

EPC Advanced Infrastructure Implementation Training

Chapter 1

Introduction

Introduction

Welcome to this EPC course.

We are happy to present you with the EPC Advanced Infrastructure Implementation course where you will learn more about implementing the infrastructure required for an EPC / RFID system

Enjoy the course!

Preface

Implementing RFID is similar to implementing a new IT system or a new business process.

To do so efficiently, you will need to follow good project management methodology and define your implementation road map

This implementation roadmap can vary from one company or one industry sector to another.

Scope

This course focuses on the implementation aspects that are particular to EPC/RFID infrastructure.

Those aspects are:

- The selection of EPC/RFID system design
- The site analysis
- The installation of the system
- The security of the system
- The monitoring & troubleshooting of the system

and therefore does not cover the others steps of the implementation roadmap such as the cost-benefits analysis, the project management or the communication

This course also does not cover extensively the implementation of EPCIS as this will be covered in a separate course.

Pre-requisites

This course builds on the knowledge that you have acquired in the “Basics of EPC” and in the “EPC / RFID – Advanced technical aspects” courses.

It is strongly advised that if you're not familiar with EPC and/or RFID, that you first take the “Basics of EPC” course.

It is also strongly advised that you first take the “EPC / RFID – Advanced technical aspects” if you are not familiar with the technicalities of tags, antennas or radiofrequency waves.

Chapter 2 –

**Selection of the EPC/RFID
system design**

What is in this chapter?

Selecting the Vendor(s)/Solution Providers

Selecting the Operating Frequency

Selecting the Tags

Selecting the Readers

Selecting the Antennas

Selecting the Transmission Lines

Selecting the Portals

Selecting the RFID Peripherals

2.1 Selecting the vendor(s)/solution provider(s)

Why is it important?

Vendors play a major role in helping you design, implement, and manage your solutions and therefore finding the right vendors who can help you address your business issues is critical.

This means that proper vendor selection often makes the difference between a successful project and a failed one.

For an RFID project, this is especially true because its usage is relatively new in areas such as supply chain where only a small set of industry-wide references, best practices, and case studies are available.

The Best-of-Breed approach

- Selection of the best vendor for each specific portion of an RFID project.
- The choice often depends on the specific application and industry.

IMPLICATION:

You are in control and manage all aspects of the project in-house.

The One-Stop-Shop approach

- Involves selecting one single vendor to act as the primary contractor vendor for the RFID project.
- Primary contractor often manages the entire lifecycle of the project and is responsible for all phases of the project including the selection of additional vendors/sub-contractors

IMPLICATION:

one vendor is primarily in control, manages all aspects of the project, and takes responsibility for the overall outcome of the project.

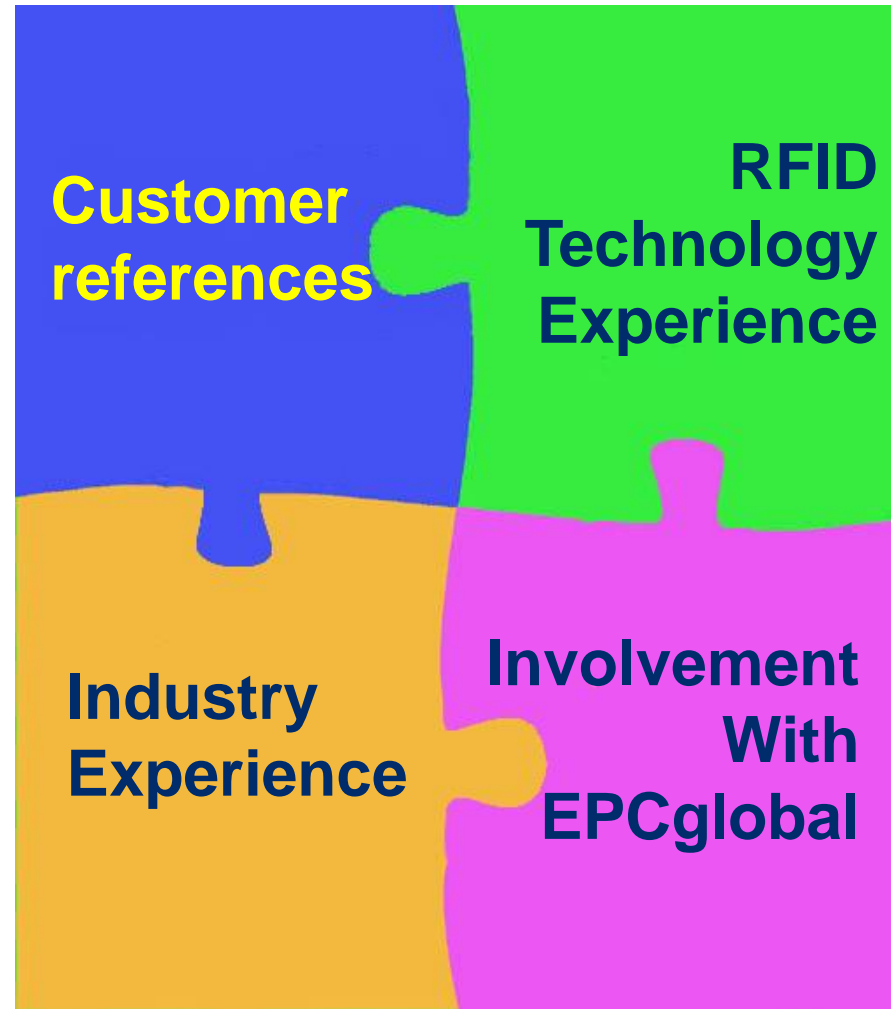
Which approach is best?

- Both approaches have PRO's and CON's and you can mix both for example by maintaining the overall project management responsibility in-house and hiring a vendor to act as a trusted advisor

Best-of-Breed	One-Stop-Shop
More flexibility in substituting another vendor if one does not work out as planned	Generally ensures you will have more time to focus on the business aspects and less problems in integrating the different portions of the projects.
Requires in-house expertise	Having a single point of contact makes it clearer as to whom is responsible
Requires in-house resources for the project management	Failures are expensive in this configuration.

How do I compare vendors?

Generic Criteria +



2.2 Selecting the operating frequency

Why is it important?

Tag and reader use radio waves of a certain frequency (operating frequency), to communicate with each other.

The choice of frequency does affect the system's performance in areas such as speed, range, and accuracy that are critical to your application.

In addition, considering other radio services such as radio, television or mobile phones have operated before the arrival of RFID systems, it is also important to ensure that the selected operating frequency does not disturb these services.



What are the frequency ranges?

An RFID systems operates in one of the four main ranges of the radio frequency



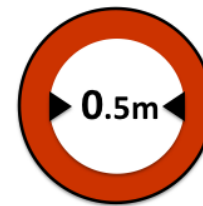
We will look at the PROs and CONs of each range and which bands are available for EPC / RFID systems within these ranges.

The Low Frequency (LF) range

LF range: **30 KHz - 300 KHz,**
RFID systems: **125 KHz & 134 KHz.**

Characteristics of RFID systems at LF:

- Short read range (<0.5m)
- Low reading speed
- Very few interferences with the surrounding and absorption or reflection problems due to water or metal.



Applications:

- access control
- animal and personnel tracking



The High Frequency (HF) range

HF range: **3 MHz - 30 MHz**

RFID systems: **13.56 MHz**

(only globally accepted radio frequency for RFID systems)

Characteristics

- Read range: +/- 3 m.
- More problems to penetrate through materials (vs LF)
- Better data transfer speed (vs LF)



The High Frequency (HF) range

Applications:

Building access control



Item-level tracking, including
baggage handling



Libraries



The Ultra High Frequency (UHF) range

UHF range: **300 MHz - 3 GHz.**
RFID systems: **344 MHz & 860 - 960 MHz**
(Depending on country/region regulations)

List of UHF bands available for RFID systems -> EPCglobal website.

Characteristics:

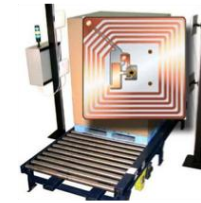
- Read Range ≤ 10 m.
- Higher probability for interferences (consumer devices)
- Higher probability for problems due to absorption by metals or matter.
- High data transfer
- Limited portability



The Ultra High Frequency (UHF) range

Applications:

- Automated toll collection
- Warehouse management
- Inventory tracking



The Microwave range

Microwave Range: **1 GHz - 300 GHz**

RFID systems: **2.44 GHz and 5.80 GHz**

Characteristics:

- A long read distance
- A high reading speed and data transfer rate
- Poor performance around water and metal



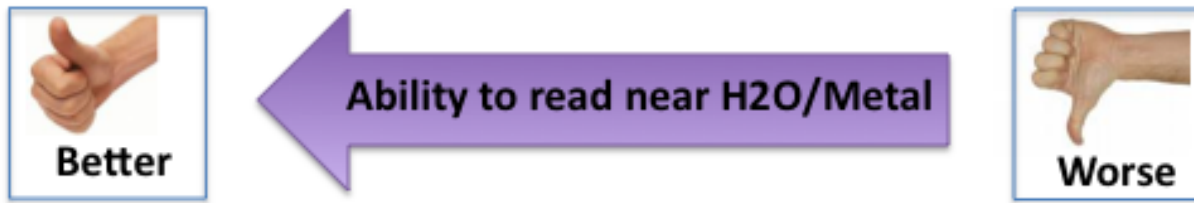
The Microwave range

Applications:

- vehicle identification
- automated toll collection



How do I select the operating frequency?

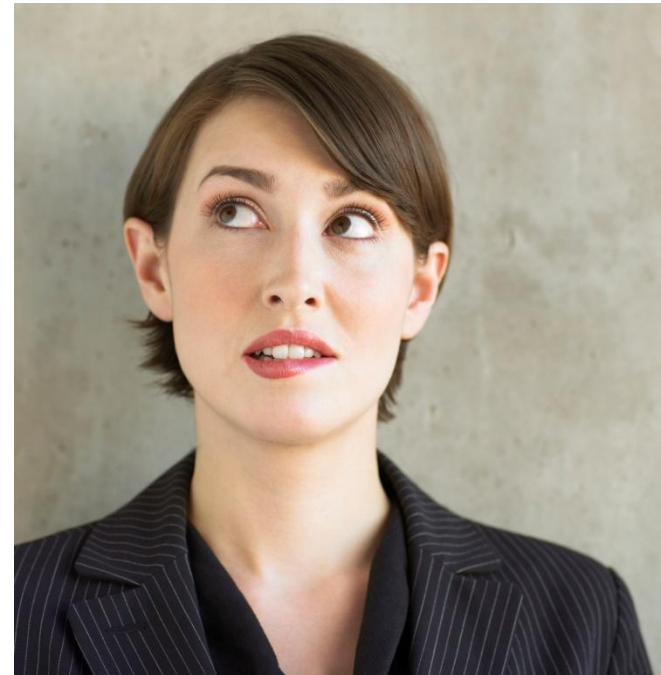
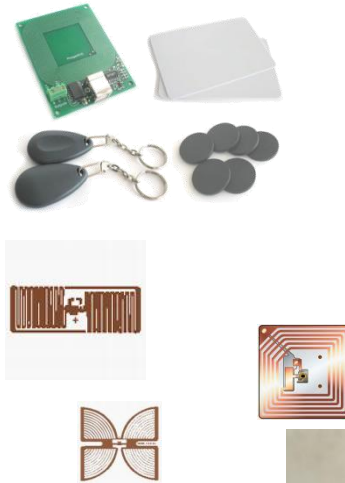


2.3 Selecting the tags

How do I select the tags?

Consider various factors:

- tag types and classes,
- operating frequency,
- read range,
- data capacity,
- tag form and size,
- environmental conditions,
- standards and regulations



The kinds of tags

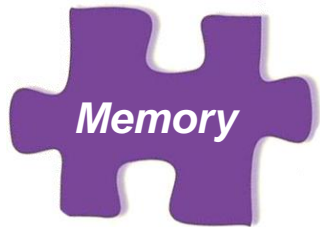
Type of tag depends on your application:



Requires tag to store some data (e.g. ID)
& provide it on request

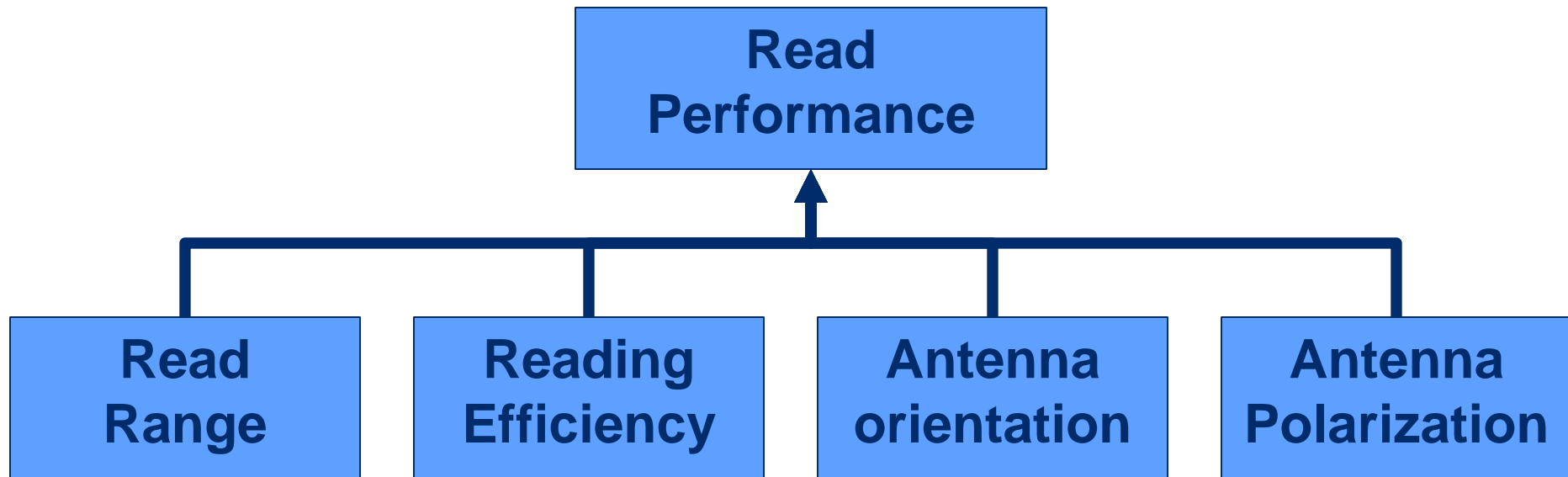


Requires a very long read range or real-time features such
as sensing the temperature or the humidity.



Read Only (RO), Write Once Read Many (WORM) or Read
and Write (RW) tags depending on the data you wish to
store on the tag and whether this data is subject to
change.

The read performance of the tags



=

Reading Robustness: $\frac{\text{\# of Successful Reads}}{\text{Total \# of Reads}}$

Other consideration for the tags



Data Capacity

More data capacity = more useful
= more cost



Security

Data locking prevents tampering with
the tag data.



Compatibility

With item to be tagged and environment.
Appropriate size
Enough ruggedness if in contact with harsh
environment humidity or corrosive material.

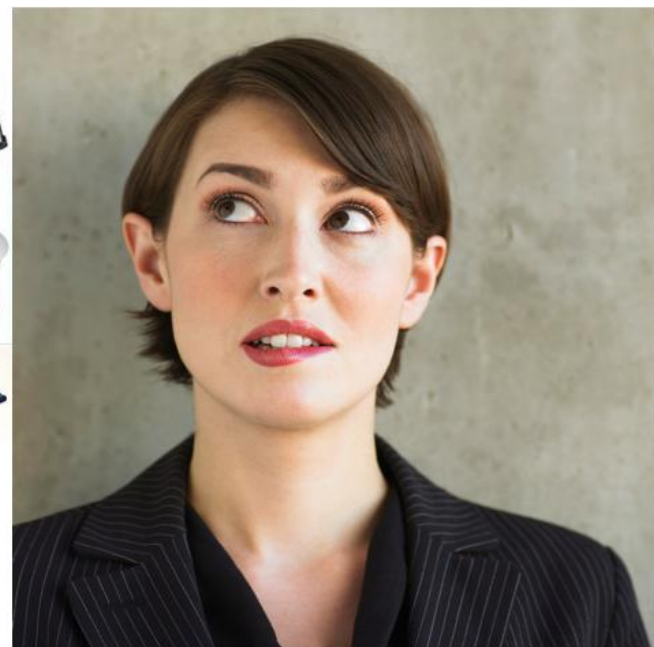


Tag compliance with EPCglobal standards
ensures compatibility and interoperability with
other systems meeting those standards

2.4 Selecting the readers

How do I select the readers?

- Ensure reader operates at your chosen frequency
- Ensure reader complies with legal requirements (e.g. maximum power).
- Ensure reader should has correct interface for your application.



Other considerations for the readers



Readers usually have 2-4 antenna ports. Some readers have up to 8 antenna ports. Offer a better flexibility in covering a wide area zone.



Readers that can be easily upgraded save costs.



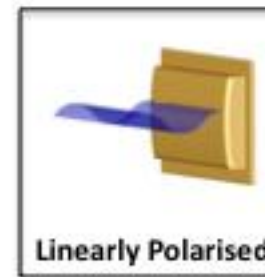
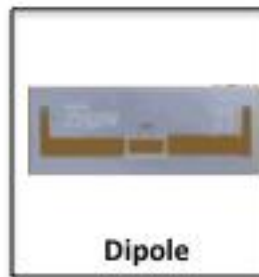
Application might require readers to be managed remotely for diagnosis and fixing without visiting the site.

2.5 Selecting the antennas

What are the types of antennas?

Both tags and readers have their antennas and these come in various types.

The main antenna types are:

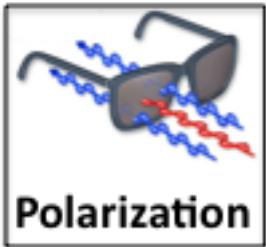


How do I select the antennas?

Two key factors: the **footprint** and the **polarization**



- Ground area over which the antenna delivers the signal.
- All tags placed within the footprint of a reader's antenna can be read by the antenna.
- Footprints can be mapped using a spectrum analyzer.



- Depends on the tag orientation with respect to the antennas:

UNKNOWN	KNOWN
Use circularly polarized antennas. This ensures some amount of power will be transferred between the reader and the tag antennas, regardless of the tag orientation	Use a linear antenna to receive the maximum power and thereby increase the read range.

2.6 Selecting the transmission lines

How do I select transmission lines?

Transmission line:

physical medium (e.g. cable), connects signal source of reader to antenna.

Optimal transmission line:

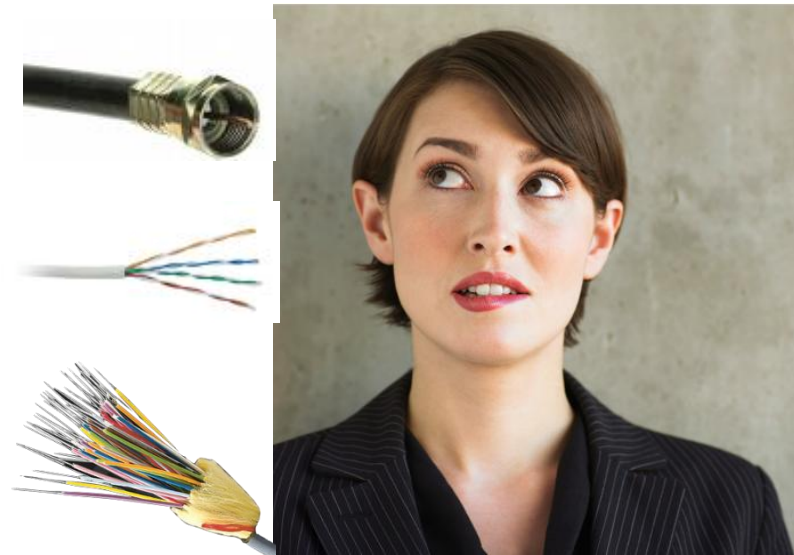
transfer energy from source to antenna with minimum power loss.

RFID systems generally use 50 ohms **coaxial** cables as transmission lines as these have low cable loss.

Shielded pair cables are also used frequently.

The longer the cable, the greater the loss of power.

Impedance of transmission line should match input impedance of antenna.



2.7 Selecting the portals.

What is a portal?

Area where RFID tags are being read or written to.

Types of Portal:

Stationary:

- Dock doors
- Conveyers
- Stretch wrap stations
- Smart shelves



Mobile:

- Forklifts



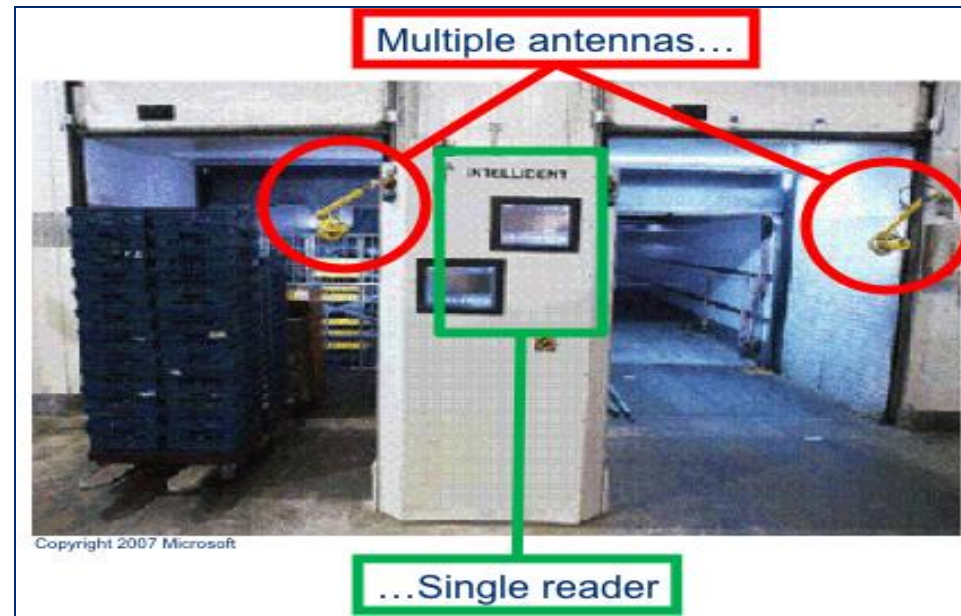
The dock doors

Read at pallet level all tags attached to items on vehicles passing through its interrogation zone

Multiple antennas mounted in array on both sides of door (covers interrogation zone of +/-3 m x 3m HxW)

Position antennas to form an efficient interrogation zone.

Readers activated by motion of vehicle: should be turned on rapidly so vehicle doesn't have to slow down for all tags to be read.



The conveyers

- Generally used for case-level tracking (e.g. luggage in airport or boxes in distribution center.)
- Multiple antennas mounted on gantries around conveyor to cover the 4 faces as item to be read passes.
- Optimal reading: belt and roller for conveyor to be made of Radiofrequency friendly material at read point (not of metal).
- Speed of conveyor to be adjusted for optimal reading



The forklifts

Especially well suited for reading tags from items on pallets
Can be connected to data collecting computers
(e.g. for improving inventory management).

Disadvantages of mounting antennas on forklifts:

- Forklift based systems require manual intervention from operators
- Tag readability can be affected by various factors:
 - metal of the forks,
 - communication devices of the forklift operator
 - speed of the forklift



The stretch wrap stations

Usually final step before shipping, so, RFID system at this place guarantees integrity of the containers.

Extremely attractive for a portal because orientation of tags continuously changes while the pallet spins (making their reading very efficient).



The smart shelves

Significant advantage: helping reduce out-of-stocks.

Disadvantage:

- Require multiple readers and antennas
- Potential overlapping of interrogation zones and signal interferences.
- Densely packed items on the shelves could result in stationary readers missing some items resulting in inventory issues.



2.8 Selecting the RFID peripherals

The RFID printers

Devices printing smart labels (labels combining barcode with RFID tag).
Able to print barcodes on label and read & write tag inside label.
Can be connected to PC via parallel, serial or USB port
Can be connected to network using Ethernet connection.



How do I select the RFID printers?

Factors to consider when selecting RFID printers:



- Automatically void faulty labels?



- EPC compliant?



- Support for harsh conditions?



- Support for various label sizes and multiple tag protocols?



- Printing speed sufficient for application now and in the future?

The label applicators

Machines applying the labels on the products in an automated way.



Pneumatic Piston

Pneumatic piston label:

Detect product and have piston to stop it for labelling.

Advantage:

product doesn't have to be moving at a constant speed.



Wipe-on

Wipe-on label applicators:

Detect product and perform labelling using roller or brush to wipe down label on package.

Require the product to be reliably moving at constant speed

The feed back systems

Generally used to report problems with system or to perform action when event encountered: (e.g. activating readers when tagged items are detected).



Feedback systems include:

- **Photo eyes:** detect presence of something coming or verify if labels are correctly placed



- **Light trees:** indicate with green light that package has been read successfully, and with red light that something is missing or incorrect



- **Motion sensors:** indicate arrival of tagged items at dock door



- **Real time location systems:** track & report in real time location of assets tagged to be tracked

2.9 Summary

Summary

In this chapter, you have learned that you want to design your RFID system to meet your application's performance requirements and that vendors play a major role in helping you do so.

The type of your application, the required read range and the operating conditions will be the key factors for selecting your operating frequency.

From there, you will select your tags and readers based on read performance operating conditions and compliance to standards.

Choosing the right portals will depend upon your application and whether you want to track at the item, case or pallet level.

Finally, you have discovered that RFID peripherals will enhance your system and enable it work in a more automated way

Chapter 3 –

The site analysis

What is in this chapter?

Design of EPC / RFID system not final until site survey performed.

Understand what information is in blueprint to start site analysis and what information to be entered into blueprint after finish of site analysis.

How to analyze environmental conditions to identify potential sources of interference and how to define where to place interrogation zones

3.1 What is a site analysis?

Why is it important?

- Need to determine how RFID system will fit into existing site infrastructure
- Site analysis required before finalizing RFID system design
- Site analysis required before you install the RFID system

Main goal of site analysis:

To ensure that interrogation zones will function properly, with maximum performance and without interrupting existing services.

- Site analysis also facilitates smooth integration with existing IT systems (e.g. by identifying need to upgrade network infrastructure)

What are the steps of a site analysis?

You site analysis = ***project*** and should be planned accordingly!

Perform your site analysis in **3 steps**:

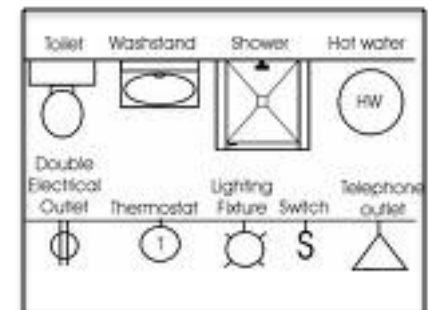
- ***Prepare*** your site visit
- ***Visit*** the site and perform a physical and an radiofrequency environmental analysis
- ***Document*** your results in reports and include findings in blueprints.

3.2 Preparing the site analysis

What is a blueprint?

Plan or facility diagram that helps visualizing big picture of site infrastructure.

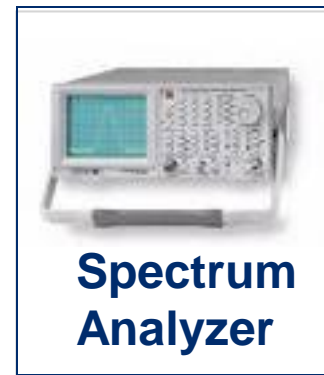
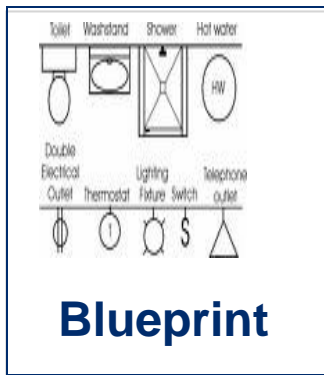
- Preliminary determination of where you can possibly set up interrogation zones by showing for example which are the places you need to avoid such as metallic material or motors that can cause interferences.
- Look on blueprint where to get power sources for RFID system.
- Generally uses standardised symbols to represent electrical and telecom devices.



Which equipment do I need?

Main part of site analysis is to perform physical and electrical environment analysis.

The equipment that you need consists of:



3.3 Performing a physical and an electrical environment analysis

How should I perform a physical environment analysis?

Look for ***physical conditions*** or ***objects*** that might affect RFID system:

Harsh environmental conditions

E.g. corrosive material, extreme temperature or humidity which can damage tags
moisture and water contents which can absorb the Radio Frequency signals.



Electrical devices (e.g. motors & cabling) that could create interferences and noise.



Metallic objects that would reflect the Radio Frequency signals.



Any other physical sources that may have adverse effects on the radiofrequency signal propagation.

Why should I perform a radiofrequency environment analysis?

Since you have performed the physical environment analysis, you have identified some of the potential sources of electromagnetic noise and interferences.

Now you need to perform a radiofrequency environmental analysis for further identifying the sources of interference and noise and measuring them.

This analysis will help you decide where to place your interrogation zones and also help you fine-tuning and configuring these zones for optimal performance



The analysis will also ensure that your RFID system will not interfere with the existing radiofrequency systems on the site.

The radiofrequency environment analysis – step 1

Measure ambient electromagnetic noise (AEN) generated by electrical devices existing at site.

AEN = measured in decibel by spectrum analyzer.

Measures spectrum of electromagnetic wave, helps:

- To identify sources of radiofrequency interferences
- To measure RF output from these interfering sources in terms of distortion, harmonic, modulation, quality and noise
- To display signal interference if it overlaps intended signal



The radiofrequency environment analysis – step 2

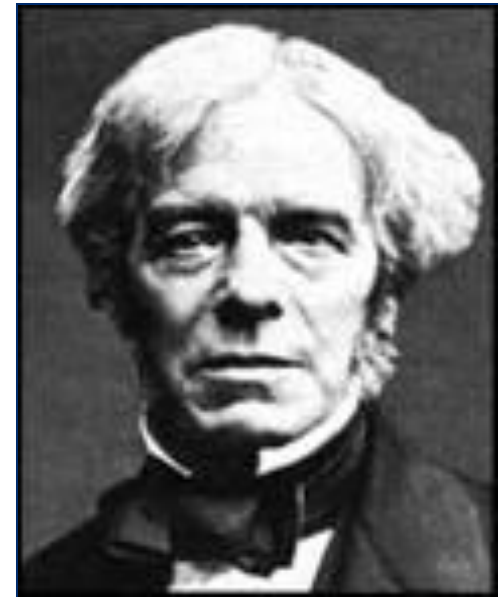
Identify sources of interference and collect data with the help of a spectrum analyzer over a full operational business cycle (typically minimum 24 to 48 hours).

Called *full Faraday cycle analysis (FFCA)*

Will tell what frequencies cause most problems when operating RFID system in facility.

When device that might create electro-magnetic noise is identified:

- 1) Turn on device
- 2) Measure and record results in planned interrogation zone nearby.



The radiofrequency environment analysis – step 3

Protect your EPC / RFID System from the interferences and noise.

To eliminate or minimize the effects of interference, you can consider implementing the following solutions:



Remove source of interference, if possible. E.g. may be possible to ensure forklift causing interference does not operate in interrogation zone.



Shield source of interference or your RFID system next to this source



Use filters, which permit only selected frequencies to pass through a connected device by rejecting all other frequencies.

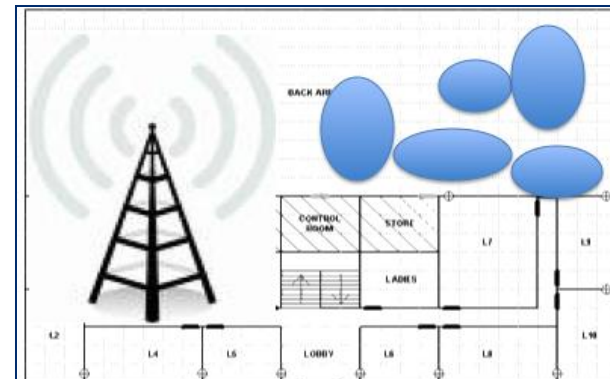
The radiofrequency environment analysis – step 4

Metals, liquids and obstacles affect radiofrequency signal: measure radio-frequency coverage area for reader antenna at different spots of planned interrogation zones.

For each spot:

- Set up antenna
- Use spectrum analyzer for measuring strength of signal emitted by antenna
- Measure in different directions
- Mark down for each direction at which distance from antenna signal becomes too weak to be useful.

Signal coverage area decreases around spots near obstructions, (e.g.) metallic equipment!



The radiofrequency environment analysis – step 5

Perform a path loss contour analysis (PLCA) to map how field strength and shape of radio-frequency coverage in interrogation zone varies in zone.

- Shows how radio-frequency signals are degraded and distorted and how shape of coverage changes throughout interrogation zone.
- Helps determining location of antenna in interrogation zone, alignment of antenna and optimal emitted power.

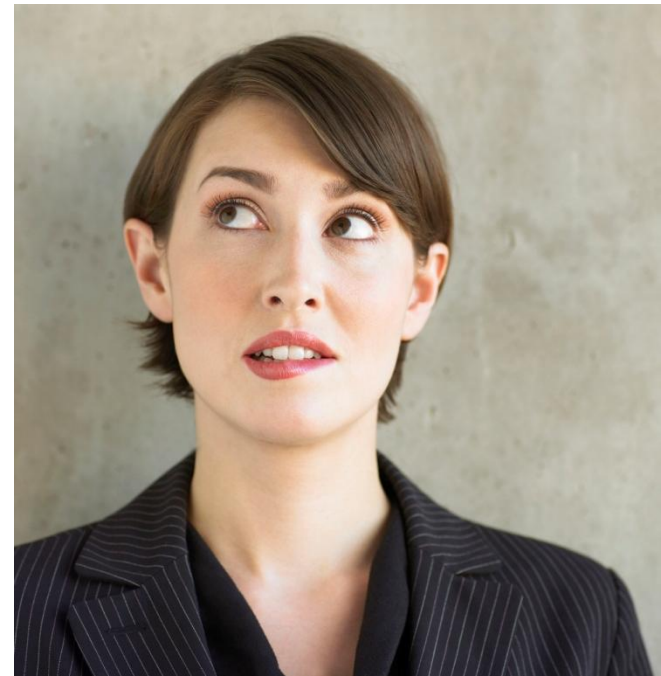


3.4 Documenting your results

What should I document?

*Report findings on blueprints or some other documents:
Very useful during installation and deployment of EPC / RFID system*

- Sources of interferences
- Coverage Areas
- Potential Barriers



3.5 Summary

Summary

In this chapter, you have learned that the purpose of site analysis is to determine how the proposed RFID system will fit into the existing site infrastructure.

You understood that a site analysis has 3 phases that are:

- Preparing the equipment and the blueprints
- Performing a physical and a radiofrequency environmental analysis.
- Document your results

Finally, you have also learned in more details how to perform the radiofrequency environmental analysis using a spectrum analyzer

Chapter 4 –

**Installation of the EPC/RFID
system**

What is in this chapter?

In this chapter, you will understand how you can successfully install your EPC / RFID system.

You will discover the 3 steps of the installation process that are:

- Preparing the installation
- Installing and configuring the hardware
- Setting up the portals
- Integrating the infrastructure with the application

Finally, you will learn how to ensure safety for your EPC / RFID system and for the personnel in the area

4.1 Preparing the installation

Which documentation is needed?

During the selection of the EPC/RFID system design, you have understood the various RFID solutions available in the context of your application requirements.

Equipped with that understanding, you have performed the site analysis and determined how the RFID system will fit into the existing site infrastructure.

You will now use the information collected and documented during the system design and the site analysis to get your RFID components from your vendors and install the system.

But first you need power for your system, don't you?

Where can I find power?

Readers and tags need power for their operation:

Get needed power sources and cabling from your vendors

Passive tags get power from RF signal emitted by reader

Active tags have own power source (typically battery)

Lifetime or operating temperature defined by application.



Where can I find power?

Readers can use various power sources, including:



**Power Supply Units
(PSUs)**



**Uninterrupted
Power Supply
(UPS)**



**Power over Ethernet
(POE)**

Getting a solution from the vendors

We have seen in chapter 2 the main criteria for selecting your components and your vendors.

Based on your system design and site analysis documentation, you will now ask your vendors for a solution that would meet your application requirements.

The vendor's solution generally combine the components of your EPC / RFID system and support from the vendor for installing these components.



Which solution should I choose?

First ensure:



- Compatibility,
- Consistency with operating frequency
- Withstanding operating conditions



- Correct type
- Appropriate maximum power radiated and coverage area



- Read tags efficiently for all different products to be tagged

Proposed solution can be easily integrated with existing network and application and can be easily maintained

4.2 Installing the hardware

How should I install the hardware?

Typical process for installing core hardware for EPC / RFID system:



1 Test Components

This step shows various hardware components including a forklift-mounted reader, a laptop, a printer, and a handheld reader, indicating the initial testing phase.



2 Mount Antenna

This step shows an antenna being mounted on a stand, illustrating the physical installation of the antenna hardware.



3 Mount Reader

This step shows a handheld reader being mounted on a stand, illustrating the physical installation of the reader hardware.



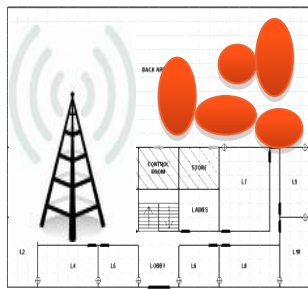
4 Install Cables

This step shows a network cable with a BNC connector and a bundle of Ethernet cables, illustrating the installation of the network infrastructure.



5 Turn on Reader

This step shows a handheld reader, indicating the final step of turning on the hardware.



6 Test the interrogation zone.

This step shows a floor plan diagram with a radio tower and signal waves, illustrating the testing of the interrogation zone. The diagram includes labels for 'BACK HALL', 'CONTROL ROOM', 'STORE', 'LABS', 'L1', 'L2', 'L3', 'L4', 'L5', 'L6', 'L7', 'L8', 'L9', 'L10', and 'L11'.

Testing the components



You need to validate that a particular component of a system (software, hardware, or both) is functioning properly with the promised performance before installing it.

For example, you should test that a reader meets the performance specifications, such as read range and multiple tag read rate, as specified by the vendor.

Mounting the antenna



Somewhere in or near interrogation

maximizing propagation pattern.



Map from path loss contour analysis (PLCA) helps:

- Determining exact location of antenna in given interrogation zone
- Configuring and fine-tuning the antenna.

Consider protection from damage:

- Attach using drills and screws,
- Use a rack holding antenna, reader, power supply (UPS), and cables.
- Racks are good to protect your system from harsh environmental conditions such as dust, humidity, and moisture.





3 Mount Reader

Mounting the reader

Mount reader in rack or some surface or edge (e.g. wall or gantry placed around conveyor).

Consider the following factors when mounting the reader:

Leave space around reader:

- for cables
- to keep air flowing (reader stays cool)

Avoid:

- placing readers close to each other (minimize reader collisions)
- placing readers close to sources of interferences
- spots of harsh environmental conditions

Choose spot in which reader is safe from accidental physical damage



Installing the cables

You will need cables for various purposes such as:

- Connecting the antenna to the reader port
- Powering your components
- Enabling your data transfer, for example from the reader to the host computer

When installing cables you should:

- Use the correct standard cable for a given connection
- Keep the cables away from sources of electromagnetic waves such as motors and electronic
- Use labels to identify the cables and keep a cable layout to avoid confusion and to have easy access for maintenance.
- Use protective caps to cover the exposed parts of the cables, such as cuts.



Turning the Reader on

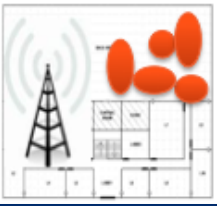
Turn the reader on:

This defines interrogation zone

(area around the reader within which the reader can successfully communicate with a tag).



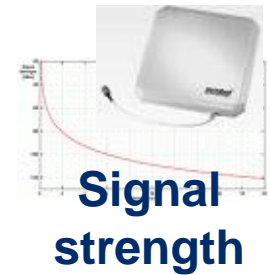
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Testing the interrogation zone

To test the interrogation zone, you will:

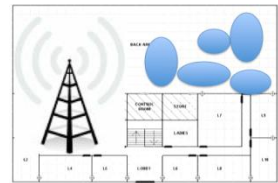
- Determine the boundaries of the coverage area (interrogation zone) by measuring signal strength at various points around antenna
- Use spectrum analyzer to verify map of the path loss contour analysis (PLCA) determined during the site analysis
- Use the map of the PLCA to fine-tune and configure the RFID system.



Signal strength



Spectrum Analyzer



PLCA

Configuring the interrogation zone

Take into account the following aspects:

- Read rates required by tag traffic
- Power required by reader and tags
- Distance required/available between interrogator and tags

Configuring the interrogation zone involves configuring the reader's commands and settings and adjusting the power of the reader to an optimal value



Configuring the reader's commands

Commands usually issued on host computer
(Either by application or using Graphical User Interface/GUI).

Common reader's commands are:

- **QUERY** initiate the communication with tag
- **READ** get the data on tag
- **WRITE** write data on tag
- **LOCK/UNLOCK** prevent or allow writing data on tag
- **KILL** disable tag permanently

Additional commands such as

SELECT, INVENTORY or ACCESS

can also be available to help you
isolate group of tags or
isolate tags from a group.



Configuring the reader's settings

Settings and features allow to:

- Adjust power output of reader.
- Set operating frequency for reader
- Select RFID protocol used by reader (e.g. anti-collision protocol)
- Set if reader will communicate in duplex or half duplex mode
- Be notified when certain events occur.
E.g. if number of tags in interrogation zone exceeds a threshold
- Filter which kind of tags to read and which to ignore
- Define computers allowed to communicate with reader and users allowed to use it.



Optimising the interrogation zone

Consider the following:

- Network has limited bandwidth and reader's read cycles consume this bandwidth:

monitor your network traffic

- ***Adjust the power output for reader:*** attain required read range while avoiding zone overlaps and staying in limits set by safety regulations.

- If tags are in motion:

balance tag speed with reader's read speed



Monitor Traffic



Adjust Power Output



Match Speed

4.3 Setting up the portals

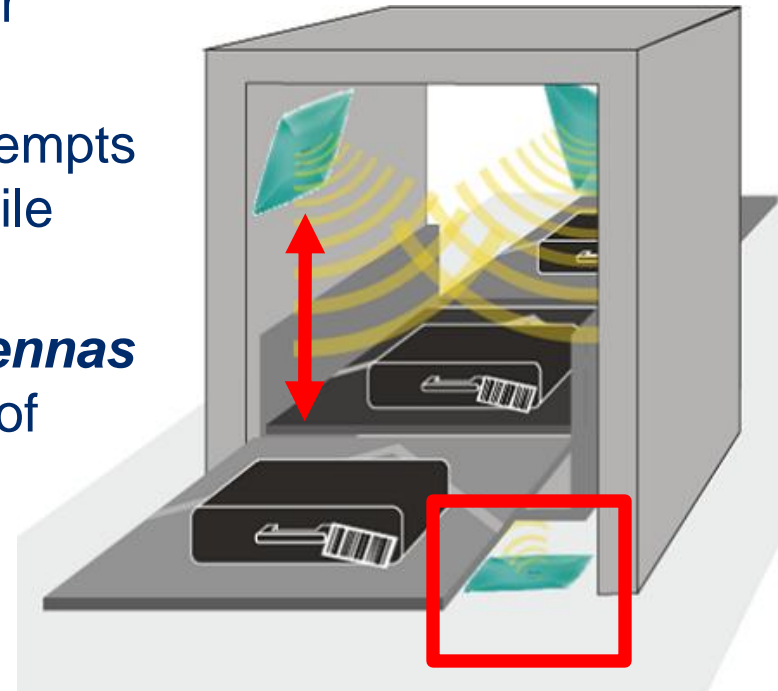
Setting up a conveyer portal

Keep in mind:

- **Keep antennas +/- 45 cm (1.5 ft) away from conveyor edges.**

This avoids signal reflection by metal and other adverse effects

- **One of the 4 antennas** to be designed for optimal operations **under conveyor**.
- Reader must be able to make multiple attempts to read tag: **mind speed of conveyor** while configuring reader
- **Polarization & alignment of reader antennas** to be compatible with random orientation of tags.



Setting up a dock door portal

UHF systems provide required read range for dock door portals.

When setting up a dock door portal, make sure:

- To keep the cables out of harm's way.
- Antennas are protected against accidental damage.
- # of antennas is large enough to cover width and expected height at which tagged items will be passing
- Not to have too many antennas: creates dense interrogator environment problem
- Most dock doors have 2 or 4 antennas on each side of door
- Antennas from the 2 sides of door are not directly pointing at each other: could cause interferences.



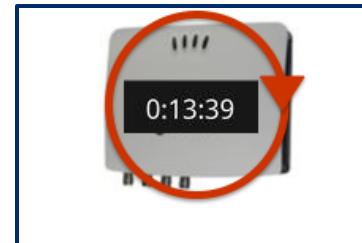
Setting up shelf portal

HF systems are generally used for shelf portals:

- sufficient read range
- relatively less affected by metals and liquid content

When setting up a shelf portal:

- Reader antennas to be properly placed, configured & oriented to avoid interference between neighboring antennas.
- You can create multi-shelved portal with 1 antenna per shelf using a multi-antenna reader. Configure reader to use antennas for reads in some sequential order.
- If change in # of items on shelf needs to be detected: readers to be configured to either continuously keep reading tags or have read cycles at preset intervals.

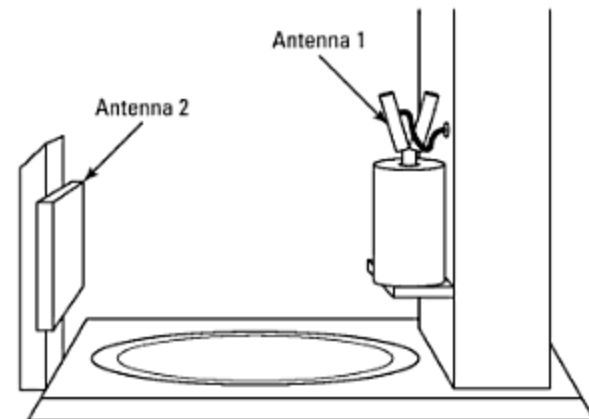


Setting up a stretch wrap station portal

Stretch wrap station portals have generally 2 antennas, one on the arm that moves with the roll of stretch wrap and the other one just next to the stretch wrap machine.

When setting up a stretch wrap station portal:

- Protect the cabling of the first antenna taking into account the arm movement that is give extra length to the cable so that it can follow the arm up and down
- Make sure the second antenna is not in the way of the forklift that will drop and pick up the pallet



Setting up a forklift portal

When setting up a forklift portal:

- Mount reader on either interior or exterior of vehicle.
- If exterior mounted: consider adequate clearance from external objects such as doorways.
- Reader to be protected against mechanical shocks and vibrations.
- Mobile RFID system will most probably be using wireless network for transferring data to central location:
possibility of interference with other electromagnetic devices should be considered.



4.4 Integrating the infrastructure with the application

Why is it important?

Tag and readers are only able to capture RFID data.

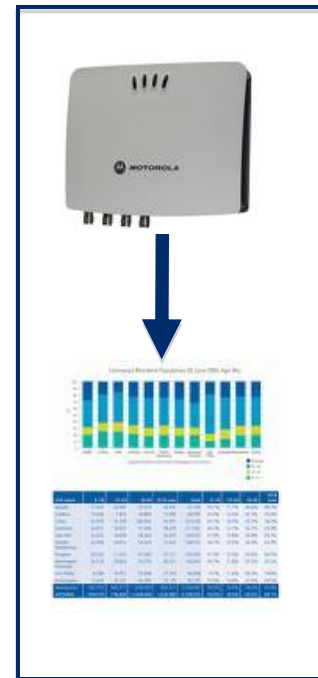
To uncover operational benefits of EPC / RFID

(e.g. reducing out-of-stocks or better visibility along supply chain) :

- incoming RFID data to be processed
- incoming RFID data intelligently to be integrated into business application.

Software is needed to route EPC / RFID data between readers and enterprise systems (“RFID middleware”):

- Ensures RFID data is valuable (e.g.by eliminating duplicate reads and filtering)
- Enables readers speaking different languages
- Passes RFID data in correct format to various applications (e.g. Warehouse Management System requiring the data)



What should the middleware do?

Middleware should include 7 core capabilities:



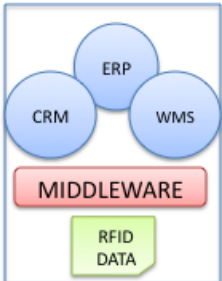
1) *Reader and device management*

Allows users to configure, deploy & issue commands to readers through common interface.



2) *Data management*

Ensures captured data is intelligently filtered & routed to appropriate destinations



3) *Application integration*

You need messaging, routing & connectivity features to reliably integrate RFID data into existing systems (e.g. ERP, WMS or CRM)



4) *Partner integration*

You need B2B integration features (e.g. partner profile management & communication protocols) to efficiently integrate with partner's data over EDI or web-based systems

What should the middleware do?



5) *Process management*

Allows orchestrating RFID related end-to-end processes.
E.g. link receiving process to inventory & POS process
so system automatically reorders more products without human intervention when inventory is too low



6) *Packaged RFID content*

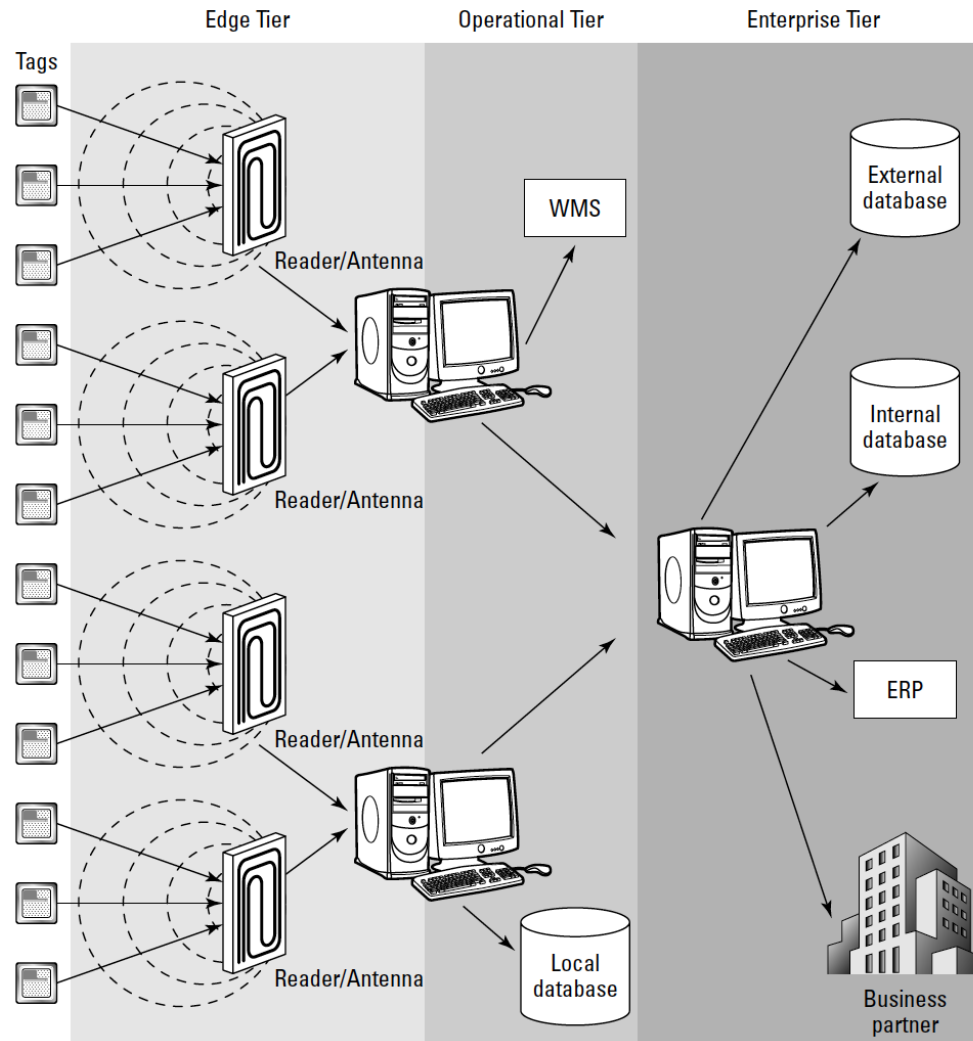
You don't have to start developing RFID applications
(e.g. shipping or asset tracking) from scratch .



7) *Architecture scalability*

Allows system to balance processing load across multiple servers
& reroute data automatically if a server fails.

Where should the middleware go?



Source: Forrester Research, Inc.

4.5 Ensuring safety

Ensuring safety is a requirement

Ensuring safety for EPC / RFID system & personnel working in zones where system is installed is mandatory step of the installation process



We have already learned that racks or similar protections can be used for protecting components of your system from shocks or harsh conditions.



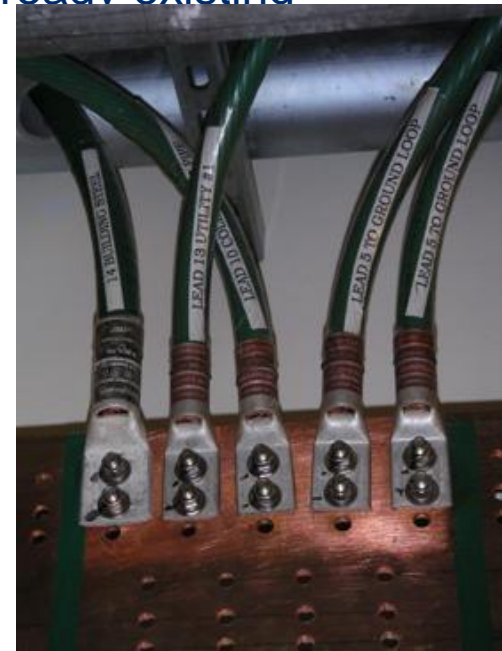
You also have to protect your system and the personnel operating it from electrostatic discharges by installing for example wrist straps or floor mats

Grounding and ground loops

System Components must be ***grounded***:

- ***To prevent electric shock or fires*** caused by voltage difference between earth and conducting metal.
- ***To protect personnel & equipment*** from lightning strikes.
- ***To reduce noise & interference*** coming from computers & readers ensuring system has minimal impact on already existing radiofrequency systems.

Protect your system and personnel from ***ground loops*** by ensuring that the conductor used for grounding is short enough and that all the readers are connected to the same grounding system.



4.6 Summary

Summary

In this chapter, you have learned that the implementation of an EPC / RFID system is a process that starts with the documentation collected during the system design and the site analysis.

You have learned how to install your hardware components such as antennas, readers and portals and how to integrate this infrastructure with your application by using the middleware.

Finally, you have been reminded that you must safely protect your system's components as well as the personnel operating close to your system

Chapter 5 –

The monitoring & troubleshooting of the system

What is in this chapter?

Now that you have designed and installed your RFID system, you have to expect to encounter problems such as reader failure, tag failure or network connectivity problems.

Therefore you need to monitor and troubleshoot your system and this chapter will explain you how to do it successfully.

You will learn that monitoring your RFID system involves status monitoring and performance monitoring

You will also learn that you will need to troubleshoot the system for finding the causes for the problems identified during the monitoring and fix these problems.

5.1 What is monitoring?

Status monitoring

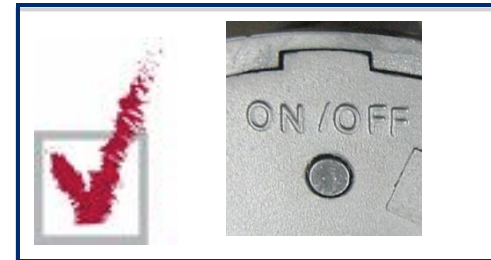
Monitoring of basic status of system and devices within it, e.g.:

- Is the device connected to the network?
- Are the devices powered?
- Are the antennas operating?
- Is a reader reading the tags successfully?

Please note

Some solutions include status indicator panel on your desktop allowing to monitor status of all readers from one location.

Feedback systems (e.g. light tree and horns) discussed in Chapter 2, can also play an important role in status monitoring.



Performance monitoring

Monitoring performance of a system and the devices within it, e.g.:

- Read rates of readers



- Reading accuracy



- Error frequency



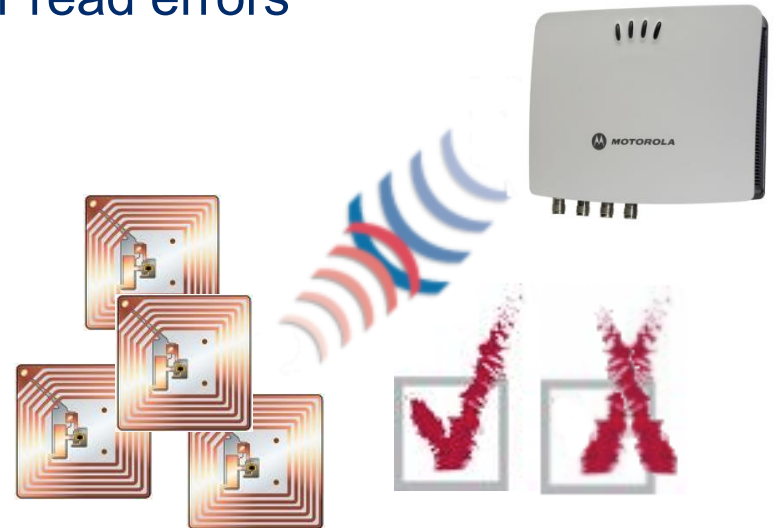
Performance data on predetermined metrics (e.g. read rates) helps determine normal behavior of the system & identify the variance in normal behavior and hence a problem.

5.2 Monitoring the interrogation zones

What should I look for?

The Interrogation Zone has several parameters characterizing it:

- Number of tags passing through the zone
- Number of tags being successfully read
- Number of tag that can't be read or read errors
- Reader failure



Mean Time Between Failure

MTBF:

Average time between two consecutive failures of a device or a system.

- Indicates robustness of system measured in the past & predicts rate of failure in near future.
- Calculated as:
$$\frac{\text{total lifetime of the device}}{\text{total number of failures recorded}}$$

Example:

- 20 readers on system
- In 10 day period: 6 readers fail once
1 reader fails twice
- 20 readers x 10 days = 200 reader days of operation
- MBTF:
$$\frac{200 \text{ days}}{6+2 \text{ failures}} = 25 \text{ days/failure}$$

Average tag traffic volume (ATTV)

Average number of tags passing through an interrogation zone during an interval of time (e.g. minute or hour).

- Monitoring system collects tag counts and time at which tag was counted from readers.
- Example:

Time interval = 1 hour

During the last 4 hours, 10, 20, 30 and 40 tags respectively were detected.

$$\text{ATTV is : } \frac{10+20+30+40 \text{ tags}}{4 \text{ hours}} = \frac{100 \text{ tags}}{4 \text{ hours}} = 25 \text{ tags/hour}$$

From the ATTV measurements, you can predict how much traffic is expected to pass through an interrogation zone during a certain period.



Actual Versus Predicted Traffic Rate (APTR)

Variance of actual tag traffic from predicted tag traffic through interrogation zone over a time period.

A significant variance could indicate a problem with the system.

APTR = **Current Average Tag Traffic Volume (ATTV) - predicted ATTV**

Example:

Current ATTV: 25 tags/hour for the past 4 hours.

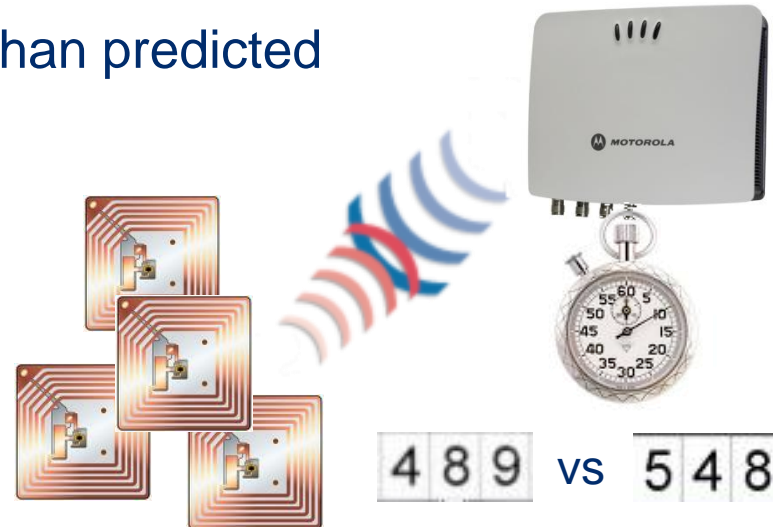
Predicted ATTV: 15 tags/hour

Variance : 10 tags/hour more than predicted

$$\text{APTR:} \quad \frac{25}{15} = 166\%$$

Compare actual value to predicted value for the **same time interval & period of day**

(e.g. from 2.00 to 6.00 pm) as tag traffic can be different at different hours of the day.



Read Error to Total Read Rates (RETR)

Read errors to total reads rate (RETR) is the total number of read errors divided by the total number of read attempts.

Example:

450 tags read successfully

50 tags couldn't be read

$$\text{RETR: } \frac{50}{50+450} = \frac{50}{500} = 10 \%$$

I.e. You have a problem with 1 tag every 10 tags.

High RETR value is alarm for problem with RFID system:

- **internal problem:**
faulty antenna or low signal strength
- **adverse environmental effects:**
absorption and/or interference.



Read Error to Total Read Rates (RETR)

High RETR value is alarm for problem with RFID system:

- ***internal problem:***

faulty antenna or low signal strength

- ***adverse environmental effects:***

absorption and/or interference.



5.3 Monitoring the tags

Why is it important?

Process of manufacturing tags & application to items has significantly matured, still tag failures do occur.

- Monitoring tags is important task for RFID professional.
- Ensure tags are properly placed on items.
- Know the reasons why tags can fail and how to manage these failures.
- Tags are placed on items to be tracked **before** the items get out into the world.

The first step in monitoring tags is to identify improperly tagged items.



Identifying improperly tagged items

There are four kinds of improperly tagged items:

- Items tagged with ***faulty*** tags.
- Items on which tags are placed ***incorrectly*** (where they cannot be read properly by the reader).
- Items on which tags are placed at ***correct spot*** but they are ***applied incorrectly***, (e.g. bent or folded).
- Items on which tags are ***not properly oriented*** when correct orientation is required for efficient reading.



Identifying improperly tagged items

Methods for identifying improperly tagged items:

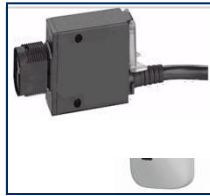
- ***Inventory discrepancies***

Tags on the items were not properly read; hence the items were not counted.



- ***Feedback devices, (photo eyes, motion sensors, ...)***

Provide presence information of item + instruct reader to read it. If reader cannot see it, it could be an improperly tagged item.



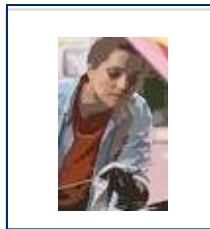
- ***Placing interrogation portal right after application point***

If the tag cannot be read, it might be defective or improperly placed.



- ***Manual inspection,***

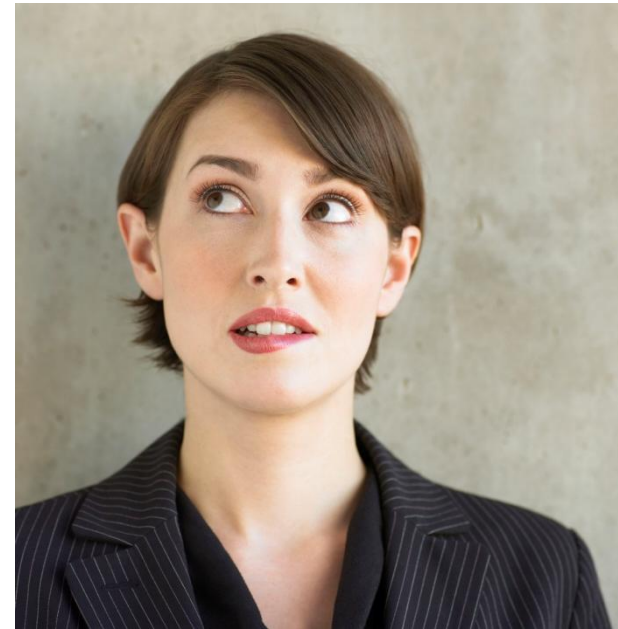
Perhaps before shipping.



Identifying Reasons for Tag Failures

Main reasons for tag failures:

- ***Defects introduced during manufacturing.***
Can sometimes be detected by device itself
Smart label printer identifies which tags it printed incorrectly
- ***Wrong tag type*** was applied for a given application.
- ***Electrostatic discharge*** has damaged the transistors in the tag's integrated circuit
- Tag has suffered from ***harsh environmental conditions***
- The tag is ***misplaced***
- There is a ***dense tag environment*** and tags are ***shadowing*** each other.



5.4 Troubleshooting

Identifying the problem

Now that you have identified the problem, it is time to solve it by using standard troubleshooting procedure.

The first step is to clearly identify and define the problem.

You should do so by documenting the symptoms and by identifying the affected area

If you have identified and defined the problem, in most cases you should be able to reproduce it.



Identifying the causes of the problem

Once problem has been identified and defined, find what is causing the problem.

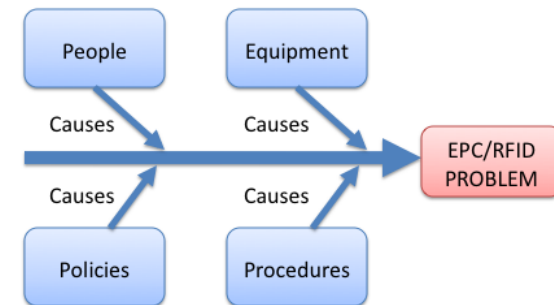
Root Cause Analysis method

Problems are best solved by attempting to correct or eliminate root causes, (vs addressing immediately obvious symptoms)

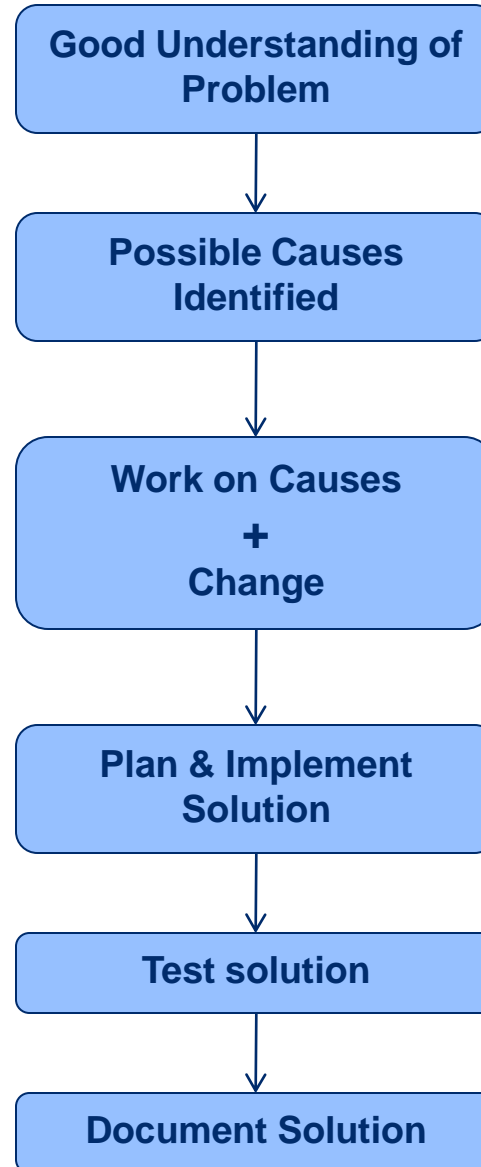
Ask what has changed since last time system was working fine.

Use *method of elimination* to narrow down and isolate the real cause.

- Eliminate relatively obvious causes/problems
- Make your way to more complex causes or problems.



Solving the problem



5.5 Summary

Summary

In this chapter, you have learned that the monitoring and troubleshooting are essential parts of running an effective RFID system.

You understood that status monitoring consists of monitoring the status of a system and its devices while performance monitoring consists of measuring the performance metrics of the system or device.

Significant variation in the values of some of these performance metrics can indicate instability of or problems with the system that you will need to troubleshoot.

The standard troubleshooting procedure is identify the problem, identify the cause, implement the solution, test the solution, and document the solution.