White paper

Supply Chain RFID: How It Works and Why It Pays

Intermec®

Radio frequency identification (RFID) is one of the most promising and anticipated technologies in recent years. Magazine articles, television shows, analyst papers and the like are frequently trumpeting the potential benefits to users of RFID. This white paper will help you to understand what RFID is, how it works, describe the current standard and compliance environment and some considerations to make sure that you have a successful implementation and get the most from your investment. The stakes for RFID implementations are high – for both expenditures and benefits. Arming yourself with a good understanding of the technology and important considerations can ensure that the decisions that you make minimize any missteps and maximize your experience.

Manufacturers, retailers, logistics providers and government agencies are making unprecedented use of RFID technology to track, secure and manage items from the time they are raw materials through the entire life of the product. Manufacturers can especially benefit from RFID because the technology can make internal processes more efficient and improve supply chain responsiveness—for example, early RFID adopters in the consumer goods industry reduced supply chain costs between 3 and 5 percent and grew revenue between 2 and 7 percent because of the added visibility RFID provided, according to a study by AMR Research.

Many drivers have seen RFID in action at automatic toll collection stations used at bridges, tunnels and turnpikes. In business, RFID will be commonly used to identify pallets, containers, vehicles, tools and other assets, monitor inventory, and route materials through production processes.

RFID can provide immediate and tangible benefits throughout the supply chain. Organizations who take the time to understand the technology's capabilities and limitations can increase their inventory visibility while streamlining their operations.

How RFID Works

RFID systems include tags, readers and software to process the data. Tags are usually applied to items, often as part of an adhesive bar-code label. Tags can also be included in more durable enclosures and in ID cards or wristbands. Readers can be unattended standalone units (such as for monitoring a dock door or conveyor line), integrated with a mobile computer for handheld or forklift use or incorporated into bar-code printers.

The reader sends a radio signal that is received by all tags present in the RF field tuned to that frequency. Tags receive the signal via their antennas and respond by transmitting their stored data. The tag can hold many types of data, including a serial number, configuration instructions, activity history (e.g., date of last maintenance, when the tag passed a specific location, etc.), or even temperature and other data provided by sensors. The read/write device receives the tag signal via its antenna, decodes it and transfers the data to the computer system through a cable or wireless connection.

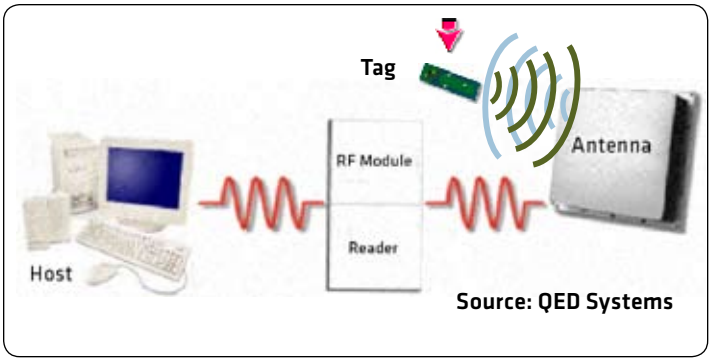

Figure 1: RFID System Components

The following sections provide more details about RFID tags, readers, printers and performance.

Tags (Transponders)

RFID tags have two basic elements: a chip and an antenna. The chip and antenna are mounted to form an inlay (figure 1). The inlay is then encapsulated in another material to form a finished tag or label (figure 2).

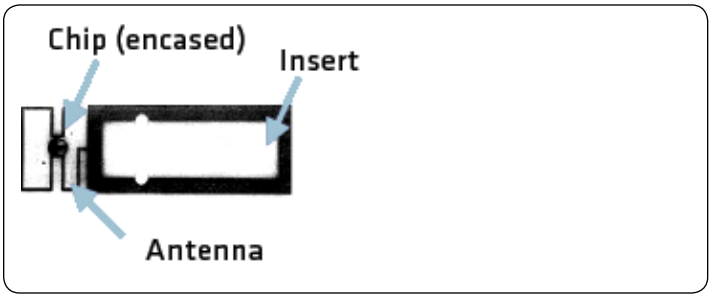

Figure 2: Inlay—RFID Tag Components

Figure 3: Finished Tag

Various types of tags serve different environmental conditions. For example, tags suited to cardboard cases containing plastic items may not be ideal for wooden pallets, metal containers or glass. Tags can be as small as a grain of rice, as large as a brick, or thin and flexible enough to be embedded within an adhesive label. Tags also vary greatly in performance, including read/write ability, memory and power requirements.

Figure 4: Smart Label

Paper-thin labels referred to as "smart labels" usually serve single-use applications, such as case and pallet identification. Printer/encoders produce smart labels on demand, encoding the tag while printing text and/or a bar code on the outer label. Smart labels will satisfy most RFID compliance tagging requirements for cases and pallets.

Figure 5: Large and Small Rigid Tag

RFID tags also range in durability, depending upon the application and environment. Tags for permanent identification may be encased to withstand extreme temperatures, moisture, acids and solvents, paint, oil and other conditions that impair text, bar codes or other optical-based identification technologies. RFID tags can be made reusable and suitable for lifetime identification, thus yielding a total-cost-of-ownership (TCO) advantage over bar-code labels and other disposable/impermanent identification methods.

RFID tags can be either read-only or read-write (though the latter is now standard). Read-only tags are programmed at the factory with a serial number or other unalterable data. Data on read/write tags can be revised thousands of times. Read/write tags are often partitioned with a user-defined secure read-only area that may contain a unique ID number and a writeable portion of memory that users can freely reprogram. Thus a user may permanently encode a pallet ID number in read-only memory and then use the read-write bank(s) to record items loaded onto the pallet. Then once the pallet is unloaded, the writeable section can be erased for reuse. For more information about read/write technology and applications, see Intermec's white paper, The Write Stuff: Understanding the Value of Read/Write RFID Functionality.

Tags are also classified as passive, semi-passive or active. Passive tags, by far the most common, receive transmission power from the reader. All RFID smart labels are passive. Active tags include a battery to power transmissions, which also provides a longer range. This makes active tags larger and more expensive than passive tags. Semi-passive tags communicate like passive tags but also have a battery. Their range falls between passive and active, and though their batteries have a long life, their size is comparable to passive tags.

Reader/Writer Options

RFID devices allow pronounced flexibility for placement because unlike bar-code readers, direct line of sight is not necessary and read ranges can be extensive. For example, readers can be installed under floors and mounted on ceilings. And the ultrahigh frequency (UHF) band used in many commercial RFID systems can provide a read range of more than 10 meters. There are several types of readers that can be incorporated into supply chain operations, portable readers integrated with handhelds, readers mounted on vehicles/forklifts, and fixed readers on dock doors and portals.

IF5 **IP4** **PM4i**

Figure 6: Readers (fixed and portable) and Printer

One of the most desirable implementations of RFID readers is mounting them on forklifts. The advantage of forklift mounted readers is that they are typically fewer forklifts in a facility than dock doors, so less readers are needed to cover a facility. Forklift mounted systems are portable so they can go wherever they are needed.

IV7

Figure 7: Forklift Mounted Interrogators

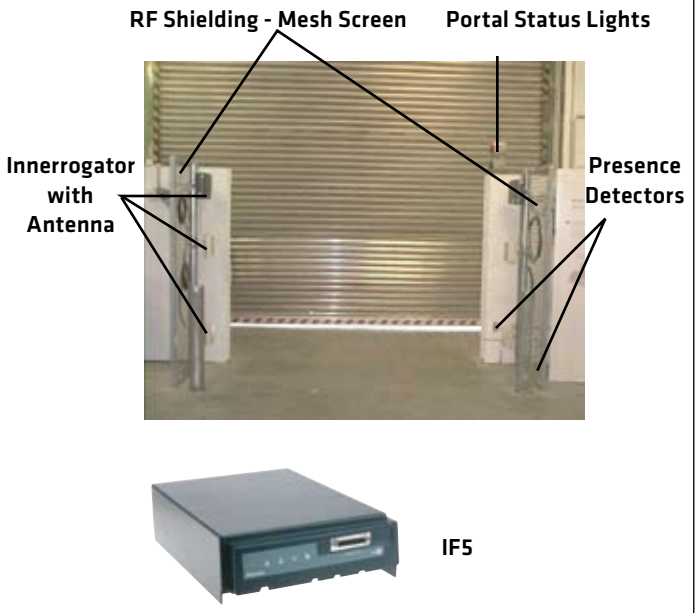

Figure 8: Dock Door Fixed Mount Reader

RFID systems can also function simultaneously with wireless networks, and are often integrated with wireless LANs to exchange data with host computer systems–Wi-Fi LANs do not cause interference for RFID systems. (Older, proprietary 915MHz wireless networking equipment can interfere with UHF RFID systems, but few of these devices are still in use.)

RFID Performance
The basic characteristics described above apply to all RFID technologies. RFID systems vary by the range and frequency used, chip memory, security, type of data collected and other characteristics. Understanding these variables is key to understanding RFID performance and how it can be applied to operations. The following sections briefly describe the most important RFID characteristics.

Frequency
Frequency is the leading factor that determines RFID range, resistance to interference and other performance attributes. Most commercial RFID systems operate at either the UHF band, between 859 and 960 MHz, or high frequency (HF), at 13.56 MHz. Other common RFID frequencies include 125 KHz (a short-range frequency often used for vehicle identification), and 430 MHz and 2.45 GHz, both used for long-range identification, often with expensive, battery-powered tags. The UHF band is most common for supply-chain and industrial-automation applications. EPCglobal's popular Gen 2 standard (which will be detailed later) is a UHF technology.

Range
An RFID system's read range–the proximity to the tag that a reader antenna must be within to read the information stored on the tag's chip–varies from a few centimeters to tens of meters, depending on the frequency used, the power output and the directional sensitivity of the antenna. HF technology is used for short-range applications and can be read from up to about three meters. UHF technology provides a read range of 20 meters or more. Range also depends greatly on the immediate physical environment–the presence of metals and liquids may cause interference that will affect range and read/write performance. Thus multiple systems within the same facility may function within differing ranges depending on immediate surroundings and antenna location. For read/write tags, the read range typically exceeds the write range.

Security
RFID chips are extremely difficult to counterfeit. A hacker would need specialized knowledge of wireless engineering, encoding algorithms and encryption techniques. Furthermore, different levels of security can be applied to data on the tag, making information readable at some points in the supply chain but not others. Some RFID standards entail additional security. Because of this innate security, the U.S. Food and Drug Administration (FDA) has encouraged RFID as a safeguard against pharmaceutical counterfeiting. Thus, drug makers have begun to exploit RFID's relative impregnability, as have electronics, apparel and other manufacturers.

Standards
In the early days of RFID, there was a lingering misperception that RFID was a proprietary technology lacking standards. Today, numerous standards ensure diverse frequencies and applications. For example, RFID standards exist for item management, logistics containers, fare cards, animal identification, tire and wheel identification, and many other uses. The International Standards Organization (ISO) and EPCglobal Inc. are two of the standards organizations most relevant for the supply chain. Many national and industry standards are based on ISO or EPCglobal standards, such as the U.S. ANSI standard MH10.8.4, for returnable container identification (based on an ISO specification).

By definition, ISO standards can be used anywhere in the world, and serve as the national standard in many countries. The EPCglobal Generation 2 (EPC Gen 2) UHF standard has been submitted to ISO and is expected to become part of the ISO-18000 series of standards.

The Gen 2 standard was created to facilitate the use of Electronic Product Code™ (EPC) numbers, which uniquely identify objects such as pallets, cases or individual products. EPC standards provide both RFID technical specifications and a numbering system for unique, unambiguous item identification. Gen 2 and other EPC standards are administered by EPCglobal, a subsidiary of GS1 (the same not-for-profit organization that issues U.P.C. numbers and manages the EAN.UCC system). Many manufacturers, retailers, other companies, public sector organizations and industry associations have adopted or endorsed EPC standards, particularly Gen 2. Visit Intermec's Web site (www.intermec.com/RFID) for more white papers and additional resources about Gen 2 and other RFID technology.

Using RFID
RFID provides options when it is impractical or impossible to use other technologies or manual labor to collect data. RFID can operate in environments where factors such as indirect line of sight, high-speed reading requirements, temperature extremes, and exposure to gases and chemicals prevent the use of other data collection methods. RFID also provides convenience for innumerable common tasks. Consumers regularly use RFID to unlock car doors remotely, to quickly

check books in and out of libraries, and to speed gas-station transactions by waving a key fob at the pump. Businesses rely on RFID to securely track and report the locations of thousands of assets, shipments and inventory items.

And RFID still has a wealth of untapped potential—especially when integrated with other technologies and software applications. Imagine a temperature or shock sensor integrated into an RFID tag to automatically issue warnings about changing conditions that could damage or spoil products. RFID and wireless network systems could be integrated to provide full-time, wide-scale monitoring. Inventory movements from monitored locations could automatically trigger a replenishment request, or contact security if the item was moved by unauthorized personnel. These applications are already in the works, as are other future-looking systems to further convenience and efficiency in consumer transactions, healthcare, personal identification, manufacturing, logistics, asset management and many other operations.

Asset management
RFID tags can be permanently attached to capital equipment and fixed assets including pallets, RPCs, cylinders, lift trucks, tools, vehicles, trailers and equipment. Fixed position readers placed at strategic points within the facility can automatically track the movement and location of tagged assets with 100 percent accuracy. This information can be used to quickly locate expensive tools or equipment when workers need them, eliminating labor-wasting manual searches. Readers can be set to alert supervisors or sound alarms if there is an attempt to remove tagged items from an authorized area.

By tracking pallets, totes and other containers with RFID, and building a record of what is stored in the container as items are loaded, users can have full visibility into inventory levels and locations. With visibility and control, manufacturers can easily locate items necessary to fill orders and fulfill rush orders without incurring undue managerial or labor time.

RFID tags or labels on pallets, cylinders, RPCs and other shipping containers can be automatically read at the dock door as they leave with an outgoing shipment. By matching the reading with specific shipment information in a database, manufacturers could automatically build a record of what specific shipping containers were sent to each customer. This information could be used to document cycle times, improve returns and recoveries and aid in disputes with customers about lost or damaged assets. Chep, the world's largest pallet pooling company, is applying RFID tags to the 250 million pallets it manages to gain the automated tracking benefits. Applications like these enable manufacturers to lower their asset base and realize some of the cost savings identified in the Auto-ID Center and AMR Research studies. For more information about this application, see the Intermec white paper Radio Frequency Identification for Tracking Plastic Pallets and Reusable Containers.

Production Tracking
The Auto-ID Center study found manufacturers can reduce their working capital needs between 2% and 8% by taking advantage of RFID to provide greater visibility into work-in-process tracking and materials inventory. By applying RFID tags to subassemblies in the production process, rather than to finished goods, manufacturers can gain accurate, real-time visibility into work-in-process in environments where bar codes are unusable. Industrial control and material handling systems can integrate with RFID readers to identify materials moving down a production line and automatically route the items to the appropriate assembly or testing station. This capability, which requires no human intervention to look up item serial numbers or other identification marks, provides the accuracy and labor savings needed to efficiently execute complex sequencing and make-to-order production.

Inventory Control
The main benefits to using RFID in the supply chain come from improved inventory tracking, especially when the technology's capabilities are used to collect information and provide visibility in environments where tracking was not done before. Manufacturers, distributors, logistics providers and retailers can all use RFID for inventory applications, and in carefully planned systems, may share the same tags to reduce implementation costs. Because it can be read through packaging, without concern to orientation, without direct line of sight between object and reader and can withstand exposure to dirt, heat, moisture and contaminants that make bar codes unusable, RFID can remove blind spots from inventory and supply chain operations.

By using the highly accurate, real-time and unattended monitoring capability of RFID to track raw materials, work-in-process and finished goods inventory manufacturers can improve visibility and confidence into their inventory to enable overall inventory levels, labor costs and safety stocks to be reduced. Readers covering warehouse racks, shelves and other storage locations could automatically record the removal of items and update inventory records. If an item was misplaced or needed urgently to complete an order, fixed-position readers or a worker with a mobile computer and RFID reader could automatically search for the item by reading for its specific ID number.

To secure inventory from theft and diversion, readers could be set to sound alarms or send notification if items are placed in unauthorized areas of the facility or removed from storage without prior approval. An Auto-ID Center study found consumer goods manufacturers would reduce shrink (inventory loss) by an estimated 10 percent by implementing secure storage areas.

Direct store delivery (DSD) and other remote sales and service personnel could take advantage of RFID readers integrated with mobile computers to quickly and accurately count inventory held in stores or in the vehicle. The automated counting would save significant time in the field, enabling representatives to visit more customers in a day. For field service applications, permanent asset tags applied to equipment could store its ID, configuration and service history information to ensure accurate and appropriate service is performed in the field where access to a central records database may be unavailable.

Shipping & Receiving
The same tags used to identify work-in-process or finished goods inventory could also trigger automated shipment tracking applications. Items, cases or pallets with RFID tags could be

read as they are assembled into a complete customer order or shipment. The individual readings could be used to automatically produce a shipment manifest, which could be printed in a document, recorded automatically in the shipping system, encoded in an RFID tag, printed in a 2D bar code on the shipping label, or any combination. For example the Serial Shipping Container Code (SSCC) data structure, which is commonly used in bar codes on shipping labels, could be encoded into RFID to facilitate automated handling. The new RFID application could be very effectively integrated into existing business processes because it takes advantage of data structures that are already supported in enterprise databases and software applications.

Manifest information encoded in an RFID tag could be read by the receiving organization to simplify the receiving process and to satisfy requirements like those for advance shipping notices (ASN), so there would not be processing delays if the physical shipment arrived before the electronic data interchange (EDI) transmission with the ASN information.

Having complete shipment data available in an RFID tag that can be read instantly without manual intervention is very valuable for cross dock and high-volume distribution environments. Incoming shipments can be automatically queried for specific containers. If a sought-after item was present, it could be quickly located and selected.

Regulatory Compliance
Companies that transport or process hazardous materials, food, pharmaceuticals and other regulated materials could record the time they received and transferred the material on an RFID tag that travels with the material. Updating the tag with real-time handling data creates a chain-of-custody record that could be used to satisfy FDA, DOT, OSHA and other regulatory reporting requirements. RFID tags are also an effective way to satisfy the tire traceability requirements of the TREAD Act.

Returns & Recall Management
Companies could supplement the basic shipment identification information by writing the specific customer and time of shipment to the tag immediately prior to distribution. Producing and recording this information would provide several benefits. In the event of a recall, companies could trace specific shipments to specific customers, which would enable a highly targeted notification and return operation and avoid a costly general recall. For general returns, companies could verify that the customer returning merchandise is actually the customer who received it, which would deter diversion, counterfeiting and other forms of return fraud.

Service and Warranty Authorizations
Authenticating the product and customer with proprietary information could also be used to authorize warranty and service work. Upon completion of repairs or service, a record of the activity performed could be encoded on the tag to provide a complete maintenance history that travels with the item. If future repairs or service are required, a technician could access the item's complete maintenance and configuration information without accessing a database simply by reading the tag. This application ensures workers have necessary information if no database access is available, and eliminates the need and expense of making phone calls or wireless data inquiries to access records.

Conclusion
Intermec Technologies Corp. offers a complete range of services and products to help organizations evaluate whether they will benefit from RFID, and how it can be integrated into existing business processes. Intermec is a leader in RFID technology and standards development, with extensive experience in helping organizations implement complete RFID data-collection systems. Visit our Web site to see complete case studies on RFID users from multiple industries, and additional white papers on RFID technology and other data-collection topics. Intermec has been helping companies profit by taking advantage of data-collection technologies for more than 35 years. Visit us today at www.intermec.com/RFID to learn more about how Intermec can help you prepare for RFID.

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