RFID: A Practical Approach

7 Critical Success Factors In RFID Deployments

(Or, How to Avoid Implementation Pitfalls & Realize Faster Returns on RFID Investments)

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Introduction

Time will come when the supply chain as we know it will be clumsy and cumbersome no longer, less demanding on company cash and assets, and much more predictable and sensitive to time and patterns of market consumption. “Perfect visibility,” they say, will emerge across almost every industry, around the world, and down to the item level.

This development is already underway driven by relentless advances in key enabling technologies – microchips, materials, miniaturization, short-range radio, and data management, mining and analysis.

It’s driven, too, by persistent pressure from Wall Street and prudent financial management to improve cash flow and asset utilization, reduce standing inventories, and generally effect greater efficiencies not just in closed loop company operations but along the entire value chain.

The AutoID Center at the Massachusetts Institute of Technology calls it an “Internet of Things” enabled by Radio Frequency Identification, or RFID for short. It promises to gather and apply real-time intelligence at the pallet, case and item levels along the entire length of nearly all physical supply chains, from source to consumption.

In recent years, Tyco Fire & Safety has joined a diverse team of key industry players to support the critical development of open RFID standards, protocols and approaches at the AutoID Center. Doing so is a logical extension of our Sensormatic roots in Electronic Article Surveillance (EAS) that we pioneered some 30 years ago and today still hold market leadership.

This paper aims to give you, the busy reader, a brief yet informed overview of what RFID is, what challenges it still faces, and most importantly, what steps are required for its successful deployment.

In concept RFID is easy enough to understand but in practice its interdependent variables are complicated enough to warrant a closer look at what you should expect. The devil, as the saying goes, is in the details.

At Tyco, we're most pragmatic in our outlook for RFID, the hype notwithstanding. We agree its potential business benefits are huge. But given that we've been involved in RFID applications for 15 years (including large-scale RFID installations at Olympic venues for safety and security), we know the factors critical to a successful implementation are not trivial and want to share them with you in this paper.

This year we've doubled our RFID investments inclusive of our support of the AutoID Center's important work on a universal Electronic Product Code (EPC), the Object Name Service (ONS), Physical Markup Language (PML) and other enabling technologies.

Our own RFID program includes the development and manufacture of standards-based RFID hardware, software and tag products as part of the Sensormatic product family, sold under the SensorID™ brand. And to offer the greatest flexibility, interoperability and legacy investment protection, we provide a range of multi-frequency, multi-protocol RFID products.

We also can integrate "best-in-class" RFID components and services that we are unable to provide, since a single-vendor, end-to-end supply chain solution is beyond the compass of any one firm.

Currently, in league with leading suppliers and retailers, we are engaged in multiple deployments of RFID solutions, with item-level, in-store applications as well as case- and pallet-level manufacturing and distribution programs. Our experience here, too, forms the basis of this paper.

You're invited to find out more about Tyco's RFID capabilities by visiting our website at www.tyco.com/business/fire_security or by contacting me directly.

Thank you.

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RFID: A Complementary Auto-ID Technology

As already mentioned, RFID is a simple concept. It's been around since the 1940s, but only in recent years have technology advancements allowed for consideration of its practical application across entire supply chains. Until now, RFID applications have been mostly proprietary and closed-loop within the boundaries of a company's operations.

The 96-bit EPC design ensures enough unique identifiers for 268 million companies to each have 68 billion serial numbers in each of 16 million classes of objects.

To explain RFID briefly, a small electronic tag comprising a tiny microprocessor and an equally tiny radio antenna is placed on a pallet, case and/or item with a unique, 64- or 96-bit identifier, its Electronic Product Code, or EPC. This tag, sometimes likened to a "license plate," can be put in place at any point in the supply chain, but ideally at its origins of processing or manufacture.

In turn, radio-frequency (RF) readers are placed at strategic points in a pallet, case and/or item's journey from source to shelf. These reader placements include the floors, doors and even forklifts of warehouses, shipping docks, distribution centers, receiving docks, retail back rooms, and so forth, including store shelves. Except in the case of weak RF signals, they do not need "line-of-sight" to be read as bar codes do.

Four primary bands have been allocated for RFID use. Low-frequency (125/134KHz) systems are most commonly used in security applications like hands-free access control and asset tracking. Mid-frequency (13.56 MHz) systems are typically used in non-security applications such as customer loyalty programs where medium read ranges are required. Ultra high-frequency (850 MHz to 950 MHz and 2.4 GHz to 2.5 GHz) systems offer the longest read ranges and highest reading speeds, and are used in environments requiring the fast

identification of multiple tags like automated toll collection and supply chain tracking.

When an RFID tag passes through a verification point, the RF reader will sense the tag's EPC if it's an active, battery-powered tag or will emit RF waves to induce a current in the antenna of a passive, non-battery tag. The data is then read and sent to a database containing a larger data record of what's tagged, plus information like where and when it was manufactured, its current location and status, and on and on.

It's easy to imagine how applying this concept along entire supply chains will reduce shrinkage, errors, and inventory needs to achieve greater efficiencies, cash flow and asset management. But even now, when RFID has become a technological possibility, its utility is rife with a wide range of challenges described on the following pages.

(You can find more details about RFID at www.autoid.org or via the respected industry online publication, the RFID Journal at www.rfidjournal.com.)

RFID Deployment Challenges

For all its promise, RFID is still in its infancy not unlike where the PC industry was just 10 years ago when 80 megabyte hard drives cost $300 and weighed 10 pounds. Few could imagine then that for about the same price today you could drop an 80 gigabyte hard drive – 1,000 times the capacity and 1/100 the weight – in your shirt pocket with headphones on to listen to your favorite MP3 tunes while walking down the street.

Likewise we believe technological advances will quickly move RFID forward, only faster given the accelerated rate of high-tech developments today. For example, work is reportedly already underway on RFID tags based on cheaper silicon alternatives as well as magnetic “chipless” tags.

So, just as in the PC industry, you can expect RFID components and systems costs to drop dramatically in the years to come – giving us humans time to figure out how to make best use of it. That explains why so many key suppliers, distributors and retailers have pilot programs underway or planned soon.

It’s also why knowing where the potholes are today can help smooth the ride for tomorrow. Following then are a number of key challenges facing RFID, as well as what we believe are critical success factors in its deployment.

- **System Costs:** Today’s passive tags cost around 40 cents apiece and basic readers from $1,000 to $4,000each. Given emerging standards, advances in micro-manufacturing and competitive volume economics, the RFID industry should approach its targeted price points of an order of magnitude less or better within the decade. In the meantime, however, RFID applications are relatively expensive compared to other auto-ID approaches.

- **Material Matters:** Water absorbs radio waves and metals reflect them, making it difficult for RFID to track products with high water content or in metal or even foil packages.

- **Wireless Reliability & Consistency:** Anyone with a cell phone today knows that wireless transmission can be unpredictable (“can you hear me?”) wherever gaps exist in cell coverage.

- **Electromagnetic Interference:** Almost anywhere along the supply chain and especially in the through-ways where processing, auditing and verification points are best located, you can find multiple sources of RF interference – other readers, other tags, cordless RF and cellular phones, wireless LANs and data transmission systems, neon lights and so forth.

- **Data Warehousing:** An entire supply chain, RFID-enabled to the item level, has the potential to generate enormous amounts of dynamic and temporal data, far beyond today's data management software capabilities.

- **Numbering Incompatibilities:** Established numbering systems in which companies have sunk large investments may be incompatible with EPC-encoded systems, requiring extensive reworking of existing systems, additional translation schemes, or wholesale change-outs.

- **Varied RF Frequencies:** Existing RFID or other auto-ID systems may use different RF frequencies, not to mention that different countries have assigned different parts of the radio spectrum for short-range RF transmissions. This means that inter-company and/or international supply chains may well need RF reconciliation at various points in the supply chain.

- **Business Process Redesign:** As is the case with most breakthrough technologies, implementing RFID can require the fundamental redesign of business processes in order to attain optimal RFID benefits.

- **Cost/ROI-Sharing:** Existing RFID implementations are proprietary and usually closed-loop, and near-term implementations are expected to remain until the AutoID Center's standards become widely deployed. But even then,

inter-company implementations across multi-enterprise supply chains will beg questions as to which company pays for what and gets what in return.

RFID is a still maturing yet important and complementary technology that will co-exist with other auto-ID technologies for years to come.

For all these reasons and more, Tyco believes that RFID is a still maturing yet important and complementary technology that will co-exist with bar codes, electronic article surveillance (EAS) and other auto-ID technologies for years to come. *(See the table on the next page for comparative advantages.)*

Bar codes, for example, are simply too widespread throughout the world's interlinked supply chains to be displaced quickly by RFID. Plus, bar codes are cheap, offer human-readable, visual confirmation of product information, and overcome RFID's technical limitations on tagging metal and foil products.

In the case of EAS, its value in reducing shrinkage today and in the foreseeable future is simply too great to discount at all for the sake of an emerging technology like RFID. Shoplifting, employee theft and other sources of shrinkage won't stop to wait for RFID to grow up and extend itself from focusing on supply chain logistics to becoming anti-theft systems designed for retail channels and environments.

All that aside, the size of the legacy infrastructure, its amortized costs, and the organizational impacts of converting to RFID ensure that existing EAS systems will continue in service for many years to come.

Clearly, but in time, we'll see a blending of existing auto-ID technologies with RFID, a layering over existing infrastructures to provide additional functionality in applications requiring it.

To ensure RFID's rapid adoption – and, most importantly, rapid payoff – support both for open standards and for the development of multi-protocol, multi-frequency solutions is paramount. Key vendor partnerships backing astute, on-site engineering will also be critical for end-to-end solutions. From there, only business process redesign and intercompany data and cost-sharing issues will stand in the way of RFID ubiquity enabling the "perpetual inventory visibility" conceived by the industry's visionaries years ago.

Table 1: Comparative Advantages of Key Auto-ID Technologies

Technology	Primary Function	Unique Benefits
Barcoding	Automatic identification & processing of merchandise	Proven, pervasive, accurate, many form factors, cost effective
EAS	Anti-shoplifting	Very robust, small label footprint, works in presence of metals & foils, many form factors, very difficult to defeat
Video management	Surveillance of property; adherence to corporate processes; identification of internal theft	Visual confirmation of exception events, remote management capability, integration with other infrastructure systems
RFID	Asset tracking and tracing	Identification to unique item level; does not require line-of-sight; speeds processes while reducing errors

RFID Deployment: 7 Critical Success Factors

At the operational level, RFID deployments face a jungle of engineering obstacles with interdependent variables that need to be controlled within relatively tight parameters. And, of course, rarely are any two sites the same.

What follows is a primer on the key success factors involved with RFID site engineering based on Tyco's 15-plus years experience in field deployments.

Each of these factors could be chapters in a book, but for purposes of this paper, will help you become better aware of the issues they suggest and in a way be a checklist for developing a practical deployment plan for RFID in your business or supply chain.

1. RF Site Survey

Every environment within which RFID is to be installed can be expected to be different from an RF perspective. Interference from wireless networks, short-range radios, cordless phones, and so forth can dramatically and negatively affect RFID system performance. Sources of this interference can be behind walls, around corners, or otherwise hidden.

Also, some environments impose mechanical and/or chemical considerations on RFID engineering that need to be addressed. Will there be vibration? What's the potential for normal operations to damage the equipment?

The purpose of a site survey, then, is to understand customer requirements for an RFID installation in the context of the facilities where it's to be deployed; to gather the information needed to define the deployment requirements; and to predict the performance of the RFID solutions to those requirements.

A careful evaluation and documentation of the RF environment by a site survey early in an implementation is key to guiding equipment selection and installation. It's also important to help vendors and customers alike set realistic performance expectations.

Tyco has built an extensive database over 30-plus years on a wide range of RF devices, their makes and models, along with their finer points of FCC Part 15 compliance. This is valuable because knowing the nuances of how these devices

“behave” RF-wise can used to optimize an RFID implementation given their existence in the target environment.

2. Installation & Tuning

Once the feasibility test, pilot or launch has been planned, systems must be installed in a broad array of site scenarios from dock doors, walkways, conveyors, trolleys, totes and wheeled carts, forklifts, pallet bays, storage areas, and so on.

In each instance, antennas must be mounted to both exploit the reflective characteristics of the scenario and to achieve the RFID objectives at the site and scenario location. Each antenna position must be calibrated for maximum real performance, using tagged items, cartons or pallets to verify the tuning depending on the level of RFID required. Theoretical performance adjustments are not acceptable.

The tendency of reader manufacturers to package readers separately from antennas makes scenario installations that much more complicated because of this tuning issue. For example, a simple installation of a one reader and two antennas is one-third more complex because the reader is not integrally packaged with at least one antenna. This minor bit of added complexity can raise substantially the ultimate cost of a major RFID implementation involving hundreds if not thousands of readers.

3. Reader Synchronization

Especially challenging scenarios are those that require multiple RFID systems synchronized to work in harmony without interfering with one another or with neighboring systems. This can be done by time-based synchronization of a

reader group to a common clock and careful placement of antennas. Unlike EAS systems that are synchronized to transmit and receive in unison, RFID systems must be synchronized to transmit at different times. A failure to properly synchronize readers that have antennas close enough to transmit to each other can result in reduced system performance as the tags themselves get confused by multiple simultaneous requests for transmission of the EPC.

4. Cable Management

RFID readers must connect to a minimum of three cables: power, communications and one antenna. In fact, a single reader could easily be fed by eight cables. As FCC Part 15 devices, the length of the antenna cable is fixed and can't be shortened or lengthened without violating federal regulations, so it's important to engineer the RFID scenarios while keeping cable requirements in mind.

In all cases, the readers and antennas will be installed in areas where equipment may be operating. This will require securing and protecting the cables from damage. Conduit will be indicated in some scenarios, or just by common sense. While a licensed electrician will usually not be needed, experienced installers will be necessary to ensure the installation will meet the rigors of the environment.

5. Label/Tag Design & Placement

No universal labels or tags – one size fits all – exist because of the number of material, packaging, environmental and application variables that can affect their selection. For example, as already mentioned, metals and liquids pose challenges that good RFID engineering can help solve.

In addition, different kinds of labels and tags are available depending on the specific need, and of course with different prices. Active, battery-powered ones

cost more than passive, inductive ones but they can be read from a much longer range. Read/write tags cost more than read-only tags, but they can have information added to them in their transit affixed to pallets, cartons or items.

Economics in most cases will guide the choice of the type of tag or label used, if not whether RFID is deployed at pallet, case or item levels. High-cost labels and tags (i.e., 50 cents or more) don't make sense for low-cost items. On the other hand, they may prove economical for cases of goods, high-cost items or items that are prone to shrinkage.

Placement is a related issue – just having the right label or tag for the application isn't enough. The label or tag needs consistent placement in the right spot for being read in the many and various scenarios it will pass through enroute to its final destination.

6. Device Management

RFID readers come in various levels of intelligence from dumb (and cheap) serial devices to smart (and more expensive) Internet-enabled appliances. In either case, these readers have a host of maintenance and management chores associated with them.

Among those tasks are firmware that has to be upgraded periodically; status that needs polling by the minute, hour or day; queues to be dumped and processors to be reset; maintenance schedules to be maintained; and so on. These chores might not be so burdensome if the number of devices were few, but even in a closed-loop deployment, their numbers could be in the hundreds, if not thousands.

Further, in open-looped, intercompany RFID applications, device management becomes even more complicated as the workload needs to be shared in some consistent and dependable fashion across different members of the supply chain.

Needed will be a meta-network to manage the devices, performing the maintenance, diagnostics, resets and so on. To save on costly technician service calls, these activities will have to be done remotely via electronic interaction as much as possible – like how Tyco manages many of its customers' existing systems today.

7. Data Management

RFID's widespread adoption is fantastic news for database and data storage firms as well as developers of data mining software simply because the amounts of data collected will be so enormous.

Current technologies are not quite capable of handling the flood of data from billions if not trillions of 96-bit EPC tags around the world transmitting their source, destination, whereabouts and status. An estimate of the data generated by a full RFID supply-chain deployment required by the likes of Wal*Mart is on the order of many *terabytes a day.*

Given this, the final critical success factor in deploying RFID is to determine what your goals are with the kinds of data you will expect to generate. Then, within realistic parameters the size of the data load that can be expected from a specific RFID deployment to ensure that your systems can handle it. Even small details like field character length in a database record format can require changing if the data string is too long for it.

Conclusion

We are excited about the wide range of future benefits RFID promises to bring supply chain logistics, and are most encouraged by the industry's enthusiasm as

well as by being privileged to take part in several important early pilot programs. Yet for all the RFID progress that's been made to date, the industry is only at its start. Like anything, the secret to RFID success will be in its execution. This, we suggest, is what will get us to our collective destination, and is how we can help you get to yours.

About Tyco Fire & Security

As a leader in electronic security for more than 30 years, Tyco Fire & Security has helped to pioneer RFID in safety and security applications, and strongly supports the development of open industry standards and protocols to accelerate its deployment across the entire supply chain.

In addition, Tyco Fire & Security designs, manufactures, services and markets the world's most advanced lines of fully integrated electronic article surveillance (EAS) systems under its Sensormatic brand, as well as other market-leading brands like American Dynamics, Digital Video Solutions and Software House Access Control.

Our EAS systems are used by all types of retailers to deter shoplifting and internal theft. We lead the security industry in integrated source tagging – helping consumer goods manufacturers apply some 10 million anti-theft tags every day in their packaging or manufacturing plants around the globe.

With more than 445,000 EAS installations worldwide, our customers include a majority of the top 100 retailers worldwide, representing all market segments including retail, gaming, government, education, public and private industries.

Over 150 retailers with more than 100,000 locations sell Tyco's Sensormatic source-tagged goods from thousands of manufacturers.

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