



Implementing a Barcode Tracking System is Easy, Isn't it?

Introduction

Plugging a barcode scanner into the USB port of a computer and having the scanned barcode data “magically” appear in the keyboard buffer, as if you had typed it in, makes the development of barcode data collection systems seem trivially easy. And yet, over the past decade, many organizations have spent hundreds of thousands and sometimes millions of dollars on tracking systems that have failed. These systems have sometimes failed technically but more often they have failed because the resultant systems failed to meet the many diverse operational needs of different users within the implementing organizations.



In this paper we will focus on the project management and people issues facing organizations such as manufacturers, food processors, and industrial distributors who face the issues of not only tracking materials but also of tracking work-in-process. Tracking the location of materials, such as in a pure inventory tracking system, is reasonably straight forward. But as soon as we have to also track the transformation of those materials, these projects get really complex as they involve a lot of people within the organization.

While most of us think in terms of classic manufacturing, materials transformation also occurs in food and drug processing, reagent and DNA sample tracking, document and repair tracking, as well as in packing and labeling products. So many non-manufacturing organizations are also faced with the same complexities when they come to implement tracking systems.

In this paper we will look at the people issues that need to be addressed as well as the multiple disciplines that need to be integrated into an implementation team in order to successfully implement a tracking solution.

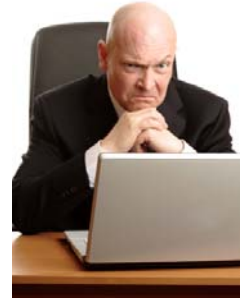
Here we will use the term industrial organization to refer to organizations as diverse as manufacturers, distributors, food and drug processors, laboratories, repair depots, mineral extractors, and defense and building contractors. We will use the term facility to refer to a single manufacturing plant, distribution center, laboratory complex or repair depot that exists at a single geographic location.

Driving Forces

I have led a team that has implemented over 70 barcode and RFID tracking solutions over the past decade. I always feel that we are in the “burglar alarm” business, in that almost nobody decides to implement a tracking solution until something goes wrong; just like the burglar alarm sales people never sell anything until after someone has broken into a home or office.

We have lots of conversations with prospective clients about ROI (return on investment) and how many barcode tracking systems will pay for themselves in less than 6 months due to efficiency savings. The results of these conversations usually appear in justification documents

to senior management but no-one, in my experience, ever committed the funds to implement a tracking system based on ROI. Even where there were spare capital funds for a tracking system, we have lost out to other worthy causes such as a new BMW for the company President or a paint reclamation system for the production people.



Sometimes the driving event is very personal, such a materials manager deciding that they are never going to spend another Christmas away from their family to take inventory again. Sometimes it is major, such as the FDA threatening to put you out of business by ordering a major recall. And sometimes it is just “the straw that broke the camel’s back” such as another large chargeback penalty from a customer or bill for expedited shipping charges because some employee made a dumb mistake.

While they may be one event that causes an organization to implement a new tracking solution, it is important to recognize that there will be many users of the resultant system, with different and sometimes conflicting needs. The event that causes the decision to implement a tracking system may be a major mistake by an employee, an old system ceasing to function, or a demand by a key customer to provide electronic tracking data to them. But as soon as the decision is made to even think about implementing a system, all the pent-up needs of other factions will quickly come to the fore.

Some of the driving motivations we have seen are:

1. Company President or division manager – improve competitive position by having better capabilities than the competition (visionary)
2. Sales – deliver customer orders on-time with correct materials, labeling and packaging (increase personal compensation by selling more)
3. Operations – keep track of customer orders in real-time and prevent mistakes (make my life easier)
4. Inventory manager – track materials and work-in-process accurately (no more nights and weekends)
5. Quality Control manager – prevent mistakes and capture traceability data (prevent mistakes for which I get blamed)
6. Information Technology (IT) manager – replace old technology with new technology (career enhancement)

Noticeably absent from this list is “to make life easier for employees”. Implementing a tracking system will not make life easier for your employees. All the benefits accrue to the senior management team and the stakeholders in the success of the organization. Employees will have to learn new skills and will have to do more work in that they now have to do barcode scanning and other data entry tasks. Barcode scanning may replace some paper and pencil data entry tasks but I can guarantee that the people who actually do the barcode scanning will have a large amount of fear, uncertainty and doubt about the new system (the FUD factor).

Even worse, many workers suspect (rightly so) that management will be tracking their activities much more closely. This leads to a lot of push-back, especially from long-term employees who have been “coasting” at their jobs. It is a truism of operations management that the performance of most non-management employees quickly sinks to equal the performance of the least productive worker (who can get away with it) in the group. By gathering accurate and timely performance data, managers can start to weed out under performing employees and more highly reward those who perform at a higher level.

So between the FUD factor and the rational fear by under-performing employees, the internal management team can expect a lot of push-back. Many tracking projects have been scuttled before they got started because management did not want to handle these human resources issues (or had lost effective management control of their organizations). So I advise managers never to tell employees that this will make their job easier. Tell them instead that data collection will now be an integral part of their jobs. Also tell them that you expect a certain percentage of employees will not be able to, or want to, master these new skills and will need to find employment elsewhere.

Pre-Implementation Planning and Budgeting

Implementing a barcode tracking solution to solve a business problem is not just a matter of buying some packaged software, plugging in a CD-ROM and running it. It is critically important to realize that the successful implementation of a tracking solution is a serious project that requires an interdisciplinary team with many skills.



Before starting implementation, it is essential to accurately define the objectives of any barcode tracking project and to plan and budget for its implementation. Some of the steps in this process are detailed here:

1. Appointment of an internal organization project manager and champion. While collaboration is important, it is even more important to have someone in charge of the project on a day-to-day basis. Barcode tracking systems projects cannot be managed by a committee. You need a strong internal project manager who works collaboratively with a team of internal and external people to get the system implemented. This project manager may be from operations, IT or manufacturing engineering. The most important skill here is that of project management. Also an in-depth knowledge of company politics and the competing aspirations of different departments and their managers is essential.
2. Documentation of problems to be solved. These problem description(s) usually come from the operating department(s) of the facility that is having the problems. Not infrequently the presenting problem (“I want to track inventory better”) masks an underlying personal goal (“I am fed up with working nights and weekends to sort out this inventory mess”). It is important that the problems get documented along with the anticipated outcomes, both operational and financial of implementing a tracking solution. It is the internal project manager’s responsibility to make sure that the problems and the anticipated solution outcomes get clearly documented. It is also critical to get inputs from all the relevant parties to an internal decision.

3. Prioritization of the problem solutions. There is never enough money to solve everyone's problems. So problems and their solutions need to be prioritized. Even if money is no object, it is critical to tackle problems one at a time so the team does not get overwhelmed. Usually the priority of fixing a problem is directly correlated to the cost of fixing the problem. If the organization has a big problem that can be fixed for relatively little money then this tends to have high priority. On the other hand, we have seen situations where the "stove-pipe" needs of a department, while very genuine, are of lower priority than fixing a strategic marketing problem for the company. Here an external consultant with lots of experience in implementing similar tracking systems can give quick "back-of-the-envelope" problem solution cost estimates that can help guide the prioritization process.
4. Preliminary systems design and cost estimating. In this step of the process, the operational problem(s) to be solved are mapped to a preliminary systems design. This preliminary systems design usually involves selection of the software and hardware components of the system. These are then used to develop a cost estimate based on the cost of the software, equipment and professional services needed to implement the proposed system. This requires a systems architect who is knowledgeable about both the operational and technological aspects of tracking solutions. Most mid-sized industrial organizations will not have a systems architect with the appropriate cross disciplinary skills on their staff, so they will need to be guided by an external consultant.
5. Budgetary approval by senior management or board of directors. It is critically important to get this approval before proceeding with the project as the necessary funds may not be available (and everyone would waste their time). The cost of departmental tracking systems starts at ten thousand dollars and up and the cost of a company wide system, operating at multiple facilities, can cost several hundred thousand dollars. In most organizations the funding of these systems is part of the capital budgeting process (which may be very informal or very formal). This approval requires the preparation of a preliminary proposal and budget plus a cost justification. The preliminary proposal is typically prepared by the external organization that will lead the external team assisting their client to implement a tracking system.
6. Selection of the internal team. A single internal project manager cannot do it all. The team should have representatives from operations management, materials management, IT and manufacturing engineering (or equivalent). The CFO or division comptroller should also be part of this team but may not attend all of the team meetings. The company President or division manager will take more or less interest depending on how well (or badly) the project is progressing.
7. Once the project is approved, at least in principle, the next step is to do process mapping. This involves a number of steps:
 - a. Determine what real-time information screens and reports will need to be produced by the tracking system, including details of the data fields. This will help identify the data to be collected.
 - b. Identify data to be transferred from the tracking system to external systems. Document frequency of transfer and data fields to be transferred as well as

mechanisms to be used (interface to external system API, ODBC connection to database, flat file).

- c. Determine all the places where data collection will take place and the most appropriate equipment to use (PCs with barcode scanners, mobile computers, RFID portals, weighing scales, tie in to process control equipment, barcode printers, etc.).
- d. Document and identify equipment to be used. This may be conditioned on the capabilities of the software it is proposed to use. Get quotes for equipment to be used.
- e. Document the data entry sequences to be used. Note that the choices here may be conditioned by what is available as standard in the software it is proposed to use.
- f. Identify data to be transferred into the tracking system from external systems to avoid duplicate data entry. Document data records and fields and data transfer mechanisms.

This is usually done by an external consultant who has interdisciplinary knowledgeable and many years of experience about operational data collection processes, tracking software, barcode, RFID and wireless mobile computing. This consultant will work with the internal team to do the process mapping. Frequently, this requires a visit to the client's facility but may be performed remotely for simpler applications.

8. Selection of the tracking software to be used. This is usually done by the internal team in collaboration with the consultant who assisted with the development of the process mapping document. There are a number of alternatives for the acquisition of the tracking software:

- a. Develop a custom tracking solution "from scratch".

Unless the tracking application is trivial (such as scanning barcode labels into an Excel spreadsheet) this is the most expensive and high risk way to go. It is not uncommon for companies to spend in excess of \$300,000 on programmer salaries in developing a custom production and inventory tracking application.

Even then, the resultant system has a high probability of not being used operationally because it takes so long to deliver that the requirements change in the mean-time. More importantly, the software development team often does not have the knowledge of how to do material and work-in-process tracking from an operational viewpoint (especially if an off-shore team is used) and so produces software that is not useable in practice.



- b. Customize an existing ERP (Enterprise Resource Planning System). These systems know about inventory, jobs and work-in-process. They often have manufacturing and warehouse management modules. Sometimes they have rudimentary barcode tracking capability. It is tempting to think that it will be easy to extend these systems to add needed capabilities such as license plate and nested container tracking.

Many companies have expended well over \$100,000 on consultants to modify their ERP systems to add the needed barcode tracking and real-time data capture capabilities. Provided the consultants are knowledgeable about both the internals of

the ERP system and are also knowledgeable about production and inventory tracking (read expensive labor rates) then these conversions seem to work fine.

The big problem with this approach is that, once the ERP system has been customized, then it is impossible to upgrade the ERP system without paying the same expensive consultants about 60% of the original customization cost to move the software changes to the next version. As new versions of most ERP systems come out every 6 months, this can get very expensive. The alternative is to not upgrade, which is why we see so many organizations with customized ERP systems of Y2K vintage. As the underlying operating systems go off-support because of security issues, these are becoming increasingly problematic.

- c. Add point-solutions, such as production tracking, warehouse management or asset tracking software to an existing ERP or accounting system. This can be an economical way to go, if a single point solution will meet the needs of an organization and the software product has a pre-built interface to your version of your accounting or ERP system.

Some point solution software products are available for as little as \$1,000. But, being packaged software products, they are not customizable; so the internal team has to carefully study the capabilities of the proposed system to make sure it really does meet their needs. Some more expensive point-solutions can be customized but it is not unusual for organizations to spend tens of thousands of dollars or even more on this approach.

The biggest problem with this approach comes when more than one point solution is required, such as tracking both inventory and production. Now you have to integrate two different point solutions with your ERP or accounting system and make them all work together. The real-time interface and data exchange problems cause many of these projects to fail operationally or to cost hundreds of thousands of dollars.

- d. Purchase a new ERP system that purports to have all the capabilities the organization needs in one system. While this may benefit the commissions of ERP sales people, inevitably the new system does not meet the tracking needs of the organization and in most cases the purchasing organization finds themselves back in the situation described in (b) above.

That is not to say that an organization does not need to also upgrade their accounting or ERP system; but such an upgrade will inevitably not solve their tracking problems. It may, however, be beneficial to coordinate the purchase of a new accounting or ERP system with the purchase of a tracking system to avoid duplication of function.

The author has seen many cases where organizations have purchased expensive ERP systems with many modules they never used when they could have achieved the same result with purchasing a simple, inexpensive accounting system combined with a tracking system that meets their needs.

Most organizations never use the planning capabilities of their ERP systems because they are too complex for many mid-sized organizations to use. Instead they use their

ERP systems as glorified accounting systems. This is OK if only the accounting modules are purchased but not OK if the organization is sold many expensive modules they will never use.

While newer ERP systems do support barcode scanning capability (usually very limited unless you are paying over \$100,000 for the ERP software) they do not support the wireless mobile computer technologies, such as store-and-forward, that are essential for reliable operation in most industrial environments, except as expensive point-solution add-ons.

The other problem with this approach is all the retraining that will be needed for the people who use the existing accounting functionality. This is very expensive and in many cases unnecessary as all that is needed is to interface a tracking system to the existing accounting functionality.

- e. Purchase a modular tracking system, such as BellHawk, that provides the middleware layer between the barcode, RFID and wireless mobile equipment and the front-office accounting, ERP and CRM systems. This software typically costs in the range of \$5,000 to \$25,000 depending on the modules selected plus the cost of software and interface customization.

The benefit here is that the software modules normally provide over 95% of the needed lines of code working out-of-the-box, thereby substantially reducing the time and cost of implementation. As the modules are designed for customization and rapid systems integration, this can be usually completed quickly and cost effectively.

Another benefit is that the existing front-office accounting and sales order entry functions can be left undisturbed when implementing the tracking solution.

- 9. Selection of the Wireless Mobile Computer methodology to be used. This is only applicable if you are planning to use wireless mobile computers with integral barcode scanners (or RFID scanners) for data collection. This is generally determined by the organization's IT staff working in collaboration with the software and equipment vendors. It may have a major effect on the selection of the software to be used.



There are two critical issues that impact this decision:

- a. The need to do point-of-action validation of the data captured and to warn users if they are about to make an operational mistake.
- b. The environment in which the wireless mobile computers will be used. Most industrial environments and warehouses have lots of metal racking and equipment that block and absorb the radio waves. They also have lots of liquids and solids that can block and absorb these same radio waves as well as electrical machinery and industrial process equipment that can interfere with the transmission of data between the mobile computers and the wireless access points.

The choices of wireless communications methodology are

- a. Terminal server, web server or client server. Here the database against which the point-of-action validation is performed is on the main tracking database server. This then requires 100% wireless coverage with no blind-spots and no interference from electrical machinery or industrial processes.
- b. Store and forward. Here all the data validation is performed against a local database in the mobile computer. This provides rapid response and warnings to users irrespective of whether they are in communications or not at the time of data entry. Data is stored in the local database, in non-volatile memory, as it is captured. Then this local database is synchronized with the main server whenever it can access the main database.

The benefits of the store and forward approach are:

- a. Data is transferred to the main server in essentially real-time when the mobile computer is in communications range of an access point.
- b. The unit automatically switches to “batch” data collection mode, with local error checking against a subset of the main database, when the unit is out of range.
- c. Data is saved in local non-volatile memory until it can be successfully transferred to the server. The mobile computer keeps retrying, without user intervention, until it receives an acknowledgement that the data has been successfully stored away on the disk of the main server.
- d. Each mobile computer has a large subset of the data from the main server in its local database so the mobile computer is able to make complex decisions about whether to issue warnings to the user. This data synchronization takes place without user intervention.
- e. Considerable cost savings is achieved by minimizing the number of wireless access points, antennas and wiring needed. Instead of needing a wireless survey followed by the installation of many expensive antennas and access points, it is sufficient to make sure that mobile computer users have frequent line-of-sight visibility to an antenna as they move around the facility. It is often possible to cover a complete plant and large warehouse with two or three access points.
- f. Store and forward technology enables scanning and data entry to take place in yards, off-site storage locations and in the field where there is no data communications. It can also be used over Internet communications links from remote facilities and over the cell phone data network.

10. Selection of the external implementation support team. Here there are choices:

- a. Use one external organization that has all the skills needed in-house to complete the project. This is usually the most expensive option. It is mostly chosen by “Fortune 1000” companies who will hire a major contractor such as IBM or CSC and spend millions of dollars on their project.

- b. Have your project manager act as the general contractor for the project. This works well, and is the least expensive, especially if you have an experienced IT or manufacturing engineer project manager. Here the project manager will separately purchase the software, equipment and services from a team of vendors.
- c. Have an external organization act as the prime contractor for the project. Here the external organization provides a project manager who will work with the internal project manager to coordinate a team of subcontractors, who will supply the various components for the system.

The choice of which way to go will depend on the available budget as well as the skills and time available of the internal project manager.

11. Document in detail and cost-estimate the software customizations to be performed. This is usually performed by the organization that will do the customizations. This may be the supplier of the tracking software or it may be an internal software development group providing that they have access to the source code. In the latter case, the cost estimate should include the cost of training in the internals of the tracking software. Sometimes the reports are customized by the client organization and the scan sequence customizations are customized by the supplier of the software.
12. Document in detail and cost estimate the implementation of interfaces between systems. This should include choosing interface development toolsets and documenting how they will be used. This is usually done as a team effort between specialists in the tracking system interfaces and experts in the interfaces to the accounting, ERP or CRM systems being interfaced to.
13. Develop and cost-estimate a training and go-live support plan. This may be as simple as training the project manager, who will train and support everyone else. It may involve external training and support consultants who are familiar with the operational application of the tracking software.
14. Develop a detailed budget and schedule for the project and get senior management approval. This will include schedules of payments to vendors and project milestones upon which the payments are based. Once approved, then implementation can proceed.

It is important to recognize that most industrial organizations do not have the needed interdisciplinary skills to carry out the above processes by themselves. They will need to hire consultants with the appropriate skills to assist them. They will also need to engage vendors of software, equipment, as well as training and support services in dialog and to get needed quotations. In some cases, such as detailing software customizations, these organizations will expect to get paid for the engineering services they provide.

Implementation Process

It is critically important to realize that the successful implementation of a tracking solution requires an interdisciplinary team with many skills. This section describes some of the tasks that need to be undertaken and the skills required.



1. Let contracts for the supply of the software, equipment and needed professional services. This is a purchasing function but the internal project manager will need to be heavily involved in this process to make sure mistakes do not occur. Normally these contracts call for scheduled delivery of the software and hardware (which often require substantial prepayments) and incremental payment for services.
2. Perform the needed software customizations. This may be done by the tracking software vendor or the IT staff of the client or a mix. These customizations may be delivered incrementally, as needed, to support incremental training and deployment schedules.
3. Setup the database server. This is typically performed by the internal IT staff or the organization providing IT support to the organization. The server may be an existing server or a new server may be purchased for the tracking system. The database, such as SQL Server, will need to be installed and configured as will the security access privileges to the server. This is followed by the installation of the server-side components of the tracking system. Again this can be performed by the client's IT staff by simply following the installation directions.
4. Setup a training-room pilot installation. This will be used for training of managers, supervisors and employees who will do the actual scanning. This training room pilot will initially have a PC equipped with a barcode scanner and a laser printer. As training progresses a barcode printer and a wireless mobile computer may be added to the training room pilot. This installation and setup can be done by the IT department.
5. Train the project manager and internal team members in how to use the software. Today, this is often done on a remote basis using PC based video conferencing. We have found that an hour or so each day of remote hands-on training for a week is much more effective than a concentrated day of classroom time. This training is typically provided by the vendor of the tracking software.
6. Implement the interface from the tracking system to the other systems. This is usually done by a combination of consultants who are specialists in the external systems interfaces and experts in the tracking system interface.

Once the data elements to be exchanged between the systems are defined then much of the interface development work can be automated using available software tools. Mostly these tools require the entry of table and field data definitions and automatically then they generate the needed interface code. The needed expertise is in the data to be exchanged and the foibles of the target system relative to what data it will and will not accept.

The implementation of interfaces is usually started immediately after the database server and training room pilot are setup. Interface implementation may be done in parallel with training the inside team unless the interface is a critically important part of the user experience. Very often data such as purchase and sales orders can initially be entered directly into the tracking system and then later imported from accounting and sales order management systems.

Usually that part of the interface needed to get setup data into the tracking system is implemented first and then exports are implemented later. In many cases, organizations elect to run their tracking systems stand alone until they are operating successfully in this mode and then they implement automated interfaces.

In many cases organizations start out using manual data transfers, using comma delimited files to get setup data and even operational data into the tracking system.

Thorough testing of interfaces is essential. It used to be essential for developers of interfaces to go onto the client site to do this testing. Now that developers can have secure access to a server over the internet, this is no longer required unless the security policies of the organization preclude this.

7. Setup the data needed by the tracking system such as units of measure, item master parts lists, employee access privileges, work centers and operations. This data may be entered directly or, where appropriate, it can be imported from another system and then edited or additional information added where needed.

This is a major project all of itself and can take an organization weeks or months to complete. This work is performed by the inside team, usually augmented by lead people who are familiar with the data items being set up. These people will need training in how to do the data setups. Also IT may be involved in transferring data from other systems to the tracking system.

The most important thing to note is that there are many possible ways of using a tracking system. These differences are reflected in the setup data. Many of the high level decisions will have been made in the process mapping step but there are a thousand and one details that can trip an inexperienced user up.

Some typical issues that confuse people are:

- a. Do we use the same part number for the same material when it appears in different configurations?
- b. Do I use separate operation codes for the same operation performed in different work centers?
- c. What is a work center and how does it differ from an inventory location?

At this stage, if the inside team does not have the needed experience, it is recommended that an outside consultant, who has been through this before, be used to guide and advise the inside team in this process. This is usually done on a remote basis.

I also advise the inside team to only put in a limited amount of data, enough for testing out the most common operational scenarios but not more. The reason is that, inevitably,

decisions made about setup data turn out to be wrong once everyone gets to try out using the system in a training room environment.

In trying out the system in a training room environment, a tremendous amount of organizational learning takes place leading, usually, to a decision to wipe out the contents of the pilot database and start again before the system goes live. Sometimes it takes two or three attempts to get a data representation for what goes on in the facility that everyone is happy with. So keeping the amount of training data small saves a lot of data entry and setup time and encourages experimentation.

8. Introduce barcode printers and possibly RFID tag encoders into the training room pilot. These require the installation of a barcode label generation program that provides the interface to the printer and is compatible with the tracking software. The installation of the equipment and the software is usually performed by the vendor of the equipment. The vendor will also be able to provide needed supplies such as labels and ribbons.

Note that it is recommended that, initially, people using the training room pilot use pre-printed rolls of “license-plate” tracking barcodes for training as these do not require any training in the use of barcode printers. Some organizations keep using these license-plate tracking barcodes forever as they are simple and can be ordered at modest cost from a variety of suppliers. But other organizations need to have labels that have human readable and hazardous materials information printed on their labels along with the tracking barcodes. These organizations then need to master the complexities of barcode printers.

Barcode printers that are capable of printing labels that will stand up to the abuse of industrial environments typically use a thermal-offset process that melts a wax or resin ribbon onto a plastic substrate. These are much more complex to setup, use and maintain than your office laser printer. It is essential that users be trained in how to use and maintain these printers. It is also important that a field technician from the vendor periodically services the printer.

Once the printer is installed and up and running, then one or more people at the using organization need to be trained in how to use the label software. Usually this training has two parts:

- a. Training in how to use the label generation software to create new label formats. This is usually done through a mix of on-line training provided by the developer of the label generation software and training provided by the supplier of the barcode equipment and software.
- b. Training in how to setup the field name relationships in the label software so they will be automatically recognized by the tracking software. This is usually provided by the vendor of the tracking software to the IT department.

If barcode labels with embedded RFID tags are to be used, then a more complex printer is needed and more training needs to be provided in the use of the printer and the setup of the label in the label generation software. Expert advice is also needed in the types of RFID tags to use for specific applications.

9. Adding mobile computers to the training room pilot. Here there are several parts to the process:
 - a. Loading the tracking software onto the mobile computers and on the main server. This is typically done by the IT department but the mobile computers may also come with the software pre-loaded by the mobile computer vendors.
 - b. Installing and wiring wireless access points and antennas. A simple office desktop access point may initially be used for the training room pilot but we highly recommend installing industrial access points before system's deployment.

Please note that the access point(s) and the main server need to be connected to a router to enable return path routing back from the main server to each individual mobile computer.
 - c. Setting up the wireless access points and their security parameters to enable the wireless mobile computers to communicate with the server. Also setting up the security parameters in the wireless mobile computers to enable them to communicate with the access points.
 - d. Testing that the wireless mobile computers are collecting data correctly and are relaying this correctly to the main server.

Installing the access points and antennas and related wiring may be done by the suppliers of this equipment or by the organization's own maintenance department. But, if an organization is using its own electricians, please make sure that they closely follow guidelines for antenna mounting and placement and cable run limitations.

Setting up the security parameters for the access points and the mobile computers will typically be performed by the organization's IT staff assisted by the equipment vendors, as needed.

10. Preparing to train users in how to perform data collection tasks. Here it is important to realize that data collection takes a small amount of a lot of people's time. The task of data collection should be segregated into actions that need to be performed by individual people or small groups of people. Material handlers doing picking, packing and shipping do not normally need to scan work-in-process between jobs so they do not need to learn these data entry actions.

For each role, it is important to prepare a sequenced list of the steps to be taken in each type of data entry that a person in that role is responsible for. These lists typically have the barcode label or a picture of the icon to be selected to initiate the scan action.

These instruction sheets are used as the basis of training users. They should be in language that the users are familiar with in their everyday usage at the plant or facility.

11. Train the users in how to perform data collection, using the training room pilot. It is beneficial to do this on a functional area by functional area, such as by starting in receiving and then moving to stock room operations. Sometimes it is useful to start with supervisors and lead people and then progress to material handlers and production workers.

This training can be done by the project manager and members of the inside team, if they have time. If not, then an external training organization can be used.

Several points to note here for the trainer(s):

- a. Pay special attention to feedback from the trainees about how the system will be used. They may well spot issues that have not been thought about and could cause operational problems if not fixed. These can sometimes require additional customization of the software to handle special cases. These conversations often begin in the form “What about the special shipment we make to XYZ Company once a quarter?” and lead to some very interesting conversations amongst managers who were not even aware of the transactions that will cause trouble if not handled..
- b. Pay attention to suggestions by trainees about how the data collection process can be improved and especially suggestions about how overall operational flow can be improved as a result of implementing the new tracking system. These are “Kaizen” events that can lead to some significant grass-roots reengineering activity.
- c. Tell employees that the intent is not to make any major changes to operations (unless major changes are planned) but simply to capture data about jobs and materials. This is to minimize the pushback due to the FUD (fear, uncertainty and doubt) factor. We have found that implementing a new tracking system can facilitate major changes and improvements in the ways that an organization does its business. But we do it in such a way that people don’t feel threatened by all the negative connotations of process re-engineering (job loss or other negative personal impact of major changes). Instead we enable them to make the changes, all under the guise of collecting data.
- d. Train the users to do their data collection tasks on at least three separate occasions and, even then, they will make mistakes when the system goes live.
- e. Encourage trainees to bring examples from their regular work-flow so that they are working on real-data. This may need some preparation by the trainers but is well worth while to ensure familiarity.

12. If the system is to be deployed in a warehouse or stockroom then all the shelves, bins and racks and floor locations need a tracking barcode. Locations should be given a rational code that is meaningful, such as “E24C” for aisle E, bay 24, shelf C, so that these are easy to identify and recognize by material handlers. The location barcodes can be printed internally, if an appropriate barcode printer is available, or outsourced to label printing organization. Large retro-reflective barcodes, suitable for hanging over floor locations, will be to be ordered from the providers of these specialty labels.



This activity can be handled entirely by the internal team although it may be beneficial to subcontract the whole time-consuming job to an organization that specializes in labeling warehouses and stock rooms.

13. Preparing for deployment. The keyword here is incremental. Do not attempt to go live with your tracking system in all departments and functions at once. This is a recipe for disaster.

Start in receiving or shipping or somewhere in the middle and get the data collection for that function working and then move onto the next.

The reason for incremental deployment is that, despite all the training, people will make a lot of mistakes and have a lot of questions. You will need to have one or more people dedicated to helping these new users in each department during the first few days of using the system. If you try to go live in multiple departments at once, you simply cannot get enough knowledgeable people on-site at once to help these people.

The demand for assistance during go-live in a department is a large time commitment for the project manager and the departmental supervisor(s) and/or manager(s). It may be well to have additional support from external organizations to assist in this process.

Be prepared to have to fix mistakes by making edits to the database. There are mechanisms in most tracking systems for correcting the occasional mistake but the volume of mistakes during the early go-live period often it easier to make the corrections directly in the database. This can be done by the IT manager or by the support organization for the tracking software. It is important to make sure that people with the appropriate technical skills are available to fix problems during these go-live activities.

In addition to this, you have to do the obvious tasks of making sure that the needed equipment is deployed and working in each department prior to going live. Also make sure that users are entered into the system with appropriate access privileges.

14. Deployment, the big event or hopefully non-event, if everyone has done their job properly as part the implementation team.
15. Post-Deployment. After the system starts running and managers and supervisors can see the information they need in real-time, two things happen:
 - a. They quickly become dependent on the tracking system and complain bitterly when anything goes wrong (even if it is due to a data entry mistake by their own people). This requires a quick response, usually by the IT department, assisted by the vendors who supplied the software and equipment to resolve issues. This implies that the organization needs to have support contracts in place, before and not after problems arise.
 - b. They want lots of different custom reports. Most tracking systems come with a set of standard reports but everyone wants their own reports with the available data presented in their way. This leads to requests for many custom reports. These can be developed by the IT organization or subcontracted, typically to the supplier of the tracking software.

Over time, responsibility for the system migrates from the project manager and the internal team to the IT manager as the tracking system becomes just another system for the IT department to manage.

Operational managers also discover some human resources challenges, such as:

- a. Employees who don't have the ability to do accurate data capture. A feature of many tracking systems is the ability for managers and supervisors to correct employee mistakes. If this happens too often then managers need to take corrective action.
- b. The data from the system shows that certain people are not working efficiently or that certain processes need improvement. This is all to the good but presents its own unique challenges.

15. Additional Phases. Usually these systems implementations are divided into phases, with each phase having its operational objectives. Once the initial phase has proved its worth then there is usually a time lag of a number of months, while the impact of the new system is assessed. Then it becomes apparent that the capabilities of the tracking system can be expanded at modest cost to meet new objectives and a truncated implementation process starts again for the new objectives.

Costs and Benefits

The external cost of implementing a barcode tracking solution, using a middleware software approach, typically ranges from about \$10,000 for a simple PC based departmental system to about \$120,000 for a wireless mobile computer system that will serve the production and inventory tracking needs of a facility. Organizations typically initially spend around \$60,000, of which one third is for software licenses, one third for barcode and wireless mobile computer equipment and one third for professional services. This is usually expended during the 3 to 6 months it takes to implement a tracking solution.

Additionally, organizations should expect to spend between 10% and 20% of this amount for consulting and pre-deployment engineering support services.

Over the following two years, most organizations typically spend the same amount again, primarily on support services, custom reports and software customizations to add capabilities to their tracking solutions.

The average payback time in improved efficiencies and reduction in labor costs for a barcode tracking solution is typically less than 6 months. Some pay for themselves in a few weeks and some take as long as a year. The average life of these systems is estimated at 5 to 7 years although they can be kept running much longer with upgrades to computer hardware and wireless mobile computer technology. So the ROI (return on investment) is very good, providing the system is successful.

Conclusions

It is apparent from the above description that successfully implementing a barcode tracking solution is a non-trivial process. The pay-off both in terms of operational efficiencies and preventing major business problems due to employee mistakes can be very high. But these are only achieved if the system is successfully deployed.

Implementing a barcode tracking solution requires a multi-disciplinary team with team members who are experienced in addressing the myriad of problems that will inevitably arise during systems implementation.

It is essential to have the following skills available:

1. An internal project manager who has good project management skills. This person may be supplemented by an external project manager.
2. A consultant/systems architect who has extensive knowledge of industrial production and inventory tracking practices as well extensive knowledge about tracking system software, barcode equipment, wireless mobile computing, information technology and human factors.
3. A knowledgeable vendor who can provide barcode and wireless mobile computer equipment as well as providing on-site equipment support and repair services.
4. A knowledgeable IT support organization that can provide support during the implementation phase and then take responsibility for on-going support of the system after it has gone live.
5. An organization that can provide most of the needed software pre-built and can provide needed customization services at cost-effective prices.
6. Technical staff members who are knowledgeable about the interfaces available for the tracking system and the ERP, accounting and CRM systems with which it will exchange data.
7. Training and support staff who are experienced in industrial operations and can assist employees during the transition to using a barcode tracking solution.
8. Senior management that is committed to seeing the system implemented and working with the implementation team to overcome the inevitable problems that will occur.

The Author

This paper was written by Dr. Peter Green, who is the Chief Technology Officer of BellHawk Systems Corporation. Dr. Green is an APICS member who is a recognized expert in the use of barcode, RFID and wireless mobile computer technology to capture tracking and traceability data. He frequently gives talks on this subject to professional groups. Dr. Green was educated at Leeds University in England where he received his BSEE and Ph.D. in electronics and computer science degrees. Dr. Green was previously a Professor at WPI and a member of the research staff at MIT. He and his team at BellHawk Systems have implemented over 70 tracking and traceability systems over the past decade for a wide variety of industrial, commercial and Government clients.

