Zebra's RFID Readiness Guide: Ensuring a Successful RFID Implementation

A ZEBRA **BLACK&WHITE** PAPER

Introduction

Radio frequency identification (RFID) has evolved into a reliable, cost-effective technology used for personal identification, asset management, security, shipping and receiving, inventory control, and many other perations. Improved performance, falling prices, and developing standards continue to move RFID into the mainstream and have made it practical for many organizations to consider its use. This white paper will help you determine if RFID is right for your organization. It describes how RFID works and how it is used, and provides tips for starting an RFID project.

What Is RFID and How Does It Work?

RFID is an identification technology that uses wireless readers to access data encoded in chips. The chip is mounted to an antenna, which receives RF signals from the read/write device. The basic form of a chip attached to an antenna is called a transponder or tag. An inlay is created by mounting the tag on a substrate. The inlay can then be layered into or attached to a label or other form factor, such as a wristband, and the result is referred to as smart media. The smart media can then be attached to an object and carry all kinds of data about that object.

Most inlays used today are passive, which means they are powered up by the read/write device and do not have their own power source. Active RFID technology includes a power source—usually a long-life battery—for the tag to power data transmission to the reader. Active tags provide much more range than passive tags, but are also bulkier and more expensive.

Data is written to and read from an inlay with an RFID reader/encoder, also called an interrogator. The reader/encoder creates an RF energy field at a specific frequency. Passive inlays receive the reader signal through their antenna, which "wakes" them up and allows them to broadcast data. All inlays within the energy field automatically respond to the reader, which accepts and decodes the data. Many tags are rewritable and most readers can also encode. Specialized middleware is used to manage the flow of and hierarchy of the data as it is transmitted from reader/encoders into the information system.

RFID tags are also rewritable. Data can be added or updated throughout the life of the tag, which makes the technology suitable for creating a pedigree to associate with an object throughout its useful lifecycle. Tags can also be reused by erasing them and encoding new data.

The characteristics described above apply to most RFID systems. There are many variations of RFID tags or inlays which work essentially the same way but have major differences in their read range, speed, chip memory, security, resistance to interference, physical construction, and other characteristics.

Frequency is one of the biggest and most important differentiators. RFID systems are available at many frequencies. RFID technologies most commonly used in commercial applications operate in either the 860–960 MHz ultrahigh frequency (UHF) band, or at 13.56 MHz, which is classified as high frequency (HF). High frequency RFID is usually used for short-range (less than 24 inches) applications such as access control, ticketing/fare collection, and some item tracking and electronic shelf-management applications. UHF technology has an upward range of around 20 feet and is used for shipping and receiving, production control, material handling, and many other industrial and supply chain operations. There are numerous technical and industry standards for both UHF and HF RFID.

The EPC UHF Gen 2 protocol was created specifically to meet RFID user needs for traceability and supply chain operations. It has been widely accepted by government agencies, retailers, logistics providers, and manufacturers, and particularly in the consumer goods, retail, pharmaceutical, and defense industries. Best Buy, Target, the U.S. Department of Defense (DoD), and Wal-Mart are among the organizations that have specified Gen 2 for their compliance tagging programs. Following is a brief outline of the EPC standard and the body that oversees developments.

The EPC System

The Electronic Product Code™ (EPC) system is developed and administered by EPCglobal Inc.™ The complete EPC system includes technical specifications for interoperable tags and equipment, a numbering system to categorize and uniquely identify billions of items, plus database and network services to help organizations process and share EPC data. As a joint venture between GS1 (formerly know as EAN International) and GS1 US™ (formerly the Uniform Code Council, Inc.®), EPCglobal leverages a nearly 30-year heritage of successfully partnering with industry. EPCglobal is a neutral, consensus-based, not-for-profit standards organization.

The **EPC number** is used to uniquely identify an item and convey its manufacturer and product type. The latest EPC standard, Gen 2, specifies a 96-bit EPC identifier. The number is divided into four sections: header, manager number, object class, and serial number. The header identifies the length, type, structure, version, and generation of EPC, so equipment and software applications can accurately process the information that follows. The manager number identifies the company or entity that assigned the EPC number. The object class categorizes the object, similar to a stock keeping unit (SKU). The serial number is what sets EPC numbers apart from U.P.C./EAN and other numbering systems. The serial number uniquely identifies the item within the object class.

The EPC system was designed to facilitate supply chain operations and object tracking by multiple organizations. EPC Discovery Services and the EPC Information Service (EPC IS) facilitate information exchange.

EPC Discovery Services help users locate and access data related to specific EPC numbers. **Object Naming Service (ONS)** is a Discovery Services component that provides a network address to where actual data for a specific EPC is held.

EPC Information Services let organizations exchange data about specific EPCs through the EPCglobal Network™, a collection of technologies and components for identification and data sharing. Companies that assign EPC numbers can maintain EPC IS servers with item information. Using EPC numbers does not require organizations to share EPC data or use other components of the system. Visit www.epcglobalinc.org for more details about the EPC system and technologies.

There are EPC specifications for UHF and high-frequency technology, and passive and active tags. By far the most activity, interest, and product commercialization has been for passive UHF technology, especially the EPC Generation 2 (Gen 2) UHF standard.

How Is RFID Different Than Bar Code?

It is important to understand the significant differences between RFID and bar code to appreciate the benefits RFID can provide. Bar code and RFID are both identification technologies that hold data that is accessed by some type of reader. In actuality, they complement each other very well and can be used effectively side by side in many applications. Bar code is an optical technology, and RFID is a radio technology. The ways these technologies exchange data account for most of the differences between RFID and bar code and help determine where each identification technology is best put to use.

As a radio technology, RFID requires no line of sight between the reader and the tag to exchange data. RFID tags therefore can be read through packaging, including cardboard containers and plastic wrap used to seal pallets. RFID is subject to interference, however, particularly from metal, so potential sources of interference must be recognized and accounted for during system planning. Because no line of sight is required, tagged objects can be read regardless of their orientation through the use of optimized RFID systems. Items don't have to be placed label side up onto conveyers to be read, paving the way for unattended handling. If workers are required to place items on conveyers to be read, they will be more productive if they don't have to locate and align labels when handling objects.

RFID readers can automatically recognize and differentiate all the RF tags/inlays in their reading field. This simultaneous processing capability provides additional flexibility for material handling, packaging, and sorting operations because there is no need to maintain spacing between objects to ensure they will be read. The ability to read dozens or even hundreds of tags per second makes RFID ideal for high-speed sorting, receiving, crossdocking, and other applications. The data capacity of RFID tags/inlays enables them to carry all the same information as bar codes and more. Just as bar codes differ in data capacity, RFID tags/inlays are available with various memory-size and encoding options.

Smart Label Printing and Encoding

Smart labels are an extremely practical and effective option for satisfying shipment tagging requirements and for many other RFID applications. According to research firm IDTechEx, a total of 2.16 billion tags will be sold in 2008, up from 1.74 billion in 2007 and 1.02 billion in 2006. Smart labels are produced by a smart label printer/encoder that programs an RFID tag embedded inside label material and prints text and bar code on the outside. Smart labels are a convenient option because they can be produced on demand and a single smart label can meet RFID, bar code, and text marking requirements. For example, in addition to EPC and other identification data, the RFID tag in a smart shipping label could include shipment manifest data or an Advance Ship Number (ASN) reference number to help match the physical shipment with an EDI message. Location and handling histories, time stamps, pedigree information, and other data to support different business processes or traceability requirements can also be encoded and updated in smart labels.

Smart label media must be carefully matched to the printer to ensure reliable performance. Media must be optimized both for the object being identified and for the specific make and model of printer/encoder used. It's not uncommon for organizations that have to tag different products to use several smart label media variations to get optimum read performance. User organizations should work with experienced smart media providers to find the best-performing and most cost-effective supplies.

For a comprehensive guide to smart label printing and encoding, visit www.rfid.zebra.com, which has extensive information about Gen 2 technology plus a lot of practical advice that applies to any smart label system.

RFID Applications

Many companies may first get involved with RFID as part of compliance tagging. Compliance programs and high-profile projects get most of the attention, but the real driver for the explosive growth in RFID use is business value. Because RFID requires no line of sight, it can be used for unattended, high-speed identification that removes labor requirements from operations. RFID can also be used in environments that are unsafe or impractical for other types of data collection or manual labor. Another key advantage is that RFID can deliver real-time updates of information as opposed to batch downloads. The data capacity available on RFID chips continues to grow. Tags can be used as mini-databases and traveling records that can be updated as needed to provide information about the tagged object. RFID-based storage and handling records are invaluable for tracking pharmaceuticals, perishable commodities, and other goods with strict pedigree or traceability requirements.

Shipping and Receiving

One of the powerful drivers behind compliance tagging programs is the clear benefits to shipping and receiving processes that are enabled by RFID-tagged shipments. For shipping and receiving, a reader positioned at a dock door can instantly identify pallets of tagged goods that pass through. Shippers can use the data to verify that all the products required for the shipment have been packed and loaded. The process helps eliminate costly shipping errors and the manual labor associated with order checking. The receiving organization uses the dock-door read to verify that the shipment matches the order or manifest, and to automatically record the items into inventory. No bar code scanning or other manual labor is required. Because RFID readers can identify hundreds of items per second, portal readers are especially useful for cross-dock applications, where incoming goods must be quickly identified, sorted, and redirected.

Compliance Tagging

Many companies will be drawn into using RFID to satisfy shipment tagging requirements from customers who want to automate their receiving processes. Implementing a "slap-and-ship" system that complies with customers' tagging requirements but has no applications at the supplier rarely provides value. Companies can begin to realize value from their compliance tagging systems by adding internal applications, which may not require major investments. For example, suppliers can read their tagged pallets to verify that the shipment is accurate and complete. The data can also be used to generate Advance Ship Notices (ASN) and other documentation. Capturing EPC numbers from shipments and associating them with the customer's ship-to address in a database will create a chain-of-custody record useful for pedigree and other traceability applications. If companies transfer tagged shipments to their own distribution centers prior to final delivery to the customer, RFID tags can be leveraged in automated receiving applications that can give the shipper, customer and all entities in the supply chain real-time visibility into tracking of goods.

Some consumer product manufacturers considered bar code shipment labeling a nuisance and a burden when retailers first began requiring it. Today, these manufacturers wouldn't think of operating their distribution centers without bar codes because of the proven efficiency the technology provides. RFID holds the same potential to improve operations. RFID will not replace bar code technology, but can effectively enhance bar code-based data collection systems where additional visibility or automated processing is desirable.

Material Handling

RFID readers may be mounted on forklifts or conveyor systems to support cross docking, sortation, and other material handling applications. By integrating the reader with sensors and the material handling system, tagged cases, cartons, and totes can automatically be recognized and diverted to the desired location.

Inventory Control, Replenishment

RFID has shown very promising results for improving inventory management. RFID-enabled processes help in three primary ways:

- Accurate data collection eliminates identification errors that lead to out-of-stocks and excess inventory;
- Fast reading and real-time report eliminate data latency that can lead to inaccurate forecasts and inefficient storage, handling, and replenishment;
- RFID can provide unattended monitoring, thus reducing labor costs for inventory counting and auditing, and reducing shrink.

These benefits have been validated by Wal-Mart and METRO Group, a leading European retailer, who are each using RFID to manage inventory in the back rooms of retail stores and at distribution centers. Wal-Mart and METRO reported retail out-of-stock reductions attributed to their RFID applications at 16 percent and 14 percent, respectively.

The principles of RFID inventory management can be applied to many operations beyond retail and consumer goods. Inventory tracking applications can be modified for raw materials management, kanban and other shop-floor replenishment, sample management, materials management, and other operations.

Production Tracking

Similar to material handling, RFID can be used to track and route assemblies through production processes. RFID tags can withstand exposure to heat, moisture, solvents, abrasives, and other conditions that impair bar code performance in industrial environments, so the technology provides a way to gain new visibility into manufacturing operations.

Warehousing

RFID's unattended, orientation-independent reading capabilities can be highly valuable for warehouse processes. Reading zones can be created to automatically monitor certain areas of the facility—such as shelf locations, secure storage areas, or even a container yard—and automatically record all movements. Business rules can be created to issue alerts if certain conditions are present, such as items being moved after hours, unusual transaction volume, or any movement of items with a certain dollar value. By integrating the RFID system with enterprise networks and applications, monitor and alert data can be automatically communicated to managers or security personnel, plus integrated into warehouse management system (WMS), asset management, and other software applications.

Imagine picking operations where workers scan shelves and bins with an RFID reader to automatically detect the storage location of the sought items. Readers would also automatically detect items stored in the wrong location and alert operators to the problem. Using RFID for these applications enables items to "self-report" their locations, rather than requiring workers to find them, thus reducing errors, saving labor, and lowering costs.

Asset Management

RFID is highly advantageous for asset management applications because tags can provide a durable, permanent identifier, with extra memory that can be updated repeatedly with configuration settings, inspection records, service information, and other dynamic information. RFID asset tagging also facilitates efficient audits and inventories because assets can be detected and recorded at a distance, without requiring a worker to manually read and record information from the asset tag. Asset movements can be tracked and recorded automatically with RFID reading portals, which can be programmed to issue alerts if assets are removed from the area.

Logistics assets represent another excellent opportunity to benefit from RFID. Many returnable containers are never brought back from customer sites after shipment, forcing companies to carry excess inventory to ensure adequate supplies of shipping materials where they are needed. Almost half of the respondents to an Aberdeen Consulting study reported that logistics asset operations consume 5 percent or more of corporate revenue. Twenty-five percent of companies say they lose in excess of a tenth of their container fleet each year. Identifying returnable containers with smart labels or fixed tags enables companies to augment their legacy bar code shipping applications by automatically recording materials shipped to customers. Companies can then find their own pallets in shipping yards or docks stacked with thousands of items belonging to dozens of companies. Higher degrees of tracking will enable organizations to lower their material costs and will provide an audit trail that can be used to bill customers if materials are not returned. The value of these applications has been proven in multiple real-world implementations.

Check-in/Checkout

Many large libraries around the world have implemented RFID to speed material check-in, checkout, shelf inventory, and security applications. Low-cost, flexible smart labels are inserted in books and can be made invisible to patrons. Counter personnel check dozens of books in or out in mere seconds without manually handling and orienting each item. The tags can also be used for theft detection, much like anti-shoplifting technology currently used by retailers. Librarians using portable computers with RFID readers can take inventory and find misfiled materials simply by walking down an aisle of bookshelves. The reader can automatically detect missing materials and alert the operator.

Video rental stores use RFID for similar applications. Readers are positioned at the checkout, unattended return bins, and doorways to record transactions and detect shoplifted items automatically. These library and video store operations are essentially in-store inventory management applications that can be adapted for use in many other industries. The application can also be adapted to manage tool crib operations, evidence management, file tracking, and other check-in/checkout applications.

Product Security

A smart label can provide secure, lifetime tracking that can facilitate accurate warranty and returns authorization and anti-counterfeiting protection. In 2004 the U.S. Food and Drug Administration (FDA) Anti-Counterfeiting Task Force recommended wide-scale adoption of RFID to stop counterfeiting, which now affects between 6 percent and 10 percent of all pharmaceuticals worldwide. The task force report, which earned widespread industry support, singles out RFID as the "most promising" tool to combat counterfeiting. For more information about how RFID can be used to protect pharmaceuticals, see Zebra's white paper *Track and Trace Solutions for the Life Sciences Supply Chain.* RFID systems and business processes to prevent counterfeiting, provide brand protection, and improve channel integrity can be adopted for use in many industries. Zebra's white paper *Brand Protection in the Supply Chain: Protecting Products and Profits with Secure Media Solutions* describes these applications in more detail.

Access Control, Personal Security, and Patron Management

Personal identification is a longtime and very widespread application for RFID. Tags embedded in employee ID cards provide hands-free access to secured buildings and a tamper-proof form of identification that ensures only authorized personnel are admitted. Similar systems are used to identify hospital patients and patrons at theme parks, where the ID card or RFID wristband is also used as part of a cashless payment system.

Cashless Payment

Cashless payment is an effective retail application unrelated to item or shipping container tagging. The most widespread example of RFID cashless payment is ExxonMobil's Speedpass program, which is saving millions of drivers countless hours at the pump. When the tag enters the reader field at a gas pump, it turns on the pump and automatically charges the gas purchase to the driver's registered credit card account, promoting quicker service while maintaining complete account number confidentiality. McDonald's restaurants are now offering a similar application to speed transactions at the counter and drive-thru window.

RFID-based cashless payment is also used for electronic toll collection applications in use on toll roads and bridges. Participating drivers have either a passive tag, which is clipped to their key chain, or a battery-powered active tag attached to the vehicle. Drivers receive their tags after subscribing to the program and depositing money into an account. The fare is deducted from the tag automatically whenever the vehicle passes through the toll gate. Drivers don't need to stop, or even slow down in some cases, to pay the toll.

Launching RFID in Business Operations

The applications described above only scratch the surface of how RFID can be used, and there are many more applications possible. Regardless of the application, there are several steps you can take to help your RFID project be productive and successful. One of the most important issues to consider is where and how to begin. As you've seen, RFID has characteristics quite unlike other technologies, and can be difficult to implement for the uninitiated. Determining how best to harness RFID's capabilities is one of the first challenges project managers face. Zebra is a pioneer in RFID smart label technology and applications. We've been involved in numerous projects and gained valuable insight into the questions that organizations face and the information they need, which we share in the following sections. Examining the questions and guidelines that follow will help build a strong foundation for your RFID efforts.

Determine the Business Benefits

Companies who already have some form of auto-ID—such as bar codes—for business processes can reap strong benefits by selectively using RFID to enhance operations. For example, making only a small, incremental improvement to shipping accuracy can produce strong benefits, as the following calculation illustrates. Various analyses have established that shipping errors cost between $60 and $250 to resolve, depending on labor rates, shipping expenses, and the amount of clerical and administrative time required. Therefore, each one percent improvement in shipment accuracy should reduce shipping expenses between $60 and $250 per every 100 shipments. For a company that ships 100 orders a day, each one percent improvement in shipment accuracy would produce annual savings of $15,600 to $65,000.

Identify the Specific Business Issue That Is to Be Solved or Enhanced

For those facing compliance mandates, the issue at hand is keeping a customer that now requires RFID shipment tagging. Compliance tagging mandates set a clear requirement for what the RFID system must do. Companies that only wish to comply with customer requirements and make no other use of RFID do not need to concern themselves with considering how RFID could improve inventory, warehousing, distribution, logistics, and security. However, the most successful RFID project managers determine what other business value can be derived from leveraging the investment made to meet a compliance mandate. RFID-enabled processes can overcome environment, reliability, and throughput limitations that restrict alternative identification methods. RFID should be used where it meets a specific need or solves a problem.

For ideas on how RFID could improve your business, review operations to determine if there are any consistent choke points or processes that require excessive human handling, such as placing items a certain side up on a conveyor. These processes are candidates to be automated with RFID, which can provide a good return on investment by reducing labor requirements and improving efficiency.

Determine What Information Is Required

Look at your business processes and limitations, and determine if things could be improved if more information was available, or if current information was available more quickly. Consider where RFID data should be collected and how often you should update related software applications.

The durability, memory, and remote reading capability of RFID tags make it practical to access information in environments where alternative technologies can't perform. In particular, the memory on RFID tags makes it possible to include information to support efficient business processes. RFID users commonly encode lot codes, expiration dates, warranty information, configuration settings, and maintenance/inspection histories that enable items to be processed or serviced when there is no access to a host database.

Identify Needed Performance Characteristics

Once data content, collection points, and communications goals have been determined it will be easier to define the performance the RFID system must provide. Application requirements drive decisions on RFID frequency, tag types, encoding method, reading equipment, and supporting software.

Test and Experiment

Pilot projects and pre-deployment testing should uncover any interference, quality, or performance problems that need to be resolved before the system is deployed. RF interference is the main concern—usually produced by other wireless or RF technologies at work in the environment. An experienced RFID solutions provider can provide an assessment of potential interference and suggest remedies. The assessment is similar to the site survey that is conducted before wireless LANs are installed. Interference can be avoided or mitigated by using different styles and sizes of RFID antennas and tags, and experimenting with different frequencies, power output levels, and tag mounting options, all within the scope defined by the application requirements. Testing may not reveal every hurdle, but thorough planning can mitigate them.

Smart label printing/encoding systems should also be thoroughly evaluated. As with any labeling system, the media and adhesive must withstand all the environmental and usage conditions the label will be exposed to throughout the supply chain. It is crucial to test all the different items that will be labeled under as many conditions as possible to ensure proper performance. Because smart labels must be both encoded/write verified and printed, they can take slightly longer to produce than non-RFID labels—and in a high-speed, automated labeling environment, this must be taken into account to ensure adequate throughput.

Determine Which Standards and Regulatory Considerations Apply

There are many RFID technical standards, industry standards, and compliance guidelines, plus various national regulations for RF transmission. Companies in compliance tagging relationships will have their conformity requirements spelled out for them. Most compliance programs and other RFID initiatives in the consumer goods, retail, pharmaceutical, and defense industries specify the use of Gen 2 and other EPC standards, although there is variation among the specific requirements.

The ISO 15693 standard is prevalent for high-frequency (13.56 MHz) RFID technology. Companies who base systems on ISO 15693-standard technology benefit from a competitive vendor market that provides a choice of interoperable products. Cashless payment systems, and personal identification applications such as access control and automated time and attendance recording, frequently use ISO 15693-compatible tags and equipment.

There are other ISO and industry standards that cover a variety of RFID uses, including electronic cargo seals, logistics container identification, toll and fare collection, animal identification, and more. When considering an RFID project, check with industry associations or user groups to see if relevant RFID standards exist or are in development.

Build an Infrastructure That Can Evolve as Your Needs Change

Standards continually evolve as user needs change, new features are developed and technical limitations are overcome, and, of course, entire new standards are created. Creating a flexible RFID architecture makes it easy to manage changes. “Multi-protocol” RFID equipment can process tags with different specifications. For example, Zebra’s multi-protocol printer/encoders can encode Gen 2 chips, plus previous-generation EPC protocols and proprietary tags from several leading vendors. Multi-protocol readers can process different tags, just as most bar code scanners can auto-discriminate and recognize multiple symbologies.

RFID products built from the start to support multiple protocols are the best option. Multi-protocol readers and printer/encoders with software-defined radios (SDR) are very easy and cost-effective to upgrade. Software defined radios use software to control the RF signal modulation and demodulation and the transfer of data. Support for frequencies, standards, and options are written into the software and are not hard-wired into the hardware. Therefore, upgrades and changes are accomplished simply by downloading new software to the device. There is no need to install new components or replace the device itself. SDRs give the advantages of providing a relatively simple and expedient way to allow end users to support multiple RFID protocols and new features as they emerge.

Multi-protocol equipment with software-defined radios protects RFID investments by providing a clear and convenient upgrade path that minimizes total cost of ownership.

Conclusion

This paper has presented an overview of RFID capabilities and usage considerations. It may seem like a lot to learn, but remember, thousands of companies have successfully completed the RFID evaluation and implementation process, and are profiting because of it. The topics presented here provide an excellent starting point from which you can begin to identify areas for further investigation and develop specific questions to advance your project. For more information and assistance, look to RFID industry associations such as AIM Global (www.aimglobal.org) or EPCglobal (www.epcglobalinc.org), and professional societies in your specific industry. Zebra offers more white papers, implementation tips, RFID case studies, and FAQs at www.rfid.zebra.com.

Zebra is playing a leading role in the development of smart label technology, standards, and applications for supply chain and business improvement programs. Zebra has provided solutions to many RFID early adopters, including suppliers in the Wal-Mart and U.S. Department of Defense (DoD) compliance programs. Zebra, as a member of the EPCglobal Hardware Action Group, was also a leading contributor to the development of the Gen 2 standard.

Contact Zebra Technologies to learn more about setting up an efficient smart labeling system for your organization. As a member of EPCglobal, and a technology sponsor of the former Auto-ID Center at MIT, Zebra Technologies Corporation helps companies identify, track and manage assets, transactions and people with on-demand specialty printing and automatic identification solutions. In more than 100 countries around the world, more than 90 percent of Fortune 500 companies use innovative and reliable Zebra printers, supplies, RFID products and software to increase productivity, improve quality, lower costs, and deliver better customer service. For more information about Zebra's RFID printer/encoders, call +1 800 423 0442, or visit www.rfid.zebra.com.

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