides the best overall coverage. The goal is for your wireless data collection equipment to maintain its connection to the network from any point throughout the site.

The majority of wireless networking equipment uses one of the following four Institute of Electrical and Electronic Engineers (IEEE) transmission standards:

- IEEE 802.11 Data—Rates up to 2 Mbps (million bits per second) in the 2.4-GHz (gigahertz) band.
- IEEE 802.11a Standard—For WLAN (wide area local area networks) operations at data rates up to 54 Mbps in the 5-GHz band.
- IEEE 802.11b Standard—For WLAN operations at data rates up to 11Mbps in the 2.4-GHz band. (WI-FI).
- IEEE 802.11g Upgrade—For the 802.11b standard, allowing data rates up to 54 Mbps in the 2.4-GHz band, backward compatible with 802.11b equipment.

Even though the IEEE protocols are intended to produce seamless communications between equipment of all types, wireless communication equipment from different manufacturers varies slightly in transmission techniques. Therefore, wireless systems should use equipment from a single manufacturer or with a guarantee of compatibility from the vendor.

Wireless Data Collection Equipment

Portable data terminals and personal digital assistants may be used as wireless data collection equipment. The differences between the two types of devices are narrowing as manufacturers combine features once found on just one of the platforms.

Wireless PDTs share many features with PDTs that must have their data uploaded in batches. They include an operating system, keypad, and memory. A bar-code reader is integrated on some models. An RS232 port is provided for connecting a separate reader to other models. A PDT may be paired with its own receiver or use a separate compatible radio receiver. A wireless PDT may cost two or three times as much as an identical batch version.

PDTs with paired receivers are preconfigured for wireless connection, eliminating worries about compatibility with the receiver. Relay stations may be available to increase the range of coverage. Relay stations usually must be wired to the base station. Some paired-system vendors offer an installation CD that will automatically set up an RS232 serial connection for Windows users. Other systems must be programmed to allow the computer to read and write to the serial port.

Most wireless PDTs do not include a paired receiver, so receivers must be purchased separately. You have a choice among a variety of receivers, from short-range office models to long-range outdoor versions.

Wireless PDTs such as the one shown in figure 15 include an internal radio configured to one of several different protocols. The PDT radio must use the same protocol as the receiver.

Figure 15—The radios in wireless portable data terminals are configured for different radio frequency transmission protocols at the factory.

Figure 16—This wireless personal digital assistant contains an internal radio, freeing the expansion slot for a bar-code scanning card.

Figure 17—Most personal digital assistants have only one expansion slot. This expansion pack contains a radio, laser scanner, and separate power pack, transforming a normal PDA into a wireless bar-code scanning dynamo.

Wireless PDAs have a built-in radio (figure 16) or an expansion slot that will accept a networking card (figure 17). Accessories are also available to configure a PDA to make it look and feel more like a traditional bar-code reader (figure 18).

Wireless PDA communication systems use widely available wireless local area network equipment. You will need a compatible RF receiver for the wireless PDA to complete your system. You can use wireless networking cards or access points to communicate with a wireless PDA.

Wireless networking cards (figure 19) are limited to a range of about 50 to 100 feet indoors or 300 feet outdoors. The range varies among cards. They can be used on a single desktop or laptop workstation for RF communication with a PDA. Card systems are a convenient and inexpensive option for small coverage areas such as a chemical storage room.

You may need to use access points for extended RF coverage. An access point, such as the one shown in figure 20, is an antenna integrated with hardware and software that provides a link between wired and wireless data transmission and

Figure 18—Using a personal digital assistant to scan bar codes can cause hand fatigue. Handle adapters are available for many models.

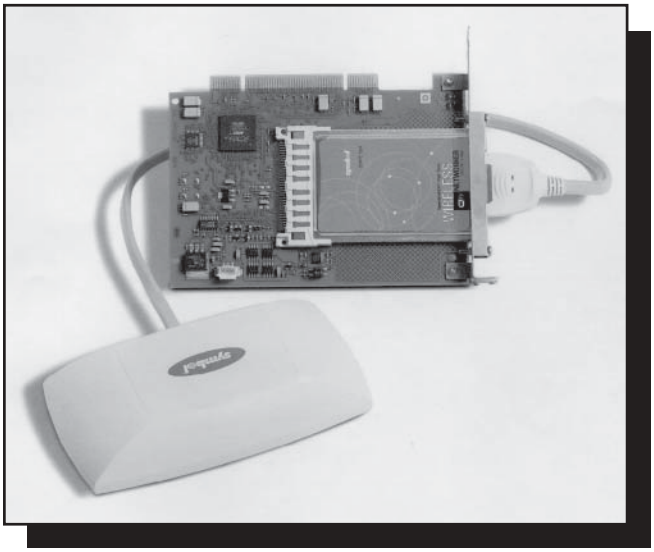

Figure 19—Personal digital assistants and some portable data terminals can use wireless networking cards, such as the PCI card shown, to communicate with other computers and networks.

Figure 20—Access points are the preferred method of establishing radio frequency coverage.

receiving equipment. Access points are usually connected to a wired network or a single workstation by a category 5 cable.

Both PDT and PDA radios communicate with access points. Your access points and radio should be from the same manufacturer or you should obtain a guarantee of compatibility from the access point vendor.

To extend the coverage area for a RF system, use more linked access points or more powerful antennas (figure 21). Linking access points through a wired network will require additional wiring and may require additional network configuration. Large warehouses, depots, and areas with high RF traffic will probably require multiple access points or an optional antenna that is more powerful than the standard access-point antenna.

Figure 21—Use supplementary antennas to increase coverage area or signal strength.

Wireless coverage for several buildings will probably require at least one access point in every building. If you use high-gain antennas, you can cover areas of up to 12 miles in radius without FCC licensing or tower mounts. These systems tend to experience interference in urban areas.

Network and Software Integration

Simple networks can be configured by persons with a basic knowledge of networking protocols using the instructions included with the access point and remote data collector. The resident network support personnel will need to be involved in configuring more complex networks to avoid interference with the existing network.

Once the wired and wireless networks are properly set up, the inventory program and operating system must be programmed to pass data back and forth between the host computer and the remote data collector, and to allow data to be managed from the remote source. Configuring the main data storage program to interact with the remote data collection system requires competency in Visual Basic or C++.

Most radio and remote data collector manufacturers offer free software development kits (SDKs) for modern operating systems such as Windows 2000 and Windows XP. These SDKs greatly ease the process of programming. Resourceful programmers may find free sample programming code for their applications from developer's forums available on the Internet.

Recently, expensive new software has been developed to reduce or eliminate configuration programming. Because of the enormity of possible equipment and software combinations, these programs can be used successfully only by those with excellent computer skills. In the future these programs will become easier to use and less costly.

Additional Information

The following Web sites are among those addressing bar-coding issues and equipment. Interested readers are encouraged to search out other Internet sites that may address their specific interests.

General Bar-Code Information Web Sites

http://www.adams1.com
—Bar Code 1 is an independent Web site devoted to everything bar coded. It contains short assessments of equipment and software from many different suppliers and links to the suppliers themselves.

http://www.aimusa.org/
—The Association for Automatic Identification and Data Capture Technologies (AIM) is a global trade association.

http://www.barcodeunlimited.com/
—Barcode Unlimited.com is a site explaining the history and technology of bar codes.

Government Resources

http://fsweb.r9.fs.fed.us/special/data_recorders/index.shtml
—USDA Forest Service portable data recorder teamroom

http://tis.eh.doe.gov/web/chem_safety/chemprofiles.html
—Profiles of U.S. Department of Energy installations using bar-code inventory and chemical management systems

Bar-Coding Industry Web Sites

http://www.eiminc.com
—Electronic Imaging Materials, Inc., bar-code labels and systems

http://www.microsoft.com/mobile/default.asp
—Microsoft's mobile computing Web site

http://www.palm.com
—Palm's mobile information management Web site

http://www.pscnet.com/index.htm
—PSC data capture systems Web site

http://www.symbol.com/index.html
—Symbol's mobile computing Web site

http://www.systemid.com
—SystemID bar-code products and services Web site

http://www.waspbarcode.com/default2.asp
—Wasp bar-code system Web site

http://www.barcodehq.com/index.html
—Worth Data bar-code systems and products Web site

Inventory and Tracking Software Web Sites

http://www.backtrackgroup.com/index.html
—BackTrack Web site

http://www.bar-scan.com/
—Bar/Scan, Inc.'s, bar-code asset management system Web site

http://www.chemsw.com/
—ChemSW, Inc., chemical inventory system Web site

http://www.pscnet.com/html/applicationsoftware.htm
—PSC tracking system Web site

http://www.waspbarcode.com/default2.asp
—Wasp bar-code Web site

Port-to-Keyboard Data Transfer Web Sites

http://www.easydataproducts.co.uk/
http://www.easydataproducts.co.uk/com2key/index.html
—Easydata's web site (Pay special attention to the *Easy Com2Key* section.)

http://members.aol.com/idinnov/
—ID Innovations, Inc., Web site

http://www.barcodehq.com/index.html
—Worth Data

PDA Data Storage Software Web Sites

http://www.fieldpalm.com/
—FieldPalm Solutions Web site

http://www.microsoft.com/mobile/developer/technicalarticles/sqlserverce.asp
—Microsoft's SQL PocketPC-based software Web page

http://www.microsoft.com/mobile/pocketpc/tips/database.asp
—Microsoft's PocketPC Database Options Web page

http://www.symbol.com/products/mobile_computers/mobile_palm_applications_solut.html
—Symbol's palm-based applications Web page

Wireless Technology Organization Web Sites

http://www.wow-com.com/
—Cellular Telecommunications & Internet Association (CTIA)

http://www.ieee.org/portal/index.jsp
—Institute of Electrical and Electronic Engineers, Inc. (IEEE)

http://www.wlana.com/index.html
—Wireless LAN Association

Wireless Technology and Equipment Web Sites

http://www.connectworld.net/interface-troubleshooting.html
—Connectworld interface troubleshooting Web page

http://www.dlink.com/
—D-Link networking, broadband, digital electronics, voice and data communications solutions Web site

http://www.symbol.com/products/whitepapers/whitepapers.html
ftp://symstore.longisland.com/Symstore/pdf/RFsitesurvey.pdf
—Symbol's white paper Web page (Pay special attention to the article on *RF Site Survey and Antenna Selection for Optimum Wireless LAN Performance.)*

http://www.telexwireless.com/index.htm
—TELEX wireless products Web site

http://www.taltech.com/TALtech_web/resources/intro_to_bc/bcsymbol.htm
—TalTech's bar-code symbologies Web page

General Information on Bar-Code Systems

The document *Bar-Code Tracking System Overview* (0271–2333–MTDC) provides a general overview of bar-code tracking systems, and provides examples of systems addressing Forest Service needs. *Bar-Code Tracking System Overview* may be ordered from:

USDA Forest Service, MTDC
5785 Hwy. 10 West
Missoula, MT 59808–9361

An electronic copy of *Bar-Code Tracking System Overview* (0271–2333–MTDC) will be available on the Internet at:
http://fsweb.mtdc.wo.fs.fed.us/cgi-bin/enter.pl?link=pubs

Notes

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Kathleen Snodgrass came to MTDC as a project leader in 2001 from the Nez Perce National Forest. She had been the facilities architect for the Nez Perce National Forest for about 7 years and had worked in facilities, landscape architecture, land line, and general engineering on the forest for about 10 years before that. She spent about 10 years in highway design and construction with the Idaho Division of Highways after graduating from Washington State University in 1974 with a bachelor's degree in architectural studies.

Library Card

Snodgrass, Kathleen. 2002. Assembling a bar-code tracking system. Tech. Rep. 0271–2834–MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 18 p.

Provides detailed information for setting up a bar-code tracking system. The report includes descriptions of bar-coding equipment, data collection and storage software, methods for setting up and running a bar-code system, sources of equipment, tips for using a bar-code system, and other useful information.

The report's companion publication, *Bar-Code Tracking System Overview* (0271–2333–MTDC), has general information about how a bar-code system works.

Keywords: bar code, barcode, chemicals, data collection, data recorders, hazardous materials, hazmat, inventories, networks, Palm Pilot, PDA, PDT, personal digital assistants, pesticides, portable data terminal, portable instruments, scanners, scanning, symbology codes, tracking, tracking systems, wireless communications, WI-FI, WLAN

Additional single copies of this document may be ordered from:
USDA FS, Missoula Technology and Development Center
5785 Hwy. 10 West
Missoula, MT 59808–9361
Phone: 406–329–3978
Fax: 406–329–3719
E-mail: *wo_mtdc_pubs@fs.fed.us*

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Copies of MTDC's documents are available on the Internet at:
http://www.fs.fed.us/cgi-bin/enter.pl?link=pubs