Understanding RFID

A Practical Guide for Supply Chain Professionals

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Executive Summary

Radio Frequency Identification (RFID) is hardly a new concept. In many areas it is already a mainstream technology—it is used every day to pay tolls, secure building access, control manufacturing subassembly movement and track assets. But until recently, its impact in supply chain management has been limited to niche roles like reusable container tracking. This has been primarily due to cost barriers as well as a lack of accepted standards, technology challenges and performance limitations.

Another automatic identification method, bar coding, already has an established position in the supply chain. From warehouse management systems (WMS) to point of sales (POS) applications, supply chain solutions depend on bar codes to track and control inventory. The need to supplant or augment bar codes with RFID technology has not been overwhelming. But as many supply chain professionals realize, this is beginning to change.

Interest in applying RFID to supply chain solutions has intensified mostly due to work done over the past few years by large retailers, consumer goods companies, academic research institutions, and automatic identification solution providers. These organizations believe that tremendous cost savings can be realized in the supply chain through the use of RFID technology. Furthermore, recent developments promise to overcome the cost, standards and technological barriers that have limited the application of RFID in supply chain solutions. This movement will be further accelerated as suppliers begin to comply with Wal-Mart and Department of Defense RFID mandates. What has been a niche player throughout the 1990s, now promises to be an arena of intense focus over the next decade.

With awareness of RFID technology and its possibilities also comes uncertainty. Many logistics operations understand that RFID is poised to make a major impact on the supply chain world. At the same time, they are also unsure exactly how this technology can affect and benefit the way they do business. Precise questions about its benefits, costs and integration issues can be difficult to answer. Furthermore, the pace at which RFID technology will actually work its way into the supply chain is still unclear.

In certain respects, the current state of RFID in the supply chain world resembles the early days of bar coding. Compliance mandates will undoubtedly accelerate the breakdown of current technology and cost barriers. Intense promotion by RFID solution providers will attempt to position their application in the supply chain as a best practice as they are able to demonstrate its benefits through successful implementations and use. But RFID's present state is also similar to the position of the Internet in the supply chain during the 1990s. There is considerable hype about cost savings and the potential reach of the technology. There is also a multitude of different vendors and solutions chasing a market whose exact shape and size can only be speculated at this point in time. No one can guarantee how successful any given vision will be in the coming years.

Despite the uncertainty, there are compelling reasons to take a close look at RFID right now. These reasons go well beyond current compliance mandates. Although existing cost and performance issues present significant challenges in using the technology in supply chain applications, RFID still can produce a positive return on investment in numerous situations. Even if it can't be currently justifiable for a specific situation, its evolutionary pace is such that it may become feasible in a relatively short time. While its long-term impact can be debated, RFID has the potential to dramatically increase the efficiency of supply chain operations.

It is no wonder that logistic operations are scrambling to figure out where their enterprises should be on the RFID curve. While Wal-Mart, the media and auto identification vendors have certainly fueled this interest, the limitations of existing supply chain systems present a compelling reason to take a look at RFID. Bar coding is a proven, well-established technology. But bar coding requires a line-of-sight scan that can add additional labor and reduce the accuracy and rapidity of information flow in a supply chain application. RFID's promise of a scan-free supply chain is too attractive to ignore.

Coming to grips with RFID is no easy matter—it takes a combination of hard work, a desire to improve operations, an open mind and some skepticism. The first step in this process is obtaining a basic understanding of RFID's components, benefits, current challenges and potential uses in applications.

Once this step has been taken, the really difficult strategic and tactical questions about RFID can be addressed.

Basic Components of RFID

RFID does not present a single technological face to the world. Its elemental building blocks vary according to the applications they are designed to address. One vendor's solution may or may not interoperate with another vendor's equipment and tags. In some respects, RFID is similar to bar coding at a component level. An RFID tag can be equated to a bar code label. RFID obtains information from tags through a reader and antenna, while bar coding depends on a laser or CCD scan. But this analogy is an oversimplification. RFID-enabled applications can do things that bar code-based systems cannot. To understand what RFID can do in the supply chain, one needs to have a basic grasp of the components that make up an RFID application.

Tags. All automatic identification technologies require a medium to store information that will subsequently be retrieved by various applications for processing. RFID uses tags to electronically encode information. These tags come in a variety of sizes and designs and there are numerous types, each tailored to meet specific application requirements. All tags have two key components: an integrated circuit (IC) chip and antenna. Information is stored on the chip and transmitted to the outside world via the antenna. The chip and antenna can be laminated on plastic cards, encapsulated in protective housings or embedded in label stock.

While some RFID chips are able to store significant amounts of information, most are designed to record a single identifier much like a bar code. The amount of information that can be stored varies by chip design. RFID tags are typically categorized according to:

- **Power source.** Active tags have an internal power source or battery. Passive tags receive their energy from the transmission of an external reader. Active tags can transmit information at much greater distances than passive tags, but cost significantly more.
- **Frequency.** RFID tags are typically designed to transmit data on one frequency. The frequencies employed by tag vendors are generally classified as low (LF), high (HF), ultra-high (UHF) and microwave. In general, the lower the frequency the shorter the read distance and the lower data transfer rate.
- **Encoding Method.** Tag designs also vary in how information is encoded on them. These encoding methods can be categorized as read/write, write once/read many and read-only. Read/write tags allow information to be recorded multiple times. As the name suggests, write once/read many tags can only be programmed a single time. However, this encoding can occur on demand. Read-only tags are encoded with data during their manufacturing process. Read/write tags are the most expensive variety.

Supply chain applications employ a wide variety of tag types. HF passive tags can be used in lieu of bar codes to track totes on conveyor systems. Some yard management systems utilize active tags to track trailers within the yard. UHF passive tags are currently generating the most interest in the supply chain world. Their relatively low cost and high read range (6 to10 feet) make them suitable for tracking product movement at the pallet, case and item level.

Readers. An RFID reader or interrogator retrieves information stored on a tag by broadcasting a signal through its antenna. This transmission prompts the tag to respond with its own transmission. RFID readers play the same basic role as bar code scanners. But a bar code scanner generally captures information one bar code at a time. On the other hand, a RF reader is capable of reading multiple tags within its transmission field.

RFID readers come in two basic configurations: mobile and fixed. Mobile readers are usually employed as peripheral devices on handheld or vehicle-mounted terminals. As such they can work in the same manner as tethered or integrated bar code scanners by capturing a single identifier as an associate moves an object. Fixed readers are typically deployed in portal-like arrays where tagged product is read by moving it through the portal. The portal concept is ideal for receiving and shipping dock doors where a pallet of tagged cases can be automatically read as a forklift driver passes through the door.

Like the early days of bar coding when scanners typically could handle only one bar code symbology or type, many RFID readers are capable of only interrogating one tag frequency and protocol. However, vendors are beginning to offer "agile" readers that are able to process multiple tag types.

Software. Information collected by RFID readers must be correctly interpreted before it's passed to an application system. An individual tag can respond multiple times to a reader's signal. When multiple tags are within the reader's transmission range, the result is a cacophony of responses that must be managed and processed in an orderly manner. This is the job of control software and middleware that resides on data capture devices or on specialized controllers and servers.

The exact functions that this control software performs varies according to the applications that it is designed to support. It can serve as a basic traffic cop that monitors a network of readers so that only a single instance of a tag's identifier is sent to an upstream application whenever the tag is within range. In another scenario it might provide processing logic that conditionally communicates with outside applications based on the

state of all the tags that it's monitoring.

Standards and EPCglobal. The lack of prevailing standards has hindered the adoption of RFID in supply chain applications. Working with major retailers and consumer packaging goods companies, the Auto-ID Center at the Massachusetts Institute of Technology (M.I.T) sought to address this deficiency through the development of Electronic Product Code standards. These standards are intended to cover all aspects of the technology from frequency to how networked readers communicate with the outside world. But they are centered on the concept of an electronic product code (EPC), which uniquely identifies objects. An "object" can be a pallet, case or individual SKU.

Like a UPC code, an EPC can identify both manufacturer and SKU. But it also contains a unique serial number. There are several different EPC types that differ in the amount and structure of information stored on tags. The 96-bit version that is currently the focus of several supply chain initiatives provides a number scheme that is more than capable of uniquely identifying every part in the supply chain.

The concept developed by the Auto-ID Center and others goes well beyond providing a framework for product identification. It provides the basis for a network that governs how product information is exchanged between entities in the supply chain. The key elements of this EPC network are:

- **Savant:** Distributed software that manages EPC data received from readers and controls the flow of information between readers and end applications.
- **Object Name Service (ONS):** Network service used to locate where information is stored for a specific EPC. This location could be a local or remote server accessed through the Internet.
- **Physical Markup Language (PML):** The language used to convey detailed product information between supply chain applications over the EPC network.

The EPC Network is designed to share information over the Internet. Conceptually it allows one organization to locate and retrieve detailed product information stored on servers maintained by another firm for any given EPC. ONS provides the appropriate network address or URL for where the information is stored, and PML provides the means for the requesting application to retrieve the information.

The EPC Network provides a vision for RFID that goes well beyond traditional automatic identification technologies. It provides the structure to track product movement throughout the supply chain. Properly maintained and updated PML servers can provide complete item-level history from the manufacturer to the end-user.

The support and continued development of EPC standards have been assumed by EPCglobal, a joint venture between EAN International and the Uniform Code Council. Building upon work done by the Auto-ID Center, EPCglobal's primary goal is to promote global acceptance of the EPC Network through compliance specifications, education and guidelines. Key to these efforts is a subscription service that assigns ONS compliant numbers or EPC managers to manufacturers and distributors throughout the world.

Benefits of RFID

According to many of its proponents, RFID promises to save billions of dollars through increased distribution efficiency and reduced shrinkage and will radically change the way the supply chain works. But even the most fervent supporter must admit that the potential benefits will vary greatly among supply chain operations. While some promises may seem a bit over-optimistic, RFID does provide significant advantages over bar coding. Before any organization can seriously contemplate using RFID to support its operations, it should have a firm understanding of the benefits that the technology can provide.

Efficiency. The primary reason that Wal-Mart and other major firms are interested in RFID is that they believe it can save them money by making their distribution operations more efficient. These companies already employ sophisticated systems that utilize bar codes. They require their suppliers to apply bar coded labels on shipments and transmit ASNs so that they do not have to manually identify product on the receiving dock. Even though they effectively utilize bar codes, they believe that RFID will allow them to make their distribution operations even more efficient.

While bar coding allows distribution organizations to improve their operational efficiency, the technology requires a line-of-sight scan to complete a transaction. Warehouse employees, as part of material movements, typically perform these scans with a hand-held scanner. Although the amount of time required is dependent on the operation being performed, the process of acquiring and scanning bar codes can require a significant amount of time in a busy distribution center.

Receiving is frequently cited as an operation that can benefit greatly from RFID. The labor saved is directly related to the type of receiving performed. Since case-level receiving requires more scans, it should benefit more from RFID than pallet-level operations. In either case the concept is fairly clear-cut. Pallet or case tags are automatically read as product is moved through an RFID portal at the receiving dock. The amount of labor saved equates to the time it takes to locate each bar-coded label and scan it. Because the portal can read multiple tags almost simultaneously, the labor savings

from receiving a pallet of tagged cases can be substantial.

This labor savings is not restricted to just the actual scan time. Operations personnel can spend considerable time positioning product so that the bar code labels can subsequently be read. It is not uncommon to see case-level shipping operations where associates build outbound pallets with all case labels facing outward so that they can be scanned prior to loading. Using RFID, pallets can be built and cases stacked regardless of label orientation. Furthermore, cases can be placed in interior pallet regions since RFID does not require a line of sight scan.

The value of the potential labor savings varies between operations. RFID receiving at the pallet level may mean more to a flow-through operation than a receive-store-pick warehouse. An operation that must do considerable inbound quality inspections may benefit less than another facility with a less stringent quality assurance program.

While receiving and shipping are common areas of interest for RFID deployment, an entirely scan-free operation is the ultimate goal from an efficiency perspective. The ability to verify putaways, replenishments, picks, counts and other warehouse activities without scanning a bar code can provide significant labor savings and improve product flow. Operations that need to capture additional information when performing inventory transactions may be able to gain even greater efficiencies by employing item-level EPC tags. For example, a pharmaceutical each pick operation may be able to forgo the scan or entry of lot numbers by utilizing EPC tags. While the practicality of these scan-free visions may be several years away, they illustrate the cost savings potential of the technology.

Accuracy. Because they provide near-perfect identification of objects, bar code-based systems can be extremely accurate. But they typically have one common weak point—they depend upon an operator to actually perform the scan. Consequently, inventory still gets lost and mis-shipments still occur because a warehouse associate performed an inventory move without performing the corresponding scan transaction. RFID has the ability to provide an inventory tracking mechanism that is not dependent on human-initiated scans. Transactions can be automatically recorded as product is moved within the warehouse.

Outbound load confirmation is a good example of how RFID can improve accuracy. In a bar code-based system, outbound cases might be systematically tied to a single bar coded license plate as they are palletized. This license plate is then scanned as the pallet is loaded onto a trailer. This is an accurate method of confirming shipment loads as long as the pallet builder scans or records each case as it is palletized. An RFID alternative that reads all case tags on a pallet as it is moved through an outbound door would eliminate both the need for the palletizing scan and the error that would occur if the scan did not take place. This may allow further labor savings by eliminating the need to audit the outbound lane for stray cases. Of course, this all presumes that an RFID tag was applied to each outbound case. Any case without a readable tag can be loaded without a load confirmation being recorded.

Given enough tags and readers, RFID can provide the ability to track all inventory movements within a distribution center. All physical moves could be systematically tracked without the need for an operator to record the transactions in the system. Mis-picks and erroneous putaways where the wrong bar code is confirmed could be eliminated. Cost and technological barriers currently make this level of tracking impractical for most operations, but it is a theoretical possibility that could become a reality sometime in the near future.

Visibility. The EPC Network offers the potential to truly extend and enhance product visibility beyond the four walls of a distribution center. While traditional EDI provides a mechanism to share information between trading partners, RFID and the EPC Network can provide the basis for tighter collaboration and greater visibility throughout the entire supply chain. Through PML servers, an administrating organization such as a manufacturer can provide a central repository for product information. This repository can contain item-level information that is updated on a near real-time basis as an item moves through the supply chain.

The EPC Network can provide extended product visibility from manufacturing through final sale and beyond. The trading partner performing the transaction can post each product move or action as it happens on the appropriate PML server. A manufacturer could use this facility to track and maintain warranty information. It would allow a transportation consolidator to alert shipment recipients of the status of each case in the hub as it is being processed. It could also be used to support product catalog synchronization between supplier and distributor, eliminating the need to maintain customer or vendor item number cross-reference tables.

Lot tracking is an excellent example of how this extended visibility can benefit a supply chain. Consider the process that a pharmaceutical manufacturer must go through to recall a specific SKU lot. Their existing supply chain systems probably only identify the immediate recipient of the lot. This recipient could be a wholesaler, hospital/clinic, drug store or retailer who in turn distributes the product to other entities in the supply chain. An individual item could go through many intermediate destinations before ending up in the hands of the final customer.

The EPC Network could be used as a facilitator to track the movement of the pharmaceutical manufacturer's products throughout the supply chain. If the need

arises to recall a specific lot, the manufacturer could reference a PML server to determine the last known location for each item in the lot. This concept could also be used to support pedigree paper regulations that require drug wholesalers to provide a record of each entity in the supply chain that has handled the controlled item being resold.

The above visions are dependant on acceptance and active participation in the EPC Network by all relevant trading partners in a supply chain. These entities must enhance their systems and products to support this type of information flow. They must overcome existing technological challenges and barriers to wide-scale RFID systems deployment. The EPC Network is currently more concept than reality. The pace at which it will evolve will vary according to industry type. For example, the appeal of this type of visibility probably means more to the pharmaceutical industry than it does to building products firms.

Security. Since RFID can passively track the movement of an individual object, it can be used in a similar manner as sensormatic and other loss-prevention technology to help reduce theft. Retailers, distributors and manufacturers can employ RFID portals by exits to detect unauthorized product movement. EPC tags can double as both product identifiers for POS and distribution systems and loss-prevention tags for security systems. However, RFID tags are susceptible to interference—a thin sheet of metal foil can easily block the signal from many tag types.

Product authentication is another area that may prompt enterprises to turn to RFID for greater security. If every object has a unique identifier and detailed information on the object is stored in a PML server, any purchaser can validate the object's authenticity by interrogating its EPC tag. This would provide some manufacturers with a powerful tool to combat product counterfeiting.

The Challenges of RFID

Given the current state of RFID technology, its challenges and potential barriers can make RFID impractical for many situations. Like any other application of technology, RFID must produce an acceptable return on investment and meet production level performance criteria in order to be a viable solution for any supply chain implementation. But RFID is evolving at a fairly brisk pace—what is an insurmountable barrier today may or may not be an issue tomorrow.

Performance. RFID readers can fail to correctly read tags for a variety of reasons. Distance and tag orientation to the reader can prevent a successful read. Certain materials like metal or liquid can distort or absorb RFID signals. Packaging and the surrounding environment, as well as product handling, may affect read success rate. Electromagnetic background noise generated by other equipment can also present problems. Even the speed that tags move past readers impacts the ability to successfully capture reads.

Furthermore, these performance factors vary in importance according to the tag type being used. For example, a low frequency tag might be a good choice for tracking air conditioners if the reads can be performed discretely and at a short range. But the same tag would probably not be suitable for capturing outbound load confirmations for apparel shipments by driving a pallet of tagged cases through a door portal. A UHF tag is a better fit for this situation.

RFID vendors like to tout the abilities of the technology by demonstrating multiple reads of tagged cases on a cart being pulled through a portal. It is one thing to successfully read a dozen tags applied to empty cardboard boxes in a controlled environment. But it is an entirely different proposition to attempt to read 40 tags applied to palletized cases of soup as they are being driven onto a trailer. Tag type, packaging, product characteristics and other environmental conditions must be properly addressed to ensure success. This may require more work and a significantly greater investment than RFID vendors typically admit.

Cost. The plans of Wal-Mart and other RFID drivers are predicated on inexpensive tags. Passive tag costs currently range from $.20 to over $10 per tag depending on tag type and quantity ordered. The Auto-ID Center at MIT has predicted that a $.05 tag is the cost threshold needed to make RFID practical for widespread use in the supply chain. Recent advances in tag manufacturing promise to make this goal attainable. Wal-Mart and Department of Defense compliance mandates have rekindled the interest of chip manufacturers in RFID. Tag costs will continue to decrease.

But tags are only a part of the overall picture of RFID costs. Tags still must be applied to objects by some sort of mounting media or by embedding the tag in the material. Tags require readers. RFID readers vary in costs but are still generally more expensive than laser scanners. While reader costs will drop as demand spurs production, it is still a major investment for any RFID application. Furthermore, performance factors may drive other costs with prospective RFID users forced to redesign packaging or retrofitting facilities to make their application work.

Evolutionary Pace. The potential benefits of RFID and the EPC Network are quite compelling. But there is still more concept than reality in many of the visions put forth by their proponents. Many existing technological and economic hurdles will be overcome as momentum builds for RFID supply chain applications. No one can determine how quickly this will happen with any

degree of certainty. Furthermore, the ultimate outcome may not entirely match the current visions.

RFID will continue to evolve in the supply chain at a pace dictated by cost, performance and trading community acceptance. Wal-Mart and DoD compliance plans may have given the latter a considerable boost. But this hardly means that acceptance throughout the supply chain is assured. Certain issues may be difficult to surmount. For example, privacy concerns about item tagging may cause many retailers to shy away from this level of RFID tracking. This aversion may be driven more by public perception than technical reasons. If this happens, the future of RFID will look different than one where retail item-level tracking is an acceptable goal.

Redesigning Processes. While RFID can be used in lieu of bar codes, many potential efficiency and accuracy gains will only be obtained by using it in a different manner than bar code-based systems. The main advantage of RFID over bar codes is that it allows object identification in a non-intrusive manner. However, many existing supply chain applications require direct capture of bar codes through user-initiated scans. A truly scan-free warehouse will require different processes than one that relies on bar codes.

RFID receiving may be an extremely attractive prospect for many distribution operations. But real productivity gains will probably come more from making it a more flow-through process than by merely substituting a RFID read for a bar code scan. Implementing a flow-through receiving process may require changes in an operation's shipment check-in, quality, verification, special handling and vendor performance monitoring procedures.

Integration. Given existing challenges, RFID is hardly a plug-and-play solution. It can require considerable planning, engineering and tuning to make it work in a production environment. While this integration process should get easier as RFID solutions mature, any organization currently contemplating an RFID project should be prepared to devote significant resources to make the solution work. Since its usage is not widespread in the supply chain, skilled RFID integration resources are still relatively scarce, which means that many firms will have to turn to third party integrators for assistance.

Software Applications

Like other automatic identification technologies, RFID is deployed to support specific software applications. RFID can find its way into distribution operations through custom applications or commercially available software. Many supply chain execution software vendors have or are planning to incorporate RFID support into their products. Warehouse, transportation, labor and visibility applications are all potential candidates for RFID.

Since hand-held terminals and computers are available with integrated RFID readers, any solution that utilizes bar codes can claim to be RFID-enabled by substituting tags for bar codes. However, many RFID benefits can only be obtained by designing or adapting applications to work with the unique features offered by the technology. Whether as a customized solution or a commercially available package, RFID will work its way into the supply chain through a variety of application types.

Compliance. Wal-Mart and DoD RFID mandates have already sparked a new software market for RFID compliance solutions. These applications are typically designed to work with existing warehouse management modules and ERP systems. They basically allow tag identifiers to be systematically associated with carton and pallet contents. The result is an ASN that is transmitted to the trading partner.

How these packages work is a function of the host applications and tags that they support. Current Wal-Mart specifications allow suppliers to use either EPC Class 0 or 1 tags for pallet and case identification. For Class 0 tags the identifier is written on the chip at the factory. Class 1 tags provide write-once capability, so the operation applying the tag can encode the identifier. A Class 0 compliance solution might feature a scan/read function where the tag and case contents are systematically married in a staging location by a hand-held device. A Class 1 approach could utilize shipping label stock with imbedded RFID tags. The Class 1 compliance application would encode the identifier as each label is printed so that the association between the tag identifier and shipping label barcode is automatically built.

Unless a supplier ships exclusively to Wal-Mart or DoD, the compliance application must also account for customers that do not require RFID tags. One approach is to tag every shipment. While this method offers operational and systems simplicity, the extra cost of applying unnecessary tags can be overwhelming. Many suppliers will be faced with applying compliance tags at the back end of their shipping process. This can entail significant operational and material handling equipment flow changes that must balance efficiency and investment costs with compliance dictates.

Both WMS vendors and standalone solution providers are pursuing the compliance market. However, several WMS vendors do not restrict their compliance initiatives to their own product line and offer standalone solutions that can be integrated with ERP systems and other WMS packages.

Scan-Free Distribution. While compliance will drive some distribution operations into utilizing RFID,

others will be drawn by the potential operational benefits. Even those suppliers forced to adopt RFID by their customers will look to leverage the technology within their four walls. Many of these firms will first look to employ RFID to improve specific warehousing activities like receiving and load confirmation. This functionality will either be deployed as add-on applications interfaced to existing warehousing systems or by native support provided by a specific WMS package.

Under these initial deployment scenarios, RFID will coexist with bar codes. An operation might receive and load using RFID, but locate and pick by scanning bar codes. However, the ultimate goal is to replace all bar code scanning with tag readers. All product movement transactions from putway to outbound staging would be tracked and directed via RFID tags.

One way to achieve this scan-free vision with existing applications is to use pre-coded tags and mobile terminals with RFID readers. While this approach provides certain benefits, many other gains will only be achieved by redesigning applications to take full advantage of the non-intrusive nature of RFID. The advantages of redesigning a cycle count routine to take full advantage of RFID are fairly apparent. But the benefits of revamping other functions are subtler.

Consider full case picking where the user is currently directed to perform the pull via a handheld RF terminal. The user verifies the pull by scanning the case bar code and systematically associates the case to an outbound pallet by scanning the pallet's bar code. An RFID-enabled case picking routine could eliminate the need for these two scan points. The RF terminal would still display the pick location but would automatically advance to the next pick once the correct case has been placed on the pallet.

Making an existing WMS solution truly RFID-enabled will require a fair amount of redesign and coding. Most top-tier WMS vendors are moving in this direction. But it will probably be an evolutionary process where RFID capability is gradually added to packages over successive versions. The pace of this process is dependent on how quickly the technological challenges are addressed as well as the general acceptance of using RFID to support warehousing operations.

Closed-Loop Tracking. Until compliance changes the landscape, the most common use of RFID within the supply chain is for closed-loop asset tracking. This application type utilizes RFID to track or control the location of an asset. The asset might be a trailer in the yard or a reusable container that travels between fixed points in the supply chain. Closed-loop RFID applications are generally employed when bar coding is impractical due to environmental considerations or the process flow is better suited for a scan-free solution. Since it usually involves significantly fewer tags, its costs dynamics are typically more favorable than pallet- and case-level product tracking.

Closed-loop RFID tracking applications can used to support either manual or mechanized asset movement. Many material handling equipment vendors provide RFID readers as well as fixed laser scanners for their systems. Applying RFID tags to conveyable totes might provide an attractive alternative to bar codes in certain situations.

Real-Time Location. A scan-free RFID application tracks product movement using stationary portals and mobile RFID readers. It cannot help locate an object if it is moved outside of the reach of these devices. This same shortcoming exists in WMS solutions that rely on bar coding. While scanning is an extremely accurate method of identification and verification, bar coding does not prevent warehouse personnel from moving product outside of the system. An RFID-enabled WMS can help improve accuracy by reducing errors like the wrong target location being scanned. But it is not going to prevent someone who doesn't have an RFID reader from physically moving a pallet or case without identifying the new location to the system.

This deficiency can be overcome with enough tags, readers and special software. Real-time locator systems continuously track each tagged object's physical location within the coverage area. Given their high cost and existing technological challenges, real-time locator systems may not be viable for most operations for many years, if ever. However, they can already be found in certain specialty applications such as yard management systems (YMS).

Some YMS packages can track trailer movement through real-time locator technology. Active RFID tags are applied to each trailer as it enters the yard. The application systematically locates the trailer's position in the yard through an antenna array. Yard jockeys are not required to enter or scan trailer and location identifiers whenever the trailer is moved. The tag is removed when the trailer leaves the yard. Since only a small number of tags are needed, the investment for this type of solution may be eminently justifiable for certain operations.

Supply Chain Integration. RFID's potential to improve supply chain operations is not restricted to the four walls of a distribution center. The concept of an EPC Network provides the framework for increasing supply chain visibility and integration well beyond the level available from current solutions. If each tagged item's movements are posted to a PML server in near real time from the manufacturer to the final customer, then a whole new world of productivity gains is open to the entire supply chain. The retailer, wholesaler, manufacturer and even the manufacturer's suppliers can simultaneously monitor store sales at the item level. RFID and the EPC Network can improve product recall,

warranty management and return processes throughout the supply chain. This is definitely a long-range vision that may never pan out for certain supply chains. But its potential is strong enough to keep others moving in this direction.

Moving Ahead

Despite recent developments, RFID's future in the supply chain is not entirely clear. Many challenges must be overcome before its use becomes commonplace. But its potential impact is huge. Even if the ultimate visions of its most ardent supporters fail to materialize, RFID will still have an enormous influence on supply chain operations over the next decade.

Enterprises cannot afford to ignore RFID in the supply chain. This doesn't mean that every logistics operation should aggressively pursue RFID applications. Like any emerging technology, there is a proper point in time for an organization to adopt the new tool. The exact timing of this adoption point depends on many variables. An enterprise that moves too quickly or slowly can risk its competitive position.

Logistics operations need to address the potential uses of RFID in a systematic manner. Given the technology's current state in the supply chain, this is not as easy as it sounds. It requires work. Specifically, logistics operations need to:

- **Build an RFID knowledge base.** RFID is a complex proposition. It is not a 'plug-and-play' technology. The first step in moving ahead with RFID is to develop a firm grasp of its components, benefits, challenges and applications. Since the technology is still evolving, this will be an on-going process. The trade and industry media, solution providers, industry organizations and EPCglobal are good support sources.
- **Maintain a strategic outlook.** Enterprises need to account for RFID in their strategic supply chain planning process. This doesn't mean that every organization needs to have a formal RFID plan. However, any logistics operation should assess RFID's potential impact on its strategic and tactical plans.
- **Understand that RFID is not just another form of bar coding.** Any organization that only seeks to employ RFID in the same manner as bar codes risks missing out on the real benefits that the technology can generate. RFID should be implemented in conjunction with process redesign that leverages the technology's benefits and fully addresses its challenges. Be prepared to look at everything from packaging to facility layout because it can directly affect the success of an RFID rollout.
- **Recognize that bar codes and RFID will coexist.** Perhaps RFID will eventually replace bar codes as the primary identifier in supply chain systems. But it is much more likely that RFID and bar codes will coexist for many years—if not indefinitely. An operation may use RFID for pallet and case movements, but still rely on bar codes for item transactions. A distributor receiving RFID tagged product from larger vendors may still be processing bar coded shipments from smaller suppliers. This dual approach will entail additional processing, hardware and software cost for years to come.
- **Make the proper investment in the design process.** Implementing RFID is not a pure technology project. Because RFID has so many operational, product and systems touch points, it is essential that all impacted areas have representation on the design team. Give careful consideration to project scope so that each potential touch point is adequately addressed. Take the time and effort to thoroughly delineate each prospective benefit and challenge.
- **Have realistic expectations.** RFID is still an evolving technology. In many ways it is still rough around the edges when it comes to supply chain applications. Any logistics operation contemplating an RFID project should be realistic in their assessment of the potential benefits, costs and difficulties. While this may seem obvious, it may not be so easy to follow as momentum for the technology grows. Any operation undertaking an RFID project should be prepared for many challenges.
- **Look not just at today, but toward tomorrow.** RFID is a long-term investment proposition that should be evaluated in the context of the entire supply chain. Wal-Mart and other RFID leaders are not pushing into this new frontier because they simply want to implement flow-through receiving. They see many potential solutions that are not currently viable. They believe that the technology will continue to mature and cost dynamics improve in part because they are pushing the leading edge. Many early adopters do not see any real gain on their initial steps. They are positioning for far greater returns further down the road.
- **Be prepared to contend with more information.** RFID and the EPC Network can provide an abundance of information down to the item level in near real time. While all this information will greatly enhance supply chain visibility and collaboration, it does present significant information systems challenges. Many supply chain operations are already awash with information. RFID promises to grow this data reservoir into an ocean. This growth will stress existing system infrastructures.

Each enterprise and supply chain must determine their position on the RFID adoption curve. Some need to be early adopters, while others should wait until the technology fully matures. Most will fall somewhere in between. Figuring out the when, where and how is not an easy proposition. But the stakes are too high not to try.

About Tompkins Associates

Tompkins Associates delivers solutions focused on the entire supply chain—from operations to technology implementation to material handling integration—and are all designed to improve your bottom line and help you provide total customer satisfaction. Our expertise encompasses the operations and technology of supply chain planning, procurement, manufacturing, supply chain execution, organizational excellence/training and store operations. As the industry's fastest growing integrator, we plan, design and implement hardware and software. Tompkins stays with you all the way to success, training your people to operate your systems and providing support for the systems we deliver.

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