

Realizing the Promise of RFID: Insights from Early Adopters and the Future Potential

An EAI Technologies White Paper

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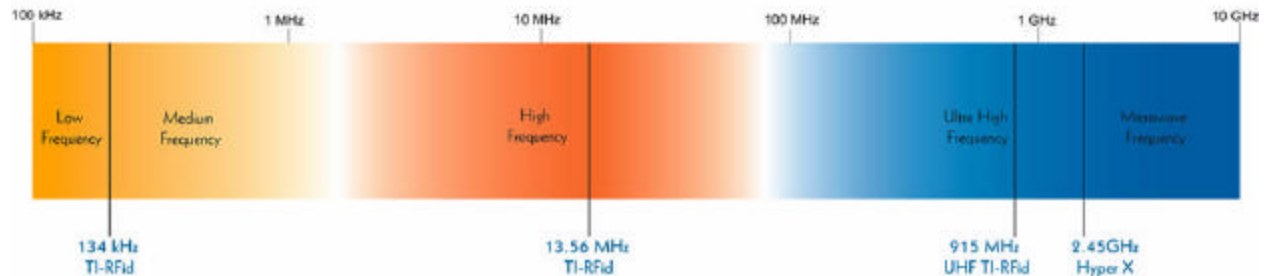


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Introduction

Radio Frequency Identification (RFID) refers to a set of technologies that use radio waves to identify and transmit information from tagged objects. While there are several mechanisms to identify objects using RFID¹, an important approach is to store a serial number that identifies a product, along with other product information, on a microchip that is attached to an antenna. The chip and the antenna together constitute an RFID transponder or an RFID tag. The antenna enables the chip to transmit identification information to a reader. Microchip-based RFID tags first started appearing in the late 1980s, with initial applications in areas such as access systems for office buildings and toll roads².

RFID technologies range from Very Short Range Passive RFID, Short Range Passive RFID, Active Beacon, Two-way Active, and Real-time Locating Systems (RTLS).³ Low-frequency (30 KHz to 500 KHz) systems have short reading range and are commonly used in asset tracking and security access implementations. High-frequency (850 MHz to 950 MHz and 2.4 GHz to 2.5 GHz) systems, offer long read ranges (greater than 90 feet) and high reading speeds. The range of frequencies and their general distance ranges are noted below.



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FREQUENCY	LF 30-300KHz	HF 3-30MHz	VHF 30-300MHz	UHF 300-1000MHz	MICROWAVE 1GHz and Up
Distance	Less than 2 meters 1cm - 1.5m typical	Less than 1 meter 1cm - .7m typical	1-100 meters 1-3m typical	1-100 meters 1-3m typical	1-300 meters 1-10m typical

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¹ http://archive.epcglobalinc.org/new_media/brochures/Technology_Guide.pdf

² http://archive.epcglobalinc.org/privacy_hearing.asp

³ <http://www.savi.com/rfid.shtml>

⁴ http://www.electrocom.com.au/rfid_frequencytable.htm

⁵ <http://members.surfbest.net/eaglesnest/rfidspect.htm>

Business Opportunities

The opportunities from leveraging RFID technologies are varied and span a gamut of application areas. For example in retail settings, radio-tagging can help to reduce theft and loss, more easily locate items, provide suppliers with better information on real-time demand for products, and improve the speed of product distribution. While conventional barcodes need to be passed in front (line of sight) of a scanner, RFID tags can be read remotely by a device up to 20 yards away, reducing the time and labor needed to recognize and process objects. RFID tags can also be encoded with data in addition to the basic identification. Some of the areas in which RFID tagging is expected to improve supply chain performance include:

Forecasting Information: RFID tagging has significant implications for generation of better forecasts. Downstream data can be accurately assembled and processed for use in driving multi-tier forecasting processes⁶. Such data can include warehouse inventories and withdrawals, inventory replenishments, as well as product consumption. Retailers such as Wal-Mart, which are pushing RFID technologies, are promising their suppliers information on products as they arrive and leave their warehouses, stores, and store stockrooms, in addition to the point-of-sale data.

On-shelf availability: Past research indicates significant incidence of out-of-stock (OOS) issues in retail settings. While a considerable proportion of the problem occurs due to inadequate order processing, studies suggest a significant fraction of OOS occurs when products are actually *in* store. According to a study conducted by Andersen Consulting, 53% of OOS situations are based on inefficiencies in the store ordering process. Another 8% of OOS situations happen while the necessary supplies are in backdoor inventory but have not been shelved. Large retailers, such as U.K. supermarket chain Tesco, have begun using RFID technology to track shipments of high-value nonfood goods. To reduce OOS issues, the retailer will attach RFID tags to its own shipping trays and dollies at its national distribution center before they are loaded and sent through its supply chain to retail stores.

Automating Proof of Delivery (PoD): Savings for suppliers can also be found in the automation of many administrative tasks associated with product delivery⁷. For example, even crate-level tagging would enable automating the proof of delivery and the invoicing process. Automatic proof of delivery would eliminate errors caused by manual processes, thus reducing costs associated with negotiating

⁶ RFID: WHAT'S IN IT FOR THE FORECASTER?

Larry Lapide. The Journal of Business Forecasting Methods & Systems. Flushing: Summer 2004. Vol.23, Iss. 2; pg. 16, 4 pgs

⁷ RFID in the grocery supply chain – a remedy for logistics problems or mere hype? Mikko Kärkkäinen.

<http://www.ecr-academics.org/partnership/pdf/award/Kaerkkalainen%20-%20ECR%20Student%20Award%202002%20-%20Bronze.pdf>

retailer claims for incomplete deliveries. Also, the arrival of tagged crates to the point of delivery could initiate an automatic invoicing process. The savings potential of automating invoice handling is much larger than what is usually imagined. For example, it is estimated to cost P&G between \$35 and \$75 to process a customer invoice by traditional means due to the high number of manual interventions needed with order, billing, and shipment systems.

Improving product security: RFID tags can be used to ensure that a product is what it represents itself to be and also to identify product movement. For example, in the pharmaceutical industry, an EPC/RFID pedigree system could enable authorized users to automatically identify and account for each unit of authentic medicine in real time as it enters and moves through the distribution system. It could identify the current location of all suspect products in the event of a recall, track disposal of damaged and out-of-date products, and allow law enforcement agencies full and accurate supply chain visibility if terrorists were to launch an attack using tainted medicine⁸.

Eliminating stock verification: RFID tags can automate the process of inventory verification. As an example, Mitsubishi's high-tech library system utilizes Microchip's MCRF450, 13.56 MHz tagging ICs that enables a library to monitor the distribution of books, video and audio materials, track sign-out and due dates, log sign-out history and "next to read" requests of library patrons, and prevent theft of materials by identifying each item in the library's inventory with a non-removable RFID tag⁹.

Incorporating shelf life of products and product self-management: Product recycling and reuse could be made easier and cheaper by shifting responsibility for product management to the product itself. That is, a combination of information technology and product design could allow products to more or less automatically manage their end-of-life. RFID tags on products could be read by garbage or recycling trucks at the same time that the main can tag is being read. Using such a configuration, the collection service could, for example, provide rebates for recycling of items¹⁰.

Reducing inventory levels: RFID is expected to lead to reduced inventory levels as firms have both the benefit of knowing what is on their shelves and better real-time forecasts based on accurate data. Thus, there is a reduced need for buffer stocks.

⁸ Safe and Secure. Lewis T Kontnik, Shabbir Dahod. Pharmaceutical Executive. Eugene: Sep 2004. Vol.24, Iss. 9; pg. 58, 8 pgs

⁹ Mitsubishi Materials Corporation selects Microchip Technology RFID Tagging IC for high-tech library system. Assembly Automation. Bedford: 2003. Vol.23, Iss. 1; pg. 91, 1 pgs

¹⁰ Product self-management: Evolution in recycling and reuse

Valerie M Thomas. Environmental Science & Technology. Easton: Dec 1, 2003. Vol.37, Iss. 23; pg. 5297

Mass Customization: RFID tags can be used to provide individual shoppers a customized product or service offering. As an example, Prada, an upscale clothing boutique, is planning an RFID pilot at one store. It announced its flagship store in Manhattan would experiment with RFID at that location¹¹. Shoppers could choose a blouse which, once brought into the dressing room, would cause the associated RFID tag to trigger a fashion show displayed on a plasma screen that showed the potential buyer exactly what other items matched that blouse, and what that blouse looked like on the runway on a model.

Benefits from component tagging: At a component level, tagging would allow better management of work-in-process inventory and also aid in the reverse logistics process.

Integrated forward supply chain management: In some industries, where the ability to supply a time or application sensitive product is a competitive advantage, tagging will allow suppliers to manage customer inventories proactively, thereby maintaining a competitive barrier to entry and a strong value proposition for the customer.

The Challenges

Cost

RFID reader costs can range from \$100 to \$3,000 or more depending on frequency and range. Companies would need hundreds to thousands of readers to cover all their factories, warehouses, and stores. Readers typically operate at one radio frequency and there is no consensus standard. If tags from three different manufacturers used three different frequencies, a store might have to have three readers in some locations, further increasing the cost.

RFID tags are also fairly expensive – 50 cents or more – which makes them impractical for identifying millions of items that may cost only a few dollars. RFID systems lack widely accepted and implemented standards for communication and functionality, thereby limiting their practical usefulness and keeping their system costs too high for many applications. In order to achieve significant item-level penetration within most supply chain applications, transponders will need to be priced well under 5 cents.

These cost targets may be achieved only with a system-level approach that encompasses every aspect of the RFID technology, from IC design to RF protocols, from reader design to back-end data

¹¹ RFID: Is This Game of Tag Fair Play?

Meg McGinity. Association for Computing Machinery. Communications of the ACM. New York: Jan 2004. Vol.47, Iss. 1; pg. 15

systems, and from IC manufacturing to antenna manufacturing. The challenge has been to develop a complete open standards-based system that enables the design and manufacture of low-cost RFID systems¹². Much of the focus surrounding RFID costs has been on chip or tag prices. But implementing a fully functional system incurs multiple costs, including tags, readers, printers, middleware, infrastructure, consulting, research and development, system changes, implementation, training, change management, service-provider fees, and additional labor¹³. For early adopters, it's likely that implementations will prove more costly in the beginning stages given the likelihood of first-time mistakes and the lack of industry best practices.

Disproportionate investments and benefits in supply chain

Studies that have simulated the financial impact of RFID implementations suggest that in most industries and scenarios, manufacturers will end up losing money, especially those that produce low-value grocery-like products. This occurs because they have to carry the cost of tagging the products. A probable exception is the electronics industry, where products have high value relative to the cost of tags. For manufacturers, losses increase as the scenarios shift from case-level tagging to blended tagging to item-level tagging, again with the exception of electronics, where the manufacturers actually increase their gains¹⁴.

Retailers, on the other hand, face a very different scenario. In almost all situations, large retailers are winners. As the scenarios shift from cases to blended to items, retailers tend to realize a greater proportion of the gains. However, the retailers experience a lot of risk, as the required capital expenditure of the blended and items scenarios approaches a half-billion dollars for the \$10 billion retailer model. Big distributors experience sizable gains, which are greatest in the items scenario, but their suppliers experience even greater losses. Given this disparity in financial gains and required investments across supply chain players, mechanisms need to be developed for equitable redistributions that preserve incentives for all players.

Security and Privacy Issues

RFID systems are different from other means of identification because RF communication is non-contact and does not require a clear line-of-sight, whereas other means of identification are either contact-based or require line-of sight. In other words, it is more difficult for the owner of the RF tag to

¹² <http://archive.epcglobalinc.org/publishedresearch/MIT-AUTOID-WH-014.pdf>

¹³ Early Adopters Should Be Wary Of RFID Costs
Larry Shutzberg. InformationWeek. Manhasset: Nov 1, 2004., Iss. 1012; pg. 98, 1 pgs

¹⁴ <http://workingknowledge.hbs.edu/item.jhtml?id=3651&t=dispatch>

physically impede communication with the tag. Consumers have expressed concerns that they do not have a choice as to when or where the technology is used or as to how it will impact them.

A second major concern is that they believe that the system will be abused and that this will have a negative effect on them, especially in regards to their privacy. Consumers are also concerned about the health effects of the network's radio waves, as well as shifts in employment caused by these technologies¹⁵.

As an example, Italian clothier Benetton caused a ruckus last January when it said its apparel would be fitted with RFID tags. "People will know when I shop! What I bought...what size I wear!" were the kind of issues raised by consumers. The proponents of RFID tried to point out that this information would only be available if someone was holding a scanner to that tag, which would only work inside a store. Still, given the public outcry, Benetton discontinued the trial¹⁶.

In terms of security, RFID tags are inherently less secure, mainly because of the lack of processing capacity on these tiny devices to handle much more than their core functions. A somewhat compensating aspect is that most of the data transmitted by an RFID tag isn't all that meaningful unless it's considered in context. But as location-based or personal information is linked-in to that data, the possibility of a security threat emerges.

Information Sharing Issues

A significant challenge to RFID implementations is the lack of clear standards or conventions for the sharing of data with other firms. As an example, Pfizer Inc., maker of the much-counterfeited Viagra, will place RFID tags on cases and retail packages of the impotence drug by the end of next year. The company says it is in discussions with wholesalers and retailers to work out hurdles, including data sharing. That issue has been one of the sticking points with the technology: manufacturers, wholesalers, and retailers are looking for ways to create a detailed pedigree of the drugs' shipment history while also guarding proprietary information, such as sales volume and shipment frequency¹⁷. There are also industry specific issues that may make some organizations slow to adopt RFID; e.g., the need for regulatory approval of new technologies. In some cases, new labeling standards are emerging that may be in conflict with developing RFID standards.

¹⁵ <http://archive.epcglobalinc.org/publishedresearch/cam-autoid-eb002.pdf>

¹⁶ RFID: Is This Game of Tag Fair Play?

Meg McGinity. Association for Computing Machinery. Communications of the ACM. New York: Jan 2004. Vol.47, Iss. 1; pg. 15

¹⁷ Heather Won Tesoriero. Radio ID Tags Will Help Monitor Drug Supplies
Wall Street Journal. (Eastern edition). New York, N.Y.: Nov 16, 2004. pg. D.9

Compatibility/integration/standardization

RFID implementations require new standards to be agreed upon for identifying objects and linking them to other related information. The Auto-ID center, initially a project based at MIT, has proposed a universal standard for product “license plates” – the Electronic Product Code (EPC). Like a barcode, the EPC is divided into numbers that identify the manufacturer, product, version and serial number. Unlike the barcode, EPC uses an extra set of digits to identify unique items. The EPC is the only information stored on the RFID tag’s microchip. This keeps the cost of the tag down and provides flexibility, since an infinite amount of dynamic data can be associated with the serial number in a database. To help computer systems find and understand information about a product, the Auto-ID Center has developed associated standards and technologies. The first key element is called the Object Name Service (ONS). ONS points a computer to an address on the Internet where information about a product is stored. The concept is based on the Domain Name Service, which points computers to the address of particular Web sites on the World Wide Web.

Physical/environmental

Some implementations of RFID, in the food and drug industries for instance, may encounter physical and environmental challenges corresponding to extremes in temperature, packaging constraints, labeling standards, and the interactions between product and RFID signals.

Data storage and management

Use of RFID technology will require the high-speed handling of very large data streams from readers. The processing, storage and management of these streams and aggregated large data sets will pose a new challenge for hardware and software vendors. Much of the data stream will be repetitive information and can be ignored, but processing algorithms must still be developed to perform filtering operations, and these may be specific to applications or industries. Different industries may also have regulatory requirements that drive specific data processing and retention requirements that vary from other industries.

Moving forward

Global Standards Under Development

EPCGlobal, a member-driven organization, is leading the development of industry-driven standards for the Electronic Product Code (EPC) to support the use of Radio Frequency Identification (RFID).

Costs are falling

The costs of tags and readers are likely to fall in the future, particularly as standardization processes gain greater momentum, creating economies of scale. However, integration costs may still be prohibitive until system integrators develop industry vertical solutions they can replicate.

Consumer Education

It appears that consumer's concerns about privacy can be overcome by¹⁸:

- ❖ Offering consumers greater control by ensuring that they will be made aware of when and where the network is being used and offering them an option to kill the tag.
- ❖ Creating governance mechanisms around the use of the network through appropriate guidelines, policies, regulations, or controls.
- ❖ Offering information about the issues relating to health effects and the impact on employment.

EPC RFID tag specifications specifically include the requirement that the tag will deactivate irrevocably if it receives a 'kill command'¹⁹.

The information supply chain

RFID technologies herald the emergence of disposable computing that will offer new challenges in scalability, flexibility, and security of next-generation as they create the possibility of tracking millions of new transactions, sending and receiving small amounts of data that track the flow of goods and services throughout the supply chain²⁰. As more and more data become available in usable forms—particularly data generated after a product leaves the store—the "information supply chain" will begin to function as an independent source of revenue, generating invaluable data about product performance, consumer behavior, and logistics. This will enable businesses to be more responsive to market trends and their customers. Bundling information services with physical products, such as smart appliances, will be another key source of new value.

Industry Adoption: Supplier Pains

Not all industries are expected to be equally likely to adopt RFID technologies. Some industries (like consumer electronics, pharmaceuticals, and toys) are likely to rollout their implementations earlier due to suitable product attributes and category economics.

In June 2003, Wal-Mart greatly advanced the process of adoption when it announced that starting in January 2005, 100 of its top suppliers would need to tag all pallets and cases going to some Wal-

¹⁸ <http://archive.epcglobalinc.org/publishedresearch/cam-autoid-eb002.pdf>

¹⁹ http://archive.epcglobalinc.org/privacy_hearing.asp

²⁰ <http://cio-asia.com/pcio.nsf/unidlookup/218EE519E41C886248256D8300484409?OpenDocument>

Mart warehouses. This mandate would be expanded throughout 2005 to include other parts of its distribution network. Wal-Mart began its RFID pilot on April 30, 2004. The eight suppliers that started shipping a handful of RFID-enabled pallets were Gillette, Hewlett-Packard, Johnson & Johnson, Kimberly-Clark, Kraft Foods, Nestle Purina PetCare, Procter & Gamble and Unilever. The Department of Defense (DoD), Target and Albertsons announced their future RFID-tagging requirements to their suppliers. For now, these mandates focus on pallet and case, not on item-level tagging.

The U.S. Department of Homeland security will soon begin using RFID technology at U.S. border checkpoints. Internationally, officials in Great Britain are discussing proposals to embed tags in vehicle license plates. The U.S. Food and Drug Administration is pushing the pharmaceutical industry to tag medicines by 2007. Delta Airlines recently announced that it will invest \$25 million to deploy disposable radio tags to track and locate lost luggage, which costs the airline \$100 million annually. Las Vegas' McCarran International Airport has also announced that it will begin attaching radio tags this fall to all checked luggage²¹.

Recently, several companies across the drug supply chain have been testing RFID deployment. Three drug makers announced plans for limited RFID rollouts. Closely held Purdue Pharma LP, maker of OxyContin - a potent opioid painkiller that is often diverted to the black market - will ship 100-tablet bottles with RFID tags to Wal-Mart and H.D. Smith Wholesale Drug Co.

Despite all of these announcements, the early adoption is not without pain for the participating companies. Wal-Mart's suppliers are split into two camps: about 30 percent of them are going the whole nine yards and integrating RFID into their infrastructures now. The rest are practicing a method known as "slap and ship." Essentially, to meet Wal-Mart's mandates, these companies are sticking an RFID tag on only a certain percentage of cases and pallets in warehouses that are closest to Wal-Mart's Texas distribution centers. "Slap and ship" involves minimal data integration and continues to leave the retail supply chain blind to product movement²². It remains to be seen what kind of cost-benefit outcomes are realized by the two sets of suppliers.

Lessons from early implementations

²¹ Tagging Toothpaste and Toddlers

Nikki Swartz. Information Management Journal. Lemexa: Sep/Oct 2004.Vol.38, Iss. 5; pg. 22, 1 pgs

²² Tag ,You're Late ; Why Wal-Mart's suppliers won't make the Jan. 1 deadline for RFID tagging

Thomas Wailgum. CIO. Framingham: Nov 15, 2004.Vol.18, Iss. 4; pg. 1

Based on the experience of companies that have been rolling out early pilot implementations, we outline lessons for other companies considering RFID technologies:

1. Need for complementary change in business processes

There is a clear need to integrate RFID technology within appropriate business processes. In some cases this requires significant change in how companies manage processes such as ordering and inventory management. For example, moving from ordering to proactive replenishment would be needed to better leverage the power of instantaneous information availability. That would enable suppliers to respond quickly to changes in demand instead of accumulating information to form reasonably sized orders. The biggest value/impact will only result with a redesigned business process flow that takes advantage of the newly available information, especially at the “edge” locations. This traditionally is a notoriously slow and problematic process. It will be easier for new companies to start up in this mode than for existing companies to adopt it, and therein will lie some of the disruptors who emerge as a result of this technology.

2. Think about Impact on Consumer Value

RFID applications in many industries are being driven by consumer needs. In the automotive industry, where RFID applications are gaining traction, the deployment of RFID solutions promises clear new functional capabilities. Michelin is starting to use tags in its tires and there's great interest in next-generation consumer products, such as passive keyless entry systems, theft-deterrent immobilizers, and parts-marking initiatives. As in the infancy of any technology cycle, it's difficult to ascertain whether car makers are over-specifying demand and technical product content prior to the need or development of the real customer demand.

3. Vertical Applications are the key but a current weakness

An RFID solution consists of multiple components such as chips, tags, readers, antennas, software, and vertical market applications. Industry experts suggest that vertical market applications have been a weakness so far²³. Thus, greater effort needs to be expended in developing and deploying relevant business applications on top of the technology stack. One positive movement in this direction is the attention that has been given to the pharmaceutical industry's efforts with consumer packaged goods.

²³ Swatch group makes Sokymat an automotive offer it can't refuse
Anonymous. Frontline Solutions. (Pan-European edition). Duluth: Mar 2003. Vol.12, Iss. 2; pg. 13, 1 pgs

4. Prepare for the unexpected: Bug Zappers anyone?

As with all new technologies, RFID is expected to have its share of teething issues. For example, IBM has tested RFID equipment in the back-room grocery sections of seven pilot Wal-Mart stores, in support of the retailer's RFID project. During the deployment, IBM consultants have encountered interference from handheld devices such as walkie-talkies, forklifts, and other devices typically found in distribution facilities. Nearby cell-phone towers, which transmit at the high end of the frequency band, sometimes leak unwanted radio waves into the RFID readers. Bug zappers in the back rooms of the test stores also caused interference²⁴. Organizations need to be cognizant of such teething issues that may affect their implementations. The following illustrates an early sampling of the RFID spectra with the potential for interference.

Spectrum Characteristics for RFID					
FREQUENCY	LF 30-300KHz	HF 3-30MHz	VHF 30-300MHz	UHF 300-1000MHz	MICROWAVE 1GHz and Up
Reflection / Nulling	None	Low	High	Higher	Highest
"Skip" Interference Tropo Ducting	None	High	Low	Lower	None
Electrical Interference	Very High	High	Medium	Med to Low	Low
Distance	Less than 2 meters 1cm - 1.5m typical	Less than 1 meter 1cm - .7m typical	1-100 meters 1-3m typical	1-100 meters 1-3m typical	1-300 meters 1-10m typical
Regulations	Part 15	Part 15	Part 15	Part 15	Part 15
Data Rate	1-10KB/s	1-3KB/s*	1-20KB/s	1KB-10MB/s	1KB-10+MB/s

* (Depends on regulations and distance. At very close spacing like smart cards, higher data rates are possible.)

Reflection is signal reinforcement or cancellation (nulling) due to direct and reflected signals being in or out of phase based on distance between source and target and the length of the reflected path. Enhancement is usually only plus 3 to 9 dB while nulling can be total. Nulls can be -10 to -30 dB, however signal fill from multiple reflections in most indoor environments will generally reduce nulling losses to -6 to -12 dB or so.

Blocking (not in the chart) on the other hand, can be total in some locations. Blocking occurs when an object larger than a half wavelength gets between the source and the target and shadows the target completely from the source. This will be more of a problem at higher frequencies (microwave) than at lower frequencies (LF, HF or VHF).

Skip Interference / Tropo refers to out of area signals which may arrive at levels quite strong compared to the desired local signal due to refraction from the earth's ionosphere (HF) or tropospheric ducting (VHF / UHF). Tropospheric ducting occurs along the boundary between air masses of different temperatures. Consult the [ARRL VHF Manual](#) or [RSCG VHF/UHF Manual](#) for more complete descriptions of these propagation modes.

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²⁴ IBM Shares RFID Lessons. Laurie Sullivan. InformationWeek. Manhasset: Oct 25, 2004., Iss. 1011; pg. 64, 1 pgs

²⁵ <http://members.surfbest.net/eaglesnest/rfidspct.htm>

5. Galvanize industry collaboration

The lack of industry standards can be a significant roadblock to the use of RFID technologies. Some industries have taken a collaborative approach to this issue. The major pharmaceutical players, such as the world's largest pharmaceutical manufacturers, wholesale distributors, and chain drugstores, are working together as a group to explore key uses for EPC applications. This pharmaceutical industry group has also created three working teams to build a whole-industry perspective on issues relating to counterfeiting, shrinkage, and theft. EPC Global and their associated working groups (hardware, software and industry verticals) are collaborating and working through real life scenarios on what is needed and laying the groundwork for realistic standards. An example of such collaboration is the working group tasked with hammering out the specifics needed for EPC Information Services (IS). VeriSign also offers a prototypical EPC IS to allow for R&D efforts and increasing familiarity with the EPC Network.

Each new compliance driver, such as Wal-Mart/DOD and/or FDA drug tracking pedigree needs, will both drive additional innovation and give practical industry insight that will be beneficial for all parties.

6. Explore Applications through small pilots

Organizations should start by directing their implementations towards addressing specific goals (e.g. POS visibility for a manufacturer, or inventory shrinkage for a retailer) that create the most value for them and their customers. Certain companies with a targeted customer service focus may find item-level RFID has operational cost savings. Marks and Spencer guarantees that they will have every size of pants and suit so that the customer will always find his or her required size. They do a nightly inventory of each item sold and replenish accordingly. Automating inventory tracking would mean a reduction in operational cost impact as well as an improvement in their percentage of having all stock on hand. The driver for Marks and Spencer is their business rule requirement, designed to please their customer. With a business objective clearly defined, organizations should then focus their early pilots on tracking pallets and cases before even thinking of putting a tag on an item.

One of the most popular ways for piloting is limiting the magnitude and number of SKUs. Unfortunately, a key aspect, the Business Improvement Process—identifying and mapping out changes that can have dramatic improvements—may not always surface or become visible in these

pilots. Early and/or limited roll-outs will definitely assist with learning how to use the information within and beyond organizational boundaries.

The pharmaceutical industry has some specific needs that allow for an easier roadmap for requirements implementation, but only on a state-by-state basis. [There are certainly state differences, but there is an overall robust set of requirements for product tracking and traceability in CFR 21, as administered by the FDA. The FDA is often very cautious with respect to new technology and will likely be quite slow in approving a new RFID standard for product tracking. That said, there is a clear mandate in the pharmaceutical industry for better tracking and supply chain integration that will make RFID attractive once some of the challenges are addressed.] The pedigree directive (2129) from the state of Florida is an example of a relatively simple record-keeping form for shipped drugs. RFID technologies could simplify and improve the process and reliability of tracking drug pedigrees by providing records of point of origin and destination, which are required to comply with state and federal laws. Manufacturers are hoping for clearer overall mandates from the FDA that will point the way for a consistent approach across all states, rather than requiring manual or semi-automated process for individual states.

Observations and Summary

Analysts and end users agree that the required functions, such as EPC commissioning and central data routing, reader management, data routing, high volume data management, advanced integration, and filtering, will get easier. Readers and related devices will get smarter, smaller, and more easily incorporate RFID or tag data into edge and enterprise systems (ERP, SCM and WMS.)

Enterprises will look for more flexible business processes and evolve beyond the initial static applications that allowed for RFID entry/integration/implementation. Natural evolutionary steps will be tools like trading partner management, process automation, and data management, which are critical components for developing and managing more dynamic composite business applications.

The military's use of active RFID in their supply chain in the field operations yields some ideas for standard commercial use. In one such implementation, large payloads, such as shipping containers, have been outfitted with \$70 to \$100 large sized active RFID units. With a battery powered signal that can be read up to 100 feet, the system uses the bin or RFID number to look up the contents of the bin from the central repository database. In a theatre of operations, quickly assessing which container has the necessary supplies and accessing it are critical for supporting the mission.

Similarly, as the most critical and vulnerable parts of supply chains, both within an enterprise and across enterprises, are identified, RFID will evolve to provide cost savings, robustness, and operational improvements to current implementations of these vital processes.

There will be an obvious tendency to rely on the large provider/vendors because of their knowledge of the Fortune 1000 companies' business and back-end processes. An enterprise-wide SAP infrastructure will tend to lean towards an SAP RFID extension or an SAP-centric RFID add-on. The ongoing investment/acquisition of smaller companies in the space are indicative of the desire and needs of larger companies to expand their skill set in delivering expertise where there is not enough to go around. Different vendors are choosing various investment paths and associated road maps. Microsoft, as one example, is making some early attempts to create or forecast the need for an RFID Services platform that will fit nicely within their technology stack. BizTalk and .NET provide the underlying fundamental components while Microsoft Business Solutions provides ancillary components that can be driven through Axapta. Overall, Microsoft hopes to capitalize on the medium size business entities as they enter the RFID space after the market has matured overall and the price points are manageable for the second tier companies.

Use of RFID information locally or at the 'edge' should provide some real time operational efficiency benefits. Limiting certain types of SKUs to certain dock doors or warehouse locations with immediate notification when a rule is violated will minimize errors in shipping/routing. Time intervals for expected reads can also help to qualify when expected shipments/movements should occur within an internal supply chain view.

Various tools have already been designed and other components are evolving that filter, alert and transform RFID data reads to make intelligent use of the data for decision choices or controls that may have previously not been available. Initial deployments will help to pinpoint best practice and future uses of additional information being collected as well as how to optimally view/filter and act upon this data being made available on the edge (shop floor, warehouse, distribution center, etc.).

It will prove interesting as the supply and demand chain converge with the use of EPC tags and the EPC Network and as we learn more about changes in customer behavior patterns. The increased visibility potentially offers new value creation opportunities that will leverage targeted marketing and enhance the overall customer experience.

The challenge of integrating new technologies with existing business processes, or alternatively changing those business processes, will prove daunting if not prohibitive to many early adopters of RFID. As market channels begin to develop, including system integrators and enterprise software vendors who package industry solutions that they can scale and replicate, these challenges will diminish somewhat. In the interim, the big wins with RFID may belong to the disruptors who learn how to leverage this technology to challenge an industry and its dominant players. Who will emerge as the Southwest Airlines or Amazon.com of the RFID world? This may be the most interesting development to watch.