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Best Practices Guide:

RFID Implementation, Testing & Deployment

Lessons for Success from Real-World Implementations

Executive Summary

RFID Systems have significantly improved over the past several years, now achieving read rates close to 100% and fulfilling the vision of RFID experts. To implement a system that works this well, many factors must be taken into consideration and the correct choices made.

This paper reviews some of the design factors involved in an RFID system implementation, such as selecting active vs. passive tags, choosing RFID tags, attaching RFID tags to assets, and performing application testing. For each design factor, pros and cons of the available options are discussed, as well as common pitfalls – and how to avoid them. To illustrate the various options and their uses, the paper includes a number of real-world examples drawn from Omni-ID's extensive experience in implementing RFID systems. For anyone planning an RFID deployment, these invaluable lessons will guide you to success.

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Introduction: Achieving 100% Read Rate

It was early 2009, and John Richards was testing the RFID inventory system he'd been working on for the past several years. John Richards manages the data centers for one of the country's largest equipment providers. The data center where the RFID system was being tested was around 2000 square feet and contained over 7000 individual pieces of equipment. Clearly identifying and tracking each asset in the center was a tremendous challenge. John had a vision for how RFID could enable accurate asset tracking for the data center, but over several years he had tested numerous RFID equipment types and setups without achieving 100% read performance.

Since the fall of 2008, John had been working with Andre Cote, the CTO of Omni-ID. John was testing several changes, including the use of Omni-ID's Prox RFID tag, with the hopes of improving system performance. His goal was to tag all assets in his data center and achieve read rates of 99% to 100%, so that he could take inventory accurately and quickly. If he could prove the success of this system, he planned to implement the process globally. Long term, he even hoped to use RFID to manage the product life cycle.

The system operated with a roll cart containing an RFID reader and antenna, which would be guided down the three-foot-wide aisles, reading inventory tags on both sides. The data center's assets included items made of metal, plastic, or a combination of the two, which had to be identified at a distance of about two feet. In the earliest tests, read rates were only 85%.Since then, each piece of equipment in the system had been optimized. In addition to the new RFID tags, new readers and antennas designed for the process had been installed, and new data capture software was written.

In the final round of testing, 99% to 100% read rates were achieved, thanks to the Omni-ID ProxTM tag and the new modifications to the reader systems. The team was elated with their success. During the debrief John turned to Andre. "That's the first time," he said with satisfaction, "that I have ever been able to do this."

Implementing RFID Systems

RFID systems have been available for years, but many who have tried an RFID implementation have found it more difficult than expected. As with most complex undertakings, up front education and planning increases the chance of success.

This White Paper, brought to you by Omni-ID, manufacturer of balanced on-, off- and near-metal passive UHF RFID tags, is a guide to some of the factors to consider in planning an RFID implementation. An RFID implementation should always be done with the assistance of an experienced system integrator, preferably one with experience implementing in environments similar to your own. While this guide doesn't replace the assistance of a systems integrator, it does present issues you're likely encounter. It also shares real world success stories and pitfalls so that you can benefit from lessons learned and confidently plan for a successful RFID implementation.

Active vs. Passive Tags

One of the first decisions to be made in designing an RFID system is whether to use active or passive RFID tags. Both active and passive tags have developed significantly over the past several years, and are capable of functioning in ways that didn't work even a few years ago. Understanding how these technologies apply in the real world can help determine which type of tag is best for your application.

Because active tags have a battery in them, they have certain advantages over passive tags. Their signal is stronger, and they emit a signal without activation by an RFID

reader, so they can constantly "chirp" their identity. The additional power can overcome interference from surrounding electromagnetic fields, which means that for use on metals, active tags were the only option until a few years ago, when on-metal passive tags were introduced. In recent years, active tags have been developed with improved functionality, enabling the tag to capture and broadcast pedigree data -- time, temperature, or GPS location -- in addition to a simple identity signal.

There are also features of passive tags that are superior to active tags. The most significant is cost; the initial per-tag cost is much lower for passive tags. Passive tags also have a much longer lifespan, lasting indefinitely, while active tag batteries typically must be replaced within two-to-three years, adding both infrastructure and labor costs. The lower overall cost – both in installation and maintenance – is responsible for the popularity of passive tags today. Another important differentiation between passive and active tags is tag size.

Passive tags are generally smaller than active tags, and will therefore physically fit on a smaller surface area. As with active tags, many new capabilities have been developed for passive tags in recent years. Most notably, passive tags are now able to work on metals and liquids, and the memory storage capacity has been increased substantially to store pedigree data.

Because of the lower cost of a passive tag infrastructure, RFID system designers only use an active tag system when the "always-on" capabilities justify the additional cost.

	Active	Passive
Signal strength	Stronger	Weaker
Signal availability	Always on	Responds when read
Size	Larger	Smaller
Initial cost	Higher	Lower
Maintenance	Replace every 2–3 years	Indefinite lifetime
Environment	Available for all environments	Available for all environments

Real World Lessons: Active Tags in a Data Center

It can be difficult to quantify the additional benefits and costs of an active RFID implementation. As an example, let's look at an active-tag RFID implementation in a data center. It's the dream of many data center managers to be able to take inventory at the push of a button, without leaving their chair – and that's the appeal of an active-tag RFID system. However, the managers at this data center found that the quantity and close proximity of the tagged assets created an environment where many tags, all "chirping" at once, interfered with each other's signals. With so many tags emitting similar frequencies in close proximity, the opportunity for a tag to override another tag's signal was very high.

The data center manager addressed the issue by attenuating the tag signal frequency to only emit a signal once per minute. Even at this lower signal frequency, tags were "talking over" other tags; when the button was pushed and the inventory measured, some assets were not captured due to interference.

Additional measures can be taken to address this issue. Assets can be compartmentalized with dividers to create smaller groups of signals, with different readers installed for each group. However these measures also add infrastructure cost, which ultimately reduces the ROI of the project.

Best Practice #1

For many companies, implementing a passive RFID system gives them sufficient benefits of an automated inventory control system with less cost than an active RFID system would require.

Circular vs. Linear Antennas

Another key system design decision is the type of antenna you will use with your RFID reader. Although there are many antenna types, they can be grouped into two main categories, circular and linear, referring to the polarization of the signal emitted.

The two antenna types have different advantages. A circular antenna reads from a much wider angle and a shorter distance than a linear antenna, and it can read tags in different orientations. A linear antenna can have better read performance and accuracy when the tag orientation is controllable. When designing your RFID system, it is important to identify the following design criteria:

- How far will your reader be from the tags it is reading?
- How well can you control the orientation and position of the tags?
- How wide (or tall) is area over which you need to have read covered?

Real World Lessons: Retail Store

Let's illustrate these decisions with a couple of real-world examples. In the first, an RFID system was implemented in a retail store to enclose and maintain security in the store's electronics department. The readers and antenna were suspended from the ceiling, and needed to read tags within the entire area of the department, ceiling to floor. In this case, antennas with a wide-angle read range were used to create a large zone of read coverage. Several antennas were required, and careful measurements were made to ensure that the antenna read distance would reach the floor, and that each cone of read coverage would overlap sufficiently to create full coverage for the department. Once

this full read coverage was established, any tags that moved out of the department would raise an alarm. By using circular antennas with the appropriate range, this system was successfully able to secure the electronics department.

Best Practice #2

Take the time to draw the illumination window required to achieve your read rates and make sure you purchase hardware that can physically accomplish the goal.

Real World Lessons: Work-In-Process

In another, quite different example, a consumer products manufacturer wanted to implement RFID tagging on a high-speed Work-In-Process conveyor line. The manufacturer was adding RFID to its product as a result of a customer mandate; it was a high priority to enable RFID without changing the existing production process. In addition, the manufacturer wanted to tag the pallets without incurring the additional cost of bringing the production line to a stop. Products moved along the line at 600 ft/minute through a portal. Each pallet was tagged, programmed and verified as they moved through the portal. The RFID system was first implemented using circular antennas at the portal, and resulted in an 80% success rate for a single-read tag and verify operation. They then switched to a linear antenna, which had a stronger and more accurate signal, and found they could achieve read rates of 100% with the new antenna. The implementation using linear antennas was successful because the tags had consistent positioning on the pallet, and the pallets moved through the portal at the same orientation each time.

Best Practice #3

There is no one "best" type of equipment; rather, choose the equipment type that best fits your purpose.

Antenna / Reader Compatibility

EPCglobal standard ISO 18006 was written to ensure that RFID chips and readers would be compatible, but that standard does not address antennas. Consequently, you can't always rely on every reader working with a variety of antennas. Before buying a reader, you should ask what antennas it is compatible with, and if the choice is limited, be sure to investigate further so that you don't invest in a reader that won't accommodate your system design.

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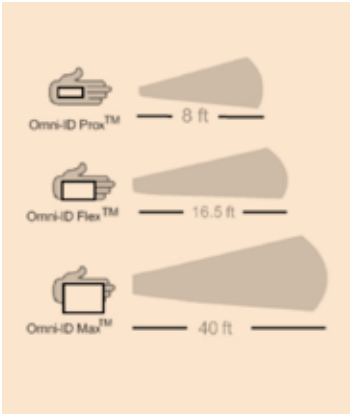
Selected RFID Tags

Read Range

The primary consideration when selecting RFID tags is finding the optimal balance between size and read range. The right read range is based on the physical distance between your assets and the RFID reader. For example, a trucking operation will need to easily identify individual trucks from a distance, necessitating RFID tags with a long read range. In a retail outlet, or any environment where many assets are close together, a long read range can cause signal interference, making it difficult to take inventory on just one aisle or section. When assets are in close proximity, a shorter read range works best.



Tag Size

As a general rule of thumb, the larger the tag, the longer its read range. For many applications, tag size is not an issue, because there's plenty of room on the asset to locate a tag. However, on smaller high-value assets such as electronic equipment, size can be a critical factor. The faceplate of many electronic devices is already competing for space between the various controls, and airflow ducts. Placing a tag over an airflow intake can cause the equipment to overheat and fail. Over the past several years, the RFID industry has developed new RFID tags with smaller footprints, such as the Omni-ID ProxTM.

Interference

After read range and size, the most important consideration in planning your implementation is the electromagnetic environment in which you'll be installing your RFID system. All materials have dielectric properties, which always impacts the operating frequency. A standard dipole RFID tag takes on the dielectric properties of the material it's on, which is why those tags have historically not worked when used on materials like metal or liquid. Today, tags are available that are optimized to work either on- or off- or near-metal. In planning your implementation, it's important to choose a tag type that will work effectively on all of your assets.

Real World Lessons: Data Center

A data center decided to do an RFID implementation using an incremental approach, starting with tagging non-metal assets that presented the maximum process improvement for the lowest cost. Using inexpensive standard dipole tags, the data center manager tagged just those assets that were plastic, covering 30%-50% of the assets in the data center. After implementing and testing the system, he found that it worked well and significantly improved their inventory accuracy.

He then expanded the RFID implementation to include tagging metal assets which required him to select a second RFID tag that was optimized to work on metal. As new equipment was deployed, an employee with no RFID expertise was responsible for deciding which tag to place on each new asset. It turned out to be much more difficult than expected to determine whether an item was metal or plastic. Many plastics today are designed to imitate metal, with a rigid feel and a black, metallic appearance. As different brands of servers, blade servers, and routers were deployed, many of them were incorrectly tagged.

The RFID system of choice was not working as planned, with many assets missed during inventory capture. The company tried to solve the problem by identifying and replacing the non-working tags. However, the cost of this effort quickly outweighed the cost savings of using the less expensive standard tags for the non-metal items.

The problem was finally solved when the data center moved to a single tag with a reliable read range on- and off-metal. Using one RFID tag that worked reliably on all assets enabled the data center to achieve accurate inventory readings for 100% of their assets, something they had previously been unable to do.

Best Practice #4

Choosing one tag that works on all of your assets can prevent confusion and decrease the cost of the deployment.

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Attaching RFID Tags to Assets

Designing an RFID system and selecting the proper equipment is the first step in any RFID implementation. Other decisions may be less obvious but are equally important to a successful implementation, such as how and where to attach the RFID tag to an asset. A secure attachment is required to accurately track and identify assets.

Real World Lessons: Networking Equipment Company

A major networking equipment company needed to tag a very small electronics board -- so small that even the smallest RFID tags were too big. The front of the board was all metal, and was grilled for air flow. Working with engineers at Omni-ID, the team decided to try using a polycarbonate tether to hang the tag through the grilling. After some testing, the Omni-ID team was able to provide the RFID tag with the tether attached. Additional testing proved that the tag could be read successfully from multiple directions, so hanging the tag backwards or sideways would not cause a problem. The new tether allowed the team to tag this asset as part of their RFID inventory tracking and management system, despite its size limitations. Omni-ID now offers the Tether as a standard product option for the Omni-ID ProxTM tag.

Real World Lessons: Financial Institution

In another example of the importance of correctly attaching tags to assets, the data center at a major financial institution deployed 10,000 RFID tags throughout the center, using a hired temporary labor force. Shortly thereafter, they found that many tags were not securely attached, and a few had even fallen off the equipment and were found on the floor. They initially suspected that the tag adhesive was to blame, but after further investigation they learned that the workers who had applied the tags were using poor processes. Given no guidance on tag placement, they had sometimes applied the tags to a curved surface or over ventilation holes. They had not checked that the surface was clean, and had applied no pressure when placing the tags. In some cases, they had even changed their minds after placing a tag, pulled it off, and replaced it in a different location. It was no surprise that these tags were not securely attached. For future deployments, the data center implemented simple guidelines for the deployment workforce. They showed the correct tag location for each class of asset, and required each tag to be placed on a clean, flat surface, applying pressure for five seconds when placing each tag.

Best Practice #5

Creating a simple but clear procedure for tag placement can prevent problems later on.

Tag Commissioning

As with tag attachment, it is important to think through how to commission RFID tags – the process of programming each tag with a unique identification number. Commissioning tags after they are applied to the asset and stored in the inventory location is not recommended – it is too easy to mistakenly commission more than one asset when working in a crowded inventory environment. Tag commissioning should be done away from the final inventory location, either by the tag vendor or in-house.

Vendor Commissioning

When programming sequential numbers into RFID tags, consider having the RFID tag vendor ship the tags pre-programmed with the identification numbers. The ease of receiving tags already commissioned with the numbers you provided makes your deployment faster and eliminates the need for you to set up an in-house commissioning line. This method works well if you are tagging a row of inventory locations or giving assets numbers for the first time, because you will be following a sequential block of numbers.

In-House Commissioning

If, on the other hand, you have an asset base that already has identification numbers, and they are out of sequence, it may be easier to set up an in-house commissioning line. For example, a row of assets in a data center contains many items that have been bar-coded and subsequently moved around, resulting in a non-sequential group of identification numbers on any aisle. The easiest way to commission tags for these assets is to collect the data for the whole aisle and then program tags for that aisle in a separate commissioning area.

A commissioning line can be set up with either an RFID reader, or with an RFID printer. Standard dipole tags can be commissioned through an RFID printer, but until recently, tags that worked on metal could not be commissioned that way because they are attached to a thick substrate. With the recent announcement of Omni-ID's On Demand deployment solution, you can now commission Omni-ID ProxTM tags by printing on the chip element with an RFID printer, and then attach the chip to the substrate like a label. As with many other recent technological advances, this new offering makes it possible to implement RFID as easily in mixed-material environments as it has been previously in non-metal environments.

Application Testing

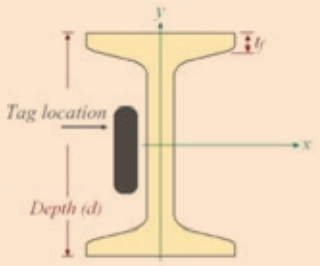
Once the RFID system is designed, ensure success by testing the system in the actual environment where it will be deployed. Because of the many sources of dielectric interference in the real world, the performance of an RFID system after implementation can vary significantly from lab test results. Many companies do initial testing in an anechoic chamber, which cancels out dielectric signals from other sources. Similarly, product specifications are typically listed at the most optimal performance levels, without interference. Testing how your system elements work together, within your work environment, can uncover potential issues that can be solved before full deployment.

Real World Lessons: Supermarket Chain

A major supermarket chain was deploying an RFID inventory system in their distribution centers. In these large warehouses, pallets were tagged, and each bin location in the warehouse racks was also tagged with a location identifier. Forklifts were equipped with RFID readers, so that as each pallet was put away, the pallet ID and the bin ID were captured. When an order came in for a pallet of a specific product, the automated inventory tracking significantly reduced the time required to locate and pick the pallet for shipping to the retail outlet.

A glitch in deployment occurred when 10,000 tags were placed on warehouse racks without prior applications testing. The racks were made of steel I-beams, and the RFID tags were placed in the recess of the steel beam. After all the tags were placed, it was discovered that the I-beam created a wave guide effect. While it looked like a regular piece of steel, the shape of the I-beam manipulated the dielectric field around it, creating a dead spot for radio frequency and effectively blocking the reader from accessing and reading the tags.

In this case, Omni-ID, the tag vendor, developed a solution for the customer which captured enough energy to read the tags. However, the entire issue could have been avoided with applications testing, which would have revealed the issue in time to place the tags in a different location on the I-beams.



Best Practice #6

Always do applications testing in the actual environment where the system will be implemented, to identify and solve issues before a large-scale deployment.

Real World Lessons: Manufacturing Warehouse

A manufacturing warehouse set up an RFID inventory system that captured pallet IDs as they moved through two dock door portals on either side of the warehouse. The system was designed using a tag with eight feet of read range, and tested successfully in an anechoic chamber. Once deployed, the portal on one side of the warehouse worked perfectly, however on the other side, read performance was only successful at a distance of one or two feet. The RFID tags were not the problem, as the same pallet was easily read by the working portal. Engineers began debugging the system, testing each piece of equipment.

Eventually they discovered that the warehouse had been equipped at one time with a wireless infrastructure that operated at 915 mHz, the mid-band of the RF frequency range (wireless systems today typically operate at microwave frequencies). Although no longer used, the access point for the old system was still operating, and was located right above the dock door where the RFID portal had been installed. In this case, it was easy to solve the problem by de-commissioning the access point, but the problem could have been much more serious. Avoid problems like this one by performing a full spectrum analysis of your site as part of the pre-implementation site survey.

Best Practice #7

RFID systems are affected by electromagnetic forces around them, and don't always work the same way in production as they do in the test lab.

New Applications for RFID

RFID technology continues to advance and new applications are evolving all the time. With the advent of successful on-metal RFID technology, industries that couldn't use RFID in the past are now able to do so.

Real World Lessons: Survey Marker Company

A survey marker company was interested in using RFID tags to track its markers. The company made survey markers out of industrial steel, with a copper endcap. These markers were buried underground with a barcode reader on the end, and personnel had to dig down to the end of the survey marker to scan the barcode. The barcode was subject to deterioration due to environmental exposure over time, so the company was interested in using RFID tags. They hoped to protect the tags from exposure by placing them inside the survey marker, and to be able to read the survey marker without having to dig it up.

The company worked with Omni-ID to test performance of their tags in the survey marker. Since the tags perform well on metal, the industrial steel pipe did not cause a problem. Yet inside the pipe with the copper endcap, the tag could not be read. The company suggested putting an aperture in the endcap, and sent samples to Omni-ID for testing. Even with the aperture, the signal was still not strong enough. The Omni-ID engineer suggested using plastic endcaps instead of metal. Testing showed that the tags performed well inside the pipe with a plastic endcap. This series of experimentation resulted in a successful solution for the survey marker company's problem. The company is now in the process of application testing.

Best Practice #8

With experimentation, RFID solutions can be found for many applications that were impossible in the past.

Summary

The real-world examples shared here are designed to help you understand and make decisions about some of the design factors that will affect your own RFID implementation. As our summary, we've included a quick checklist of the factors involved.

RFID Deployment Checklist

1. Choose active or passive tags _____
2. Select the tags based on
   - Read range _____
   - Tag size _____
   - Eliminating interference _____
3. Plan for attaching tags to assets _____
4. Plan for commissioning tags _____
5. Create an application test plan _____

Brought to you by Omni-Id

This collection of real-world implementation stories is brought to you by the executives and engineers of Omni-ID, one of the world's leading suppliers of passive UHF RFID tags. Omni-ID's technology is based on research from QuinetiQ, an international defense and security technology company known for a number of breakthrough technology discoveries. Although Omni-ID was founded in 2007, the research behind its technology started in the 1990s, and its executive and engineering team has many years of combined experience in the RFID industry – some of which they have shared with you in this paper.

Omni-ID was the first company to offer a product family of RFID tags that perform equally well on metal, non-metal, and liquid assets. The Omni-ID Prox, Flex, and Max tags provide a range of tag sizes with outstanding read-performance-to-size ratios. The OmniTether, Service Bureau, and On Demand provide additional options and services that were developed as a direct result of customer requirements and are available to make your implementation easier. As some of these stories have illustrated, Omni-ID works closely with customers to ensure a successful implementation and to solve new challenges and develop new applications.

We hope you've found value in our Real World Lessons. When you're ready to begin your implementation, contact us at Omni-ID.

Omni-ID®

Intelligent Tracking & Monitoring Devices

Omni-ID is the leading supplier of passive, low-profile UHF RFID solutions. Through our patented technology, Omni-ID “cracked the code” to overcome the problems traditionally associated with RFID, enabling a broad range of new applications that improve accuracy and efficiency in asset tracking, supply chain management and work-in-process.

Our family of versatile RFID tags works reliably in the harshest environments, including on, off, and near metal and liquids and excels in solving tracking and identification challenges with unprecedented accuracy.

With offices in the USA, UK, Asia and India backed up by a purpose-built manufacturing facility in China, our mission is to drive the widespread adoption of RFID and wider IoT technologies as the optimal tracking and identification devices.

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