A how to guide for RFID implementations

ARE YOU TUNED INTO RFID ?

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Introduction

RFID has been around for over sixty years, so why does it have such a negative connotation? Many misconceptions and horror stories of failed implementations have contributed to the negative press of this re-emerging technology. Organizations that have failed RFID implementations have been plastered all over the press because of lack of technology, deficient IT knowledge, budgetary constraints, unqualified business partners and misunderstanding of the overall effectiveness of the technology and how it relates to its business.

Navigating through a complicated new system that requires its own hardware, software, and infrastructure is a daunting mission. With the complexities of evolving standards, converting today's barcodes to tomorrow's electronic product codes (EPC), and the prospects of how all of this changes the way the company functions – it is understandable why organizations may take a long look before making the leap to RFID.

Culminations of many successful implementations, customer interviews, and case studies have spawned a five phase best practice approach to achieve a successful RFID project. To understand RFID technology, organizations must grasp the concepts of operation and the components of the system. A full RFID implementation requires thorough planning and execution; outlined below are affluent business practices, definitions, checklists and explanations that will be examined for attainment of RFID victory. It is possible to start smoothly and slowly, one merely needs to follow a phased approach.

RFID 101 and Organizational Fit

RFID Components

Before getting started, organizations should understand the components of an RFID system, the mechanics of the technology, tag types and characteristics, and if RFID is a worthwhile investment for the organization.

An RFID system generally consists of tags, encoders, readers and a host computer. This represents the minimum requirement for a functional RFID system to operate. Each component of the system will be defined and an explanation of use for that item will be explored below.

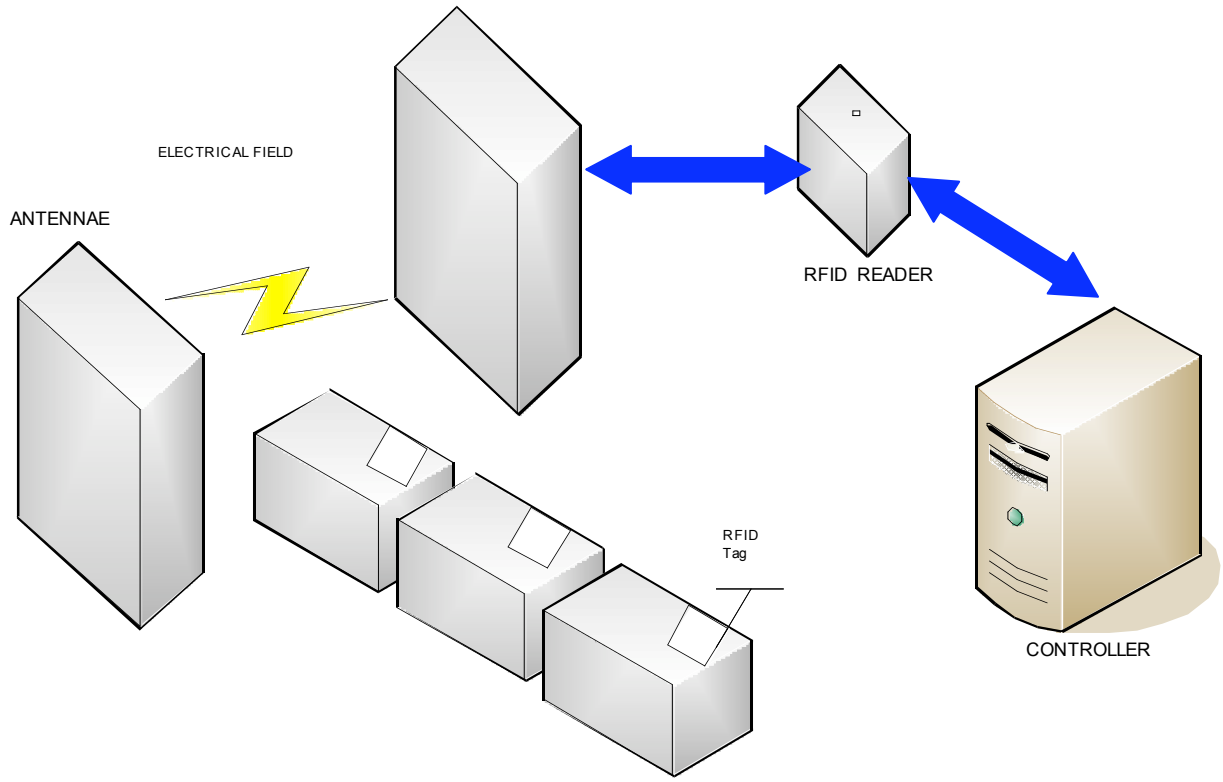
RFID Mechanics

Within RFID, everything starts with the tag. The tag has a computer chip that is programmed with information that uniquely identifies each item. Information is exchanged when the tag is activated.

Tags and readers both contain antennae because of the radio interaction it requires. The antenna attaches to the IC (integrated circuit) to absorb and emit signals. RFID is a means of uniquely identifying an object through a radio link. A reader also called an interrogator or "master" communicates with a tag, called a transponder or "slave". Each item has a unique identification code. Data between the tags and the readers are exchanged via radio waves and no direct line of sight is required for the transaction to occur. The reader requests data from the tag, or processes the signal being emitted by the tag, decodes the transmission and transfers the data back to the computer system. The type of tag determines how the tag will respond to the reader. The computer may do various tasks to process the data such as record the reading, look up the tag ID in a database to direct further action or direct the interrogator to write additional information to the tag.

The figure below represents the boxes moving through the RFID portal (see Figure 1). Within RFID, everything starts with the tag. The tag has a computer chip that is programmed with information that uniquely identifies each item. The electrical field emitted by the reader energizes the tag to trigger a read of information from the tag. The arrows indicate the flow of data between the readers, antennae and the server. In this example, the boxes pass through the portal (antennae), the data captured from the tags are transmitted to the reader and then to the host computer for processing. Information is exchanged when the tag is activated. The tag is activated either by the energy emitted from the portal, or in the case of an active tag a battery within the tag emits energy for the antenna to read.

Figure 1.



Tag Types & Characteristics

The tags are a key component of any RFID system. Understanding the properties, capabilities, and limitations of each tag type will assist in the solution design. The five types of tags currently in use within the industry are: active, semi-passive, passive read/write, passive worm, and passive read only. The chart below identifies the different types of tags, and their advantages, disadvantages, and common applications where each is employed.

Tag Type	Advantages	Disadvantages	Application

Active	Greater read range, greater memory capacity, continuous signal	Batteries require maintenance, larger size, cost	Used with high value asset tracking
Semi Passive	Greater read range, longer battery life	Battery wear, expense	Reusable containers and asset tracking
Passive Read/Write	Longer life, multiple form factors, erasable and programmable	Time and expense to program	Case and pallet applications, approved for use with Walmart
Passive WORM	Suited for item identification , controllable at the packaging source	Limited to a few rewrites, replacing existing data with new data	Case and pallet applications, Approved for use with Walmart
Passive Read Only	Simplest approach	Identification only, no tracking updates	Case and pallet applications, approved for use with Walmart

Active Tags

Active tags usually contain their own power source, are heavier and have a large data storage capacity (upwards of 1Megabytes). Given these attributes, active tags generally cost more and typically support more complicated read applications. Uses for active tags differ by applications. Active tags will alert the interrogator that a further action needs to be executed upon. This offers more flexibility to the company to track where a particular item is and which stage in the process items are.

Advantages of active tags are longer read ranges, a greater memory capacity and emit a continuous signal. Disadvantages are that batteries within the tag will need to be replaced depending on frequency of use, generally a larger size as opposed to other tag types and the cost of the physical tag as well as the cost to maintain the battery within the tag.

An example where an active tag may be implemented is the tracking of high value assets within an organization. Another example for an active tag application may be to give operational instructions, when it arrives at a particular station within the manufacturing process the tag has the ability to trigger a further operation like the activation of a robotic arm, the information is updated and appended to each step within the process.

Passive Tags

Passive tags are generally less expensive because they have no internal power source; have limited data storage capacity (typically 32 to 128 bits), are read only; and have limited read range(up to 3 Metres) The tags themselves hold very little data but can serve to identify the object to a database containing large amounts of information.

The main advantage to this type of tag is the reasonable cost, approximately 20- 30 cents per tag. Key disadvantages include; limited read range, no tracking update and the lack of ability to re-write to the tag.

Typical uses include: pallet and case level identification as in the retail mandates such as Walmart and DoD. A tag can be attached to a product that can be tracked at each stage of production; the conveyor system could identify the item and receive routing information to be sent to the correct loading dock without human intervention.

Semi Passive

The semi–passive tag has many of the characteristics of a passive tag (small, lightweight, limited memory), but has a battery backup to extend the answer range. Common uses include shop floor containers, pallets, kitting and just-in–time applications.

The advantages of this type of tag are, they have a longer read range and a longer battery life, while the disadvantages include additional expense and the battery will have to be maintained

Generation 2

Within the RFID market, lack of standards has caused many manufacturers to have different operating standards for its tags, readers, and antennae. The EPC Global has established standards for vendors to adhere to in the design of RFID infrastructure. This caused hardware and software to not be compatible between one company and another, which makes collaboration with suppliers nearly impossible. Universal standard design and adherence to those standards have caused increased adoption within the industry. Consequently read rates have increased dramatically. The Http://WWW.EPCGLOBAL.ORG, an RFID unifying body comprised standard operating specifications that consist of tag, antenna and reader standards (specifications are posted there). Adherence to this standard is easing RFID implementations. The inter-operability of multi protocol readers and consistency of tag manufacturing processes has provided more consistent read rates and allowed different types of tags to be used with different readers that aid collaboration efforts.

A distinct advantage to RFID is the automation of processes. Generation 2, with its stable operations in read rates and information exchange allows ease of operation. With extra stability, great gains in processing speed can be made using automated sorting and material handling by limiting or in some case eliminating human invention. Gen 2 allows the dozens of individual objects within a group to be uniquely identified at the same time because backscatter is controlled; previously this was an intermittent problem. Backscatter control results in very stable reads by allowing multiple objects to be differentiated within the electrical scanning field.

Organizational Fit

Before venturing down the RFID path, organizations should determine the suitability of RFID to their operations. In determining fit, organizations should evaluate existing applications and future requirements to anticipate potential stresses in their warehousing and distribution. Several constraints that may hinder business efficiency may possibly make the organization consider RFID to solve some of the problems.

If any of the circumstances below are indicative of the business conditions that the organization faces, RFID may be a fit to quell these concerns.

Below are the key issues to assess the suitability of RFID.

- Processing speed is essential or could provide a competitive advantage
- Deal in high-value assets that need to be protected
- Barcodes cannot physically survive operational processes
- Areas of our facility need to be protected from unauthorized access
- The need for more unique information on each item that a barcode can contain
- Highly automated and need to minimize human invention for greater efficiency
- Benefit by knowing where products are at all times in the supply chain in real-time

If the response to two or more of these circumstances is yes, an RFID implementation should be considered. Many organizations, while in the same industry have very different business processes, RFID can aid in the supply chain visibility argument to maximize efficiency.

Preliminary Foundations

Site Survey and Connectivity

A preparatory task for an RFID implementation and best practice approach suggests a site survey should be completed.

A few risks are associated with not completing a site survey. An AEN survey can identify possible roadblocks to reader placement as frequencies emitted by equipment and other forms may be the same or stray backscatter can interfere with reader placement and function. Other companies that may possibly interfere with the frequency of tags and readers may cause interference on equipment. The site survey will expose existing RF communications already present. Such items that can cause interference are; barcode devices, long-range radios, cordless phones, alarm systems, and other wireless gadgets.

This will expose current issues that may interfere with operation of the RFID network and consequently delay the project timeline. Interference from other RF devices and other forms of electricity can affect RFID accuracy. Wave lengths may cancel each other out where a particular frequency is already being used. The site survey answers many questions that may arise on the IT side. It provides a road map for reader placement, backscatter, and power requirements for new network equipment both electrically and network architecture - wise. Interference from other radio equipment (AEN), and RF coverage of signal density is measured that will aid in the RFID implementation.

If network infrastructure upgrades are required, that may impact the timeline for implementation as some network hardware lead times and installation of additional power requirements can be lengthy. The lead times to order some network equipment can impact the time line of the project. Any further power requirements that need to be added will also further push out the timeline for the RFID implementation. One way to minimize this delay is to mitigate the risk by building in enough time to the project plan to have these executed and tested before the RFID hardware is ordered.

The following checklist will provide criteria to address for the site survey in preparation of the four phases of the implementation. The criteria below refer to conditions that should be tested during the site survey.

AREAS TO BE ADDRESSED FOR THE SITE SURVEY	COMPLETE	INCOMPLETE
1. Refer to the workflow and business process map created and where the readers are located you must test each location. Some readers will require an additional power source with Ethernet while some may be wireless.		
2. Look for two things; the strength of the signal that propagates through the interrogation zones and the frequency those waves are broadcast over. The stronger the waves in a particular frequency band, the more difficulty implementing an RFID system will become		

3. When evaluating AEN, examine the entire cycle for a period of 24 to 48 hours. This will provide a true picture where fluctuations may be possible.		
4. It is recommended that when conducting the AEN start with the outer most points of the warehouse and work inwards toward the center		

For the first step; Test where you would like to position the readers and test for compatibility. AEN from other electrical equipment may interfere with the location where like frequencies are found. Check that power requirements exist for new equipment at the proposed area. If power requirements are not handled this would make this task incomplete. Ensure power is accounted for if this is where the reader shall be placed.

Step two: Check for the signal strength of the frequencies and actually what frequency is emitted. Record both signal strength and frequency and compare to existing noise if available. If there is no AEN in that zone this should qualify for a passing mark for a possible reader location.

Step Three: This step must be monitored for a minimum time frame of 24 hours to verify that there are no errant frequencies that may occur occasionally that can affect the reader's operation. If a like frequency is detected a new location should be found for the reader prior to roll-out.

Step four: Certain spots may be more frequency rich than others; this will give a more accurate picture as to the frequency map found within the warehouse. Once the criteria are executed and validated the reader placement should then fall into place based on the results.

Connectivity of Equipment

These tasks provide the roadmap of equipment placement and other obstacles that might affect RFID equipment. A proper site survey is required as there may be implications as to bandwidth sharing, ambient noise, etc. that may impact the reader placement, portal placement that may not suit the operations. This step identifies the properties that will alter RFID information. The next section outlines the equipment required, and the connectivity of that equipment.

Equipment needed for FFCA (see glossary)

The equipment needed for an RFID site survey are; spectrum analyzer, signal generator, ¼ wave or ½ wave dipole 915Mhz antenna and ground plane plate, a tripod stand and a laptop computer.

Connection Procedure

A best practices approach to the connection of the equipment used to conduct a site survey will aid in the completion of the site survey. This section defines the tasks to install the core equipment.

1. The antenna should be placed in the middle of the interrogation zone and placed on the tripod. This should define the optimum position to place the portal, in relation to the business process occurring on the flow of the warehouse. A common mistake to avoid is to hang the coaxial cable from the antenna as this may impede the signal. Best practices dictate the antenna can be mounted by a piece of rope hanging from above as close to the middle of the interrogation zone as possible.

2. Connect the spectrum analyzer to the antenna by attaching the coax cable into the input of the spectrum analyzer. Be sure to check that both units are off as it is good practice and it will protect the equipment from shorting out. This operation will evaluate the presence of any ambient noise that may affect the RFID equipment adversely.

3. Using an RS-232 cable or an Ethernet cable, connect the laptop to the spectrum analyzer and power it up. If there is no laptop, take a picture of the frequency every two hours. This connection allows the tracking to be traced over a period of time and should reveal any inconsistent AEN that may be cyclical.

4. This task will show if any AEN exists in the range of 902-928MHz. This can also affect signal capabilities. 902 -928MHZ is the effective North American frequency range in which RFID specifications have been set. Machinery ambient noise and other RFID installations can affect bandwidth.

To setup the spectrum analyzer to following specifications:

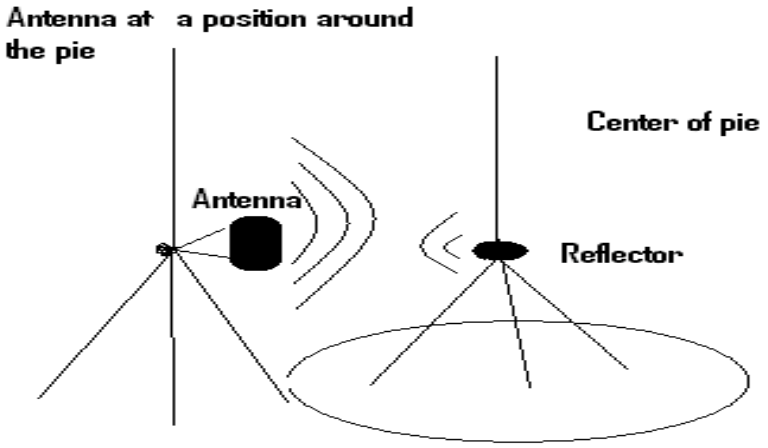
- Set the span to 60 MHz
- Set the resolution bandwidth to 100kHz
- Set the video bandwidth to 30 kHz
- Set the amplitude attenuation to 0 dB
- Turn off the maximum hold to capture the energy received from the radiating antenna

The above steps describes the set up of the equipment, the following will dissect the actual steps to perform the test.

The ¼ dipole antenna that is attached to the signal generator should be placed in the center of the proposed interrogation zone.

- Connect the UHF directional antenna to the scope and mount it at the same height as the ¼ wave dipole. Place the antennae parallel to the dock doors at zero degrees
- Tune the signal generator to 902 MHz and record the results
- Keep the UHF antenna in the same location, and set the signal generator for 915 MHz
- Repeat the process at 928 Mhz
- Relocate the directional antenna to each of the eight positions in increments of O, 45, 90, 135 …. etc. degrees in a clockwise manner and record the signal strength at each frequency with relation 45 degree increments

These results will indicate where the strongest signal strength is prorogated through and will determine where the best antenna placement is.



Once the above steps are completed, these suggestions will provide guidance for the completion of the site survey. The purpose of measuring the AEN is to ensure the RFID equipment will function effectively.

- Identify all AEN within the facility
- Log data over a 24 hour cycle
- Measure each interrogation zone to assure reader operability
- Walk around every corner of the warehouse to assess AEN
- Triangulate any sources of interference and seek them out
- Run all machines that emit noise and check it doesn't affect the signal for RFID
- Map out interrogation zones with CAD for efficient reader placement

Quick Fixes

Problems:

Barcode equipment emits a conflicting frequency.
There a few work-arounds if interference is found. If barcode equipment is emitting a conflicting frequency a good solution would be to upgrade the band of the RF. Change the band of the RF devices to 2.4Ghz or 5.8GHz. The use of fixed RFID portals or even deployment of handheld RFID units that require less power may solve this problem. The portable handheld units are more controlled and are slightly less affected by AEN.

Limited protocol capability.
Check for interrogators that have code hopping capabilities. This reduces the possibility of signal interference. With additional frequency the organization can move to another band if one is consumed with current equipment.

Lack of Documentation – (risk mitigation)
After the survey is complete, a written document should be produced by the surveying company for the company's records and as a guide for hardware quantities. This responsibility should rest upon the business partner that was chosen. This document will contain the results from the test, recommended hardware and most importantly, equipment placement. Further, this will eliminate any issues for hardware placement if the vendor and the consumer are not on the same page. Signatures and dates should be added to each change as this implies sign off and responsibility

Phase 1 – Getting Started

Best practices approach suggests 4 phases of an effective RFID project from the point of concept to implementation. The checklists combined with the 4 phases will allow a selection of a suitable business partner, and allow completion of a successful RFID implementation.

Business Partner Selection

Business partners are an intricate part of the RFID implementation. These companies may provide the proper guidance and expertise that the organization may not possess. An emerging trend within the RFID industry is that several companies partner together to provide a complete solution. One company provides the software, one company provides the hardware and one company handles the integration. This may be a possible option if one partner cannot fulfill all of the requirements. Within the RFID market space this is becoming a more popular trend. A good example of this is the HP and OATSYSTEMS partnership. HP provides the

integration and hardware recommendation where OATSYSTEMS provides the software. The IBM/Odin Technologies partnership provides the same type of model as well.

When RFID first emerged many vendors prematurely jumped into the marketplace with promises of expertise to aid in RFID deployment. A similar phenomenon was seen with the advent of many dot com companies. While trying to capitalize on the changing technology the companies that entered the market early had hardly any business plans, and could not secure the capital to continue day to day business operations, not much if any business knowledge, and no plans to execute a market. Be wary of partners that claim early adoption customers, as many have not actually architected a solution, done the testing and implemented the solution. Organizations should try to validate the vendor claims by checking references for past installations, verify that deliverables were met, and the professionalism and ultimately the success of the implementation were agreed upon.

Vendor Selection

Organizations may require the use of business partners. Business partners are a great way to bridge gaps in business and technology that an organization may not possess. Partners can offer additional expertise to map business process, provide a value proposition for the organization and aid in the implementation process.

The checklist below describes tips and functions that should be noted when selecting a business partner. A best practices approach indicates that the following criteria are major components that make suitable business partner(s). The requirements listed below are actual deliverables that need to be validated by the organization when selecting business partner(s). If the partner(s) cannot substantiate the criteria listed, the expertise and quality of service may be of concerns to the organization.

From the criteria listed below, if the vendor can prove its involvement in past projects with successful results this will aid evaluation of that vendor. At the end of the checklist if the Yes' are greater than the No's then it should be safer to proceed with that vendor.

Vendor Selection Requirements	YES	NO
1. Focus on technology-based and solution-based companies that can help you migrate and upgrade in a timely fashion through each level of the implementation process		
2. The business partners you choose should be leaders in the field, and a member of EPCglobal		
3. The partner can influence technical development, by integrating cost, performance, and needs into standards if they are a member of EPCglobal.		
4. Can provide a fully integrated cost-effective development environment		

5. Software and hardware partners should be technology-driven and market-driven companies as opposed to product-driven		
6. Have a proven record of successful Auto - ID implementations with past implementations		
7. If they are early adopters of RFID technology, have experience specifically related to Walmart and DoD madates.		
8. Directly involved in numerous pilot programs and have completed a few of these projects successfully.		
9. Is RFID research and commitment to delivery a company priority supported by management and funded for development		
10. Do they provide an end-to-end solution including hardware, software and middleware		
11. Do they have a professional services group to assist with seamless integration without interrupting current business processes of course the size of the vendor team should cover expertise in hardware, software and middleware as well as the quantity of staff, depending on vendor operations		
12. Evaluate their after sales support, application engineers should be able to answer questions on an on-going basis and are they readily available		
13. Provide technical support throughout program from integration, to spare parts, to trouble-shooting the entire system and solve critical issues as encountered		
14. Certified smart labels in unlimited number		
15. Rapid development capability of custom label formats, what tools do they use, is this a part of the software you have to buy		
16. EPCglobal work hand–in-hand with leading retailers, suppliers, and Department of Defense. By being a member of EPCglobal the partner can better understand your business for an effective implementation. This will keep the organization's plan up to date.		

17. Investigate if the vendor is partnered with other RFID companies that can leverage expertise and software solutions. Most RFID vendors are teaming up to offer a complete RFID installation, usually one software, one hardware and services are integrated as one solution from three vendors. If this is the case, always define a single point of contact for the initial issue then it may be addressed by the corresponding company that provided that piece of the solution. This is key if there is more than one vendor for the solution.		

Set Up a Development Environment

When creating the test lab, the organization should assess future requirements to build a scalable environment and one that can rapidly adapt to changes. Think of the RFID vendor as a partner. The long-term RFID team (vendor and internal team) will successfully guide the organization through deployment, and accommodate growing and changing needs

Best practices suggest, where possible, the development environment should be a smaller version of what is actually in practice. To reconstruct a smaller production model may be difficult or just not possible. To construct a smaller production environment requires additional cost for equipment and can easily spiral out of control by doubling the effort. Cost of hardware, software and middleware maybe prohibitive as well as physical layout as a portal setup at a dock door or a possible conveyor hookup may pose a problem by not being available to the RFID interrogation zones. The equipment, portals, antennae, readers, and the host should at least be the minimum components erected. The setup environment will allow the solution of problems that may occur in the production environment and be corrected before implemented.

A test lab will be valuable for testing and further RFID development. The test lab will serve several purposes; the organization should validate business processes, check validity of data, interfacing issues back to the ERP, understanding of the physics and limitations of the technology, possible reader placement issues, label placement and **very importantly** provide lessons learned before going live. Factors to avoid that organizations should be aware of are; problems caused during testing, signal strength, reader placement, noise issues, label placement, and compatibility of the tag to the package. .

Label Placement and Testing

Label placement and understanding of the material, substrates, and interference factors are critical factors in the complete RFID installation. The process of affixing the label to the package is a trial and error exercise. To assist in finding the maximum interaction between the tags and readers, best practices suggest that organizations create a detailed configuration. To effectively record where the optimal placement will occur start at upper left hand side of the package and methodically move the label down in equal segments and record if the read rate is successful or not with that configuration.

Label Placement Procedure:

- Start by moving the across the face of the package. This method should identify non or limited read zones on the item.
- Keep the reader at a fixed location while taking each measurement to ensure accuracy of signal and read rate failure.
- Track any changes in angle that the product may be placed at between the interrogation fields.

- Place the reader at another location and monitor the read rate response from the new location to which the reader now exists.
- Chart the location of the reader with respect to the item and distance from the scanner and possible speed issues that may arise if on a conveyor or moving product. A close record of documentation should be created during testing this will aid in the implementations. There is no formula for the placement of labels and the containers upon which they exist. This task requires close attention to detail as to the placement of the labels, package design, read ranges and materials to which the tag has to be applied.

As a component of the vendor selection, verify that the vendor can provide a batch of EPC numbers for use. Best practices suggest that having the EPC numbers available for use should shorten the time to acquire the numbers and could possibly delay implementation by cutting into testing time. The organization will have the means to test read ranges, data capture speeds, and read rates. From here, measurements to determine distances the label can be read from, products themselves can affect the RF signals, location of the label upon the carton, and various read angles. As the testing revelations become apparent the end user can become more familiar with the data, scans, read rates and other various components of the RFID system, insights of efficiency, improvements, and system accuracy will be discovered and investigated. These best practices testing approaches outline pitfalls that may occur based on item properties and tag characteristics.

Label Placement

The placement of the label on the container is ***vital*.** This may make the difference between a 100% read rate and a 0% read rate. Other factors such as the angle of the scanner, distance from the scanner, the material itself can even scatter the communication signal, thereby causing a no-read scenario. Be mindful of these conditions, when placing the label on the package. Try to investigate similar products that are currently using RFID and use that as a baseline or as starting point for the testing. Similar products from another manufacturer that has succeeded in label positioning could possibly save time, rather than reinventing the wheel.

Package design

Positioning of the tag may become an exercise in troubleshooting as many packages are designed from a marketing and graphic approach. The physical lack of space may prove to be an obstacle in which to place the tag. The addition of a smart label will be difficult, but best practices suggest being methodical and persistent in finding an actual space to affix the label to eventually cover the entire surface of the package in testing. Some items may be too small to affix a label to so innovative ways to possibly hang the tag are often used.

Label Requirements

MH10, a popular barcode label format, that is widely adopted, already come prepared and are ready to use(identified). The addition of a smart label combined with the barcode label is complementary, thereby offering a viable solution. Specific label requirements can further advance the identification of the product down to an item level. Specific label requirements are usually mandated by the partner such as DoD and Walmart , Target, Metro, etc. Some requirements are posted on www.epcglobal.org website but are usually passed down.

Package Contents

While conducting tests on product(s), it may be discovered that certain materials themselves are the culprit for a non-read. Certain packaging mediums and the contents of the packages diffuse the RF signal causing failed read rates. Materials such as liquids tend to absorb radio waves while metals tend to deflect and diffract radio waves. Items like water and soup are particularly troublesome as the liquid and the medium used for packaging require extensive testing. Limited space on most items,

require extensive experimentation on placement of labels on which configuration works best.

Good and Quiet Labels

For an RFID label to be considered good, it requires RFID data be correctly written to the tag, the correct image being printed, and content data verified against the source. An encoder (an RFID Label capable printer) prints the tag information onto the substrate and then verifies the validity of the tag. When one of these requirements cannot be met, it will be voided in the system and a new label will be printed to replace the defective tag. This precaution will save the use of EPC numbers being consumed. A best practices approach adopted is to control the creation of the additional EPC numbers as an extended form of inventory control. A quiet label is a verified tag that is not readable from a normal distance. It is possible to have defective tags within a roll of labels; this means that a specific label may not be readable once activated. The print/encoding system should be designed to distinguish between quiet and non quiet labels. This will remove another possible source of error from the system.

The factors listed above are all conditions that should be addressed for effective read rates. *Any item listed above singularly or in combination may and will affect read rates.* Once the tag placements have been validated on the packages further testing and validation to the other auxiliary systems should be addressed. The auxiliary systems will require interface compatibility to the RFID system and bidirectional dataflow will be necessary requirements.

Phase 2 - Test and Validation

Since RFID is uncharted territory for many organizations, deployment represents a long journey. Best practices indicate that organizations involve an experienced person that understands existing operations, systems, and processes. As a provisionary measure, additional expertise of interpretation of data to provide value to the supply chain visibility organization should be added. Usually a business analyst that can configure, interpret and modify the system for on–going support and post implementation support may become necessary. Organizations may not realize the intricacies of this technology and commitment to the project. Integration partners have realized this trend and have adopted the business model towards a service integration model. VARs and implementers have addressed this lack of expertise and are heavily leveraged as professional services organizations. The partner has filled the business analysis expertise gap to evaluate business practices and the ability to create workflows and understand the current information infrastructure. Best practices dictate that PMI methodology be followed; proper RFID expertise employed, creation of workflows, realistic performance targets, milestones, and responsibilities should be followed.

System integration

Within this step of the second phase, it is important to understand how RFID will integrate to your existing ERP and/or WMS. Lack of understanding on the integration to external systems of extra data collected can cause confusion. The sticking points may include the complexity of the data, how it is interpreted, financial impact and the comprehension of how to exchange meaningful information with trading partners Another layer of complexity will be added to your system administration overhead, in terms of data management, hardware tracking, use of a middleware RFID software, the infrastructure behind the new layer(new servers, adding it to the domain, etc.) After testing and evaluation, this will allow the organization to preview what extent of capabilities can be achieved. Look for solutions that integrate hardware and software to your WMS and/or ERP. When done properly, RFID systems minimize RF coverage and report precise readings in finite areas. Users can select systems that are multi-protocol capable and have an open data structure as an XML integration for data swap,

also a common database and if the RFID application is written in the same language as the ERP/WMS is very useful.

Interfaces

A key element of any implementation is the integration to the periphery systems. The person guiding you through the integration will contemplate, and monitor the development of the interfaces between the ERP, WMS, TMS, EDI, and shipping systems. The integration will require a new interface that should be tested with all other systems which are affected as listed above. While monitoring the creation and definition of the interfaces organizations should examine;

- Various platforms will have to be examined, operating
- The databases used between all systems, are they compatible and can they easily connect without additional programming
- Connectivity of the databases is there a tool to link them, possibly an ODBC connection, or perhaps a socket connection,
- Interface definition and mappings of the interfaces between the systems
- The workflows have to function seamlessly between systems, can your new RFID system handle this, and how will this fit in ?
- Is the data exchanged between systems the same language ?
- Who controls the data ?
- Where is the data stored ?
- Whom are the consumers of the data, is it acted upon ?
- Is the data mined from a BI system ?

Best practices suggest once the application integration is defined, implemented and tested within the test environment and end to end test be should be completed. The end to end test shall include the correct placement of the tag upon the item, a reader response, collection of the data to the RFID system and validation of that data. The organization should validate the exchanged data to be passed to other systems through integration, the receipt of the data to the auxiliary system and possible exchange to the trading partners.

Workflows

Complete workflows of entire business processes should exist and be documented so that there is a roadmap to plan the installation. If these processes do not exist be sure to allot additional time to the project plan to complete the process reengineering that is required. These questions should be answered before starting; it will provide a much smoother integration. The workflows between these systems should follow the entire product cycle, from inception to the consumption of the data or product. The interfaces should allow seamless integration between all systems. The dataflow should follow all the processes and the corresponding data should also agree with each phase. Once completed, the pilot implementation is the next phase in the four phased approached.

Phase 3 Pilot Implementation

Best practices indicate the objective of the pilot program is to develop predictability, scalability resolve as many possible scenarios that affect the business on a day to day basis. For phase three, achievement of precision, placement, output, and performance will need to be verified and recorded. The recording of the findings will provide a useful troubleshooting and training tool and can act as knowledge transfer document for personnel. At this point, proper label placement should have been established, reader interaction, flow of data between systems would have been solved through the previous phases. The pilot implementation is actually the full system in the full working environment where production system will exist in. The difference is that the operation and use of the system will be scaled back to manageable portions. Load testing should expose any further flaws in business processes, anomalies within

the system and should allow full operational scale that is required to run the business on a daily basis.

Best practices suggest the use of the checklist for tasks that should be completed during the pilot phase of the project. If a Yes is checked then proceed to the next item, if the answer is no then rectify the task and re-perform that task until advancing to the next task.

PILOT IMPLEMENTATION CHECKLIST	YES	NO
1. Set up equipment in other facilities /divisions to improve processes – test infrastructure		
2. Verify the ability to capture information and transfer data to and from other systems		
3. Educate employees on technology and use of RFID, this will affect how they work if tags are manual		
4. Employee training – make sure all employees that will utilize the system be properly trained for the operation they require		
5. Partner with suppliers to verify system compatibility. Work with partners to iron out any incompatibilities, label types, protocol etc.		
6. Subject the system to load testing and use enough quantity as per usual operations – introduce incremental amounts of data, product and collection to the system		
7. Measure results to test viability of larger scale		
8. Work with partners to eliminate errors		
9. Integration of data between ERP/WMS and other systems – this includes testing data flow, and validating the data		
10. Decide whether to use an automated process for label application or a manual process – Also devise a method to complete the operation of the tag placement and how that data can be gathered and processed		
11. Devise a cutover plan – Which systems are affected, how many systems, when and what locations		
12. Contingency plan in case of failure, have work- arounds prepared to solve data and technology issues, create alerts to employees if a part of the system should fail		

If the automation process is causing excess time in production consider a manual operation. If time is running short the organization should consider making the application of smart labels as a post production step rather than incorporating it into the manufacturing process. Deconsolidation and re-palletizing might be a short term solution (slap and ship). This will allow a quicker deployment time if necessary.

Many slap and ship solutions contain the basic necessities that are required to satisfy an RFID mandate but do not require the heavy investment that a full implementation will require. The slap and ship solutions offer the availability of tags to be applied without the investment that a full implementation can cost. The concept; apply the tags, and verify information, without having to buy extra features that organizations do not need. Many WMS companies offer a slap and ship package that is usually added at the end of the process just before products leaves the warehouse. These kits usually include readers, tags and encoders and sometimes a light version of middleware to manage the data and hardware. These are readily available from many WMS vendors. For the supplier issuing the mandate, this usually suffices the information requirement.

Best practices recommend a phased approach for the RFID implementation. This approach will allow manageable tasks that can be controlled and rectified. Use of one vendor and a handful of product items and information flow between suppliers and procedures should be validated. When a problem occurs, the physical size and manageable number of scenarios will make it easier to troubleshoot. When the organization completes the RFID transactions a combination of system and manual verification should occur to validate all things are correct. Data are manually interpreted for validity (if product data is correct) and tracked through all the systems (interface validity) affected confirms the end to end test is validated. Once verified, the organization should add suppliers and products gradually so that it can be managed in case an issue arises. The concept of adding the suppliers and products one by one allows the users to see if a problem exists with a particular product and /or supplier. If a supplier is proved to be erroneous the steps to correct should be minimized as the other customers and products have already been validated. Resolution of the problem involves dealing with the issue internally as well as informing the trading partner in question if the problem exists on its side as well. Collaboration will allow a quicker resolution to the problem. Once all products are live and suppliers are satisfied with the state of integration and data integrity is tested, then it is safe to progress to the fourth step of the implementation process.

Phase 4 Implementation

The home stretch is now in sight. Since phase three was a completed version of data and equipment in the production environment although scaled back, phase four involves the final rollout phase. The considerations from the initial planning stages allow for a complete solution. A proper rollout plan should be devised for a successful implementation. A proper rollout plan will include; a contingency plan for rollout, scheduling of resources both for hardware and software and IT resources, vendor standing by and workarounds.

The following steps of validation, data capture, network and device management and scheduling the cutover should provide a smooth wrap to the RFID implementation project.

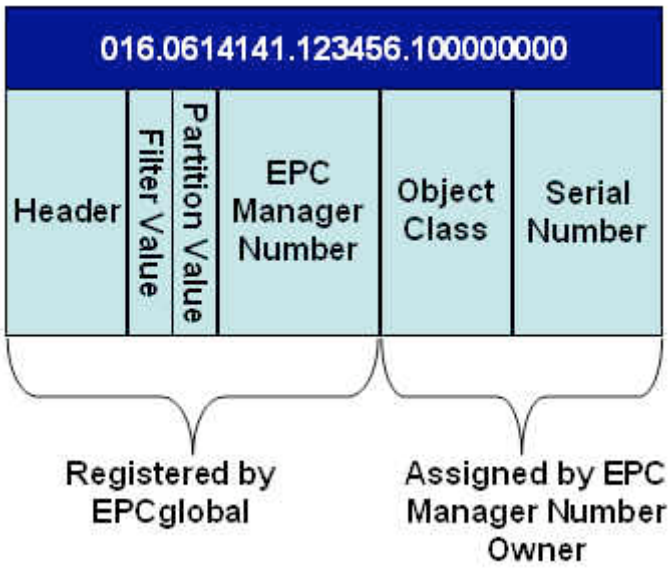
1. Validation

Validation requires correlation. By having data validation built into printing equipment the organization can correlate maximum barcode reads. Without manual intervention the system will be able to check if the correct data is read from the tag and compared to the corresponding database EPC information. If a discrepancy occurs, the system will automatically back up and cancel the label by voiding the erroneous tag and print a replacement tag, this task is executed by the encoder (printer).

2. Data Capture

Data capture is essential for supply chain visibility. The ability to track data, product location, in-transit product, on order goods and the ability to see how much is very valuable. By having the ability to track product location and quantity can translate to accurate financial information, educated supply and demand predictions and efficient planning to drive towards a lean inventory strategy. The increased real-time amount of data can provide a more complete customer experience by having the correct information required at a customer's request. The data capture by use of RFID, will facilitate nearly instantaneous visibility of supply chain activities will facilitate better demand planning, easier sales projection and assist with purchasing decisions. Once EPC data is integrated to the database it can provide real–time information, location and batch information that can identify and locate specific products at any point in the supply chain. A best practices approach suggests using both barcode and RFID technologies as they are complimentary. While barcodes offer a means of identification 2-D optical recognition RFID offers specifically, through radio waves, what are contained within the contents.

The anatomy of an EPC product is as follows:



Header Code: The first component (4 digits) of the EPC that tells the reader/interrogator how to parse the bits (decode the rest) of the EPC number.

Object Class: The third component of the EPC that describes a category of things in the supply chain (much like an Item Reference or a SKU does in the GS1 System).

Serial Number: The fourth component of the EPC that is critical to the reading and numeration of tags. How an individual company chooses to assign serial numbers (i.e. individual instances of the Object Class that precedes it) is up to them.

EPC Manager Number: The second component of the EPC that describes what company or organization has authority over a group of products or things in the supply chain (much like the Company Prefix does in the GS1 system). *Only End-Users are assigned EPC Manager Numbers.*

Once an EPC Manager Number has been assigned, EPCglobal US will ensure that it is registered within the Object Naming Service (ONS). This will ensure that your product data is accessible to your trading partners via the EPCglobal Network.

As referenced from the ww.EPCGLOBALna.org

Network and Device Management

Middleware software serves mainly two purposes, management of hardware devices and data management and integration to other systems. A further function of the middleware software is to collect, process, and aid in interpretation of the data. Middleware software contains guidelines that are broken down into base components so that data can be dissected. Graphical dashboards are common in this type of software that identifies each part of the code and then consolidates them. The information uses the ONS to communicate to external trading partners and also feeds the other systems with the collected RFID data.

The physical hardware becomes part of the network infrastructure that must follow the same maintenance and support policies as the existing network. A best practices approach defines how data will be managed on the network and for the devices for the RFID implementation (usually ITIL methodology is used here). A middleware solution that is part of the network infrastructure is a worthwhile option to consider because it will aid in the interpretation of data and monitors hardware in case a failure occurs that can impact operations. If there are any failures, alerts can be sent to the correct person(s) for notification and problem resolution.

If a middleware is selected, the organization should have the resources internally to interpret the data and understand the impact to the supply chain and the advantages this new visibility can result in. The internal resource may be a more cost intensive strategy in this case. If internal resources are not available, there is the option of outsourcing this operation. Many RFID integrators may offer the analysis and interpretation of the data and even host the middleware solutions as mentioned in the article (Tightening the Chain, cost cutting strategies for supply chains) this is the other solution and is usually more expensive for organizations. Usually, the business analyst can interpret and correct the data if necessary. A best practices approach recommends there should be pre-defined procedures in place for troubleshooting. The IT person should have the administrative rights to select the data, correct it, and reissue, process or resend to the business partner in case there are any problems.

Cut – Over

A common best practice that mitigates risk is to run each system in parallel. The system in place for tracking currently, (most likely a barcoding system) and functioning properly as to not interrupt business operations should be kept operating. Then with the addition of the RFID system to the network, the organization should introduce the new functionality in phases for vendors and items. Once everything is "live" the organization should continue to monitor the new component of the system, with the incremental tasks of items and procedures can make troubleshooting easier.

Best practices using PMI methodology suggest a cutover plan should be devised. Lack of understanding of business issues and how IT can aid in the solution of those issues is usually the breakdown that occurs. The IT and Business have different view points on the same issue but do not come together to resolve the problem.

A common pitfall of companies is that their test environment is not the same as the production environment. There sometimes are different versions of software that are within the test environment that are not in production and vice versa, therefore to resolve problems becomes

more difficult. This causes a false sense of security as the systems will not react the same way as tested. If a problem occurs it is difficult to determine the cause and what needs to be addressed to correct the problem. When solving problems, the organization should consider the solution that follows sound accounting principles, IT practices, and satisfy the operational component of the issue.

A best practice plan should contain the following:

1. Employees have been trained on the new system and some on troubleshooting techniques
2. Parallel systems should be running to mitigate risk
3. The pilot that was run was a scaled back version of the complete supplier and item master with production.
4. Decide which part of the organization is to " go-live " possibly by department or enterprise wide.
5. Have the correct resources on site or readily available by phone or email for hardware and software support
6. Consider the impact to the other systems, are there interfaces that may need to be shutdown and brought back up and the users it affects
7. Always back up your current system before going "live" including the application and database
8. Populate the database with the correct information, both items and suppliers
9. Enable trading partners and have them on standby
10. Troubleshooting procedures should be already formulated and documented so that fixes are quick and efficient while preserving data integrity

These steps should be the foundation as to the contents to the cut over plan. Since this is the final step of the implementation flipping the switch to complete integration should follow.

Conclusion

This guide provides a summary of how to implement an RFID system and the steps to do so. A basic overview of the technology, the prepatory steps required to implement an RFID system and the four phases of implementation have been laid out as the fundamentals of getting RFID implemented into the organization.

The organizational fit for RFID is examined and the technology is defined. Before the implementation begins, prepatory steps should be taken to progress through the implementation. The site survey and the selection of a business partner(s) should be executed before the implementation steps begin.

Building a development environment and testing operational scenarios which include label placement and read rates and hardware locations (three vital areas that should be addressed for a successful implementation).

Most of the initial testing will be covered in phase two as what is learned here can be applied to future steps in the implementation. System integrations, interfaces and workflows are examined in this section.

In phase three – the pilot phase, tasks are explained in detail, a checklist is included to prepare for the final phase, and possible work-arounds for common RFID issues that occur.

Phase four, the final phase examines the cutover plan formulations, validation, data testing, network and device management.

This guide should act as a tool to maximize the success for an organization's RFID project. The combined tasks should act as a guide to start the RFID implementation and walk through each step by phase that should lead to a successful implementation.

Glossary

Active tags
These tags have an on-board transmitter, usually powered by a battery, that constantly emits a signal, with a read range of a 100ft (30M) or more. EPC classes 3 and 4 These tags have its own power source and are costly.

AEN
Ambient Electromagnetic noise. This refers to the outside interference that can impact your radio frequencies within the RFID system. Radio and microwave interference created by existing electrical and other radio equipment

Auto-ID, AIDC
Automatic identification. Usually automatic information data capture done by some type of electronic equipment - scanner, biometric pad, camera, etc.

Backscatter
Electromagnetic waves that are reflected off of and propagate away from an object

B.I. System
Business Intelligence system, usually containing all information corporate wide

Code Hopping

The ability of a device to switch from one frequency to another automatically and utilize open channels within a preset range of operation

EAN
European article number. European version of a barcode. An 8 or 13 digit code originally used by companies outside North America to uniquely identify themselves and its products worldwide.

EPC
Electronic product code. A code that identifies the manufacturer, product category of an individual item. This also identifies the unique item number of the product

EPCglobal
EPCglobal is a joint venture of the EAN international and Uniform Product Council, representing 100 member organizations worldwide. EPC is backed by the United Code Council and EAN International the two main bodies that oversee barcode standards.

Encoder
A reader and an antenna built into a smart label printer to write RFID information to tags.

FFCA
Full Faraday Cycle Analysis – a method of gathering time dependant frequency analysis data also can be called site survey for RFID

Frequency bands

Band	Frequency	Read Range	Notes
LF	100-500kHZ	upto 20 inches (50.8 cm)	Access control, animal identification, vehicle key locks
HF	13.56kHZ	upto 3 feet (1 meter)	Access control, smart cards, item level tagging libraries and electronic article surveillance
UHF	866-956MHZ	FCC allows over 20 feet (6 meteres) at 915MHZ. Range at 866MHZ is about 10% less than at 915MHZ	Supply chain use, baggage handling and toll collection.. Walmart is accepting RFID tags in this range
Microwave	2.45GHZ	3 to 10 feet (upto 3 meters)	Item tracking, toll collection

GTIN
Global Trade Item Number. An generic term used to describe the entire family of UCC/EAN data structuresg for trade items.

HF
High frequency, refers to radio waves in the 13.56kHZ range

Host System
Computer that runs software applications that interact with RFID and other devices, such as WMS

Interrogation Zone
The physical area where radio waves are propagated through

LF
Low frequency, refers to radio waves in the 100-500kHZ range

MH10 Label
A label format, used widely in retail. This is one of the most popular label standards with the UCC128 barcode, used for identification purposes. Most major retail outlets like Walmart, Target, Sears etc. use this form of identification. This will become a complimentary technology to be used with RFID for maximum gains.

Middleware
Middleware is the interface needed between the interrogator and the existing company databases and information management software.

ONS
Object Naming Service that allows communication and identification to external trading partners

Passive Tags
RFID tags that are activated by electromagnetic waves of a reader, do not have on – board transmitter, read range of 10 - 25 ft (3M-8M)

PMI Methodology
Project Management Institute methodology – A methodology for project control using PMBOK

Quiet Label
A label that can not be read from a normal distance.

Reader
Also called an interrogator. The reader communicates with the RFID tag and passes information in digital format to the computer system

RFID
Radio frequency identification

RF
Radio frequency

SA
Spectrum analysis – a range of values of a quantity or set of related quantities. Measurements of radio waves and the frequency emitted.

Smart Label
A label that contains an RFID tag. It is considered "smart" because it can store information such as unique serial number and communicates with the reader.

Tag
The RFID tag is composed of a microchip and a flexible antenna encased in a plastic – coated inlay

UCC
Uniform Code Council. Based in the U.S., is a membership organization that jointly manages the UCC.EAN system, including the Universal Product Code in U.S. and Canada

UHF
Ultra high frequency. One of the RFID frequency bands. Usually 300 MHz to 3 GHz, good bandwidth and good range. UHF waves don't penetrate materials well and require more power to be transmitted over a given range than lower frequencies

WORM Tag
Write once; read many, uses a type of non volatile memory that can be written to only once typically just before it is applied to product or container. Information is Read Only. EPC class 0+,, 1 and UHF Gen 2

WMS
Warehouse management system

Sources of reference: RFID labeling, RFID for Dummies, EPCGlobal website