# A Realistic Look at Radio Frequency Identification (RFID)

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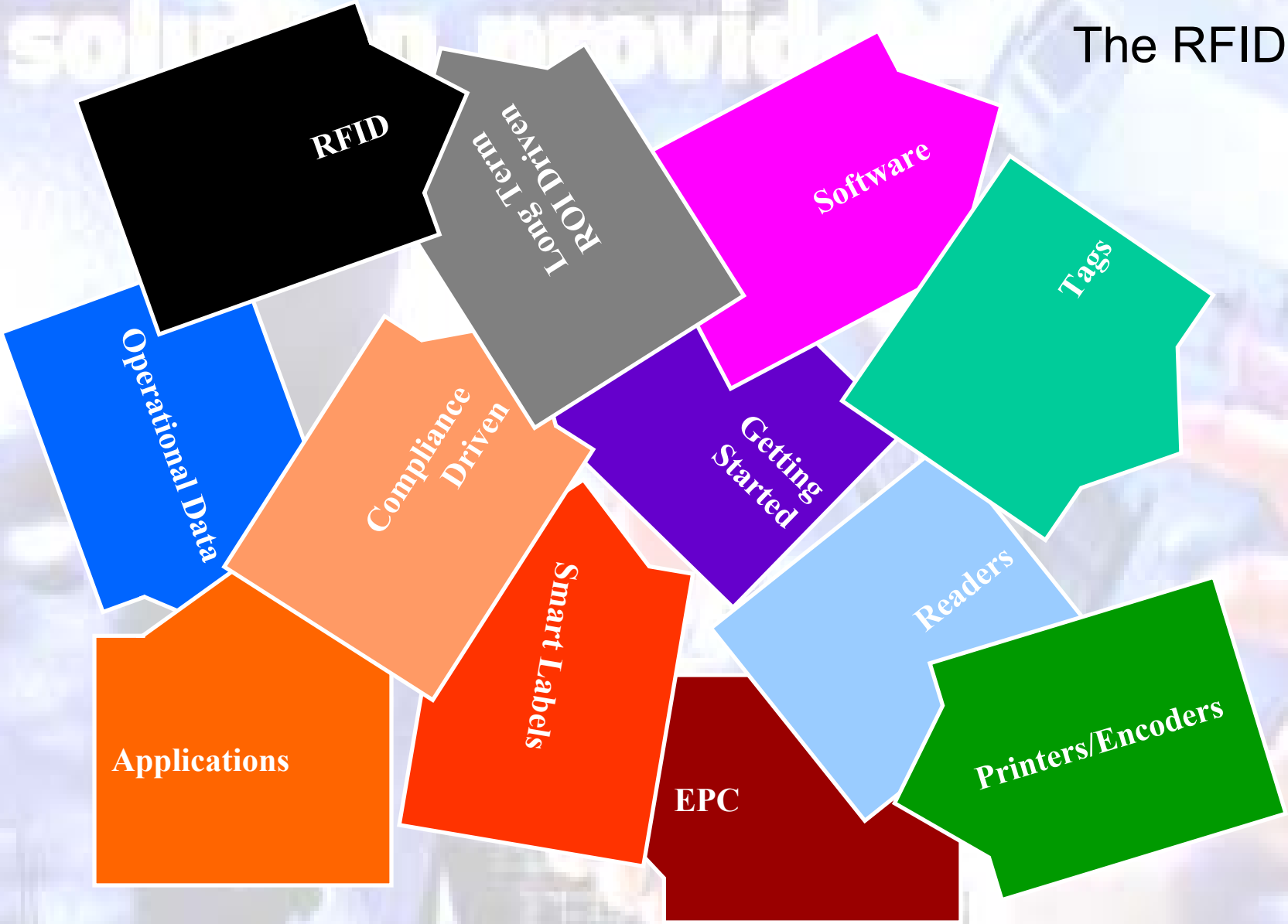
**Is Radio Frequency Identification (RFID)**

**Rocket Science?**
**A Black Art?**
**or just the next logical form of automatic data capture?**

**It depends on who you talk to!**

**Don't let RFID become a difficult puzzle to solve**
**let Newbury Data solve the RFID puzzle with you**

# The RFID Puzzle



# RFID

**A typical RFID system consists of four main components:**

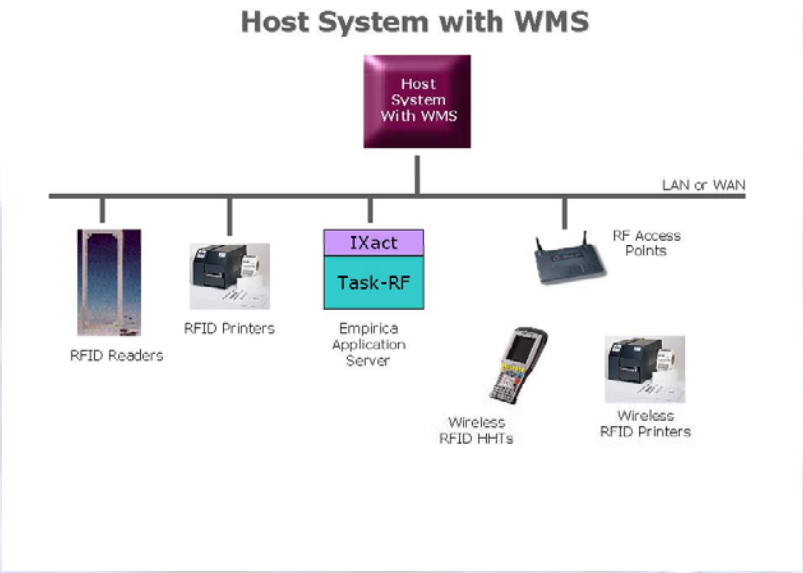
- **tags**
- **an encoder**
- **readers**
- **host computer**

## Use RFID to change the rules in your own supply chain and business

**RFID Overview**

- **The RFID Tag is made up of a microchip and a flexible antenna encased in plastic-coated inlay**
- **the encoder is used to write information to the tag**
- **the most common format is a shipping label with a built in tag, called a "Smart Label"**
- **Smart Labels can be printed and placed on each case or pallet**
- **to get an RFID tag to "talk back" a reader broadcasts radio waves**
- **if within range of the reader, that tag answers, identifying itself, and its data**
- **Tags can be read from a distance without physical contact or line of sight**
- **the distance within the which the reader can communicate with a tag is called the read range**
- **communication between readers and tags are governed by air protocols (and emerging standards such as EPC Gen 2)**

# RFID

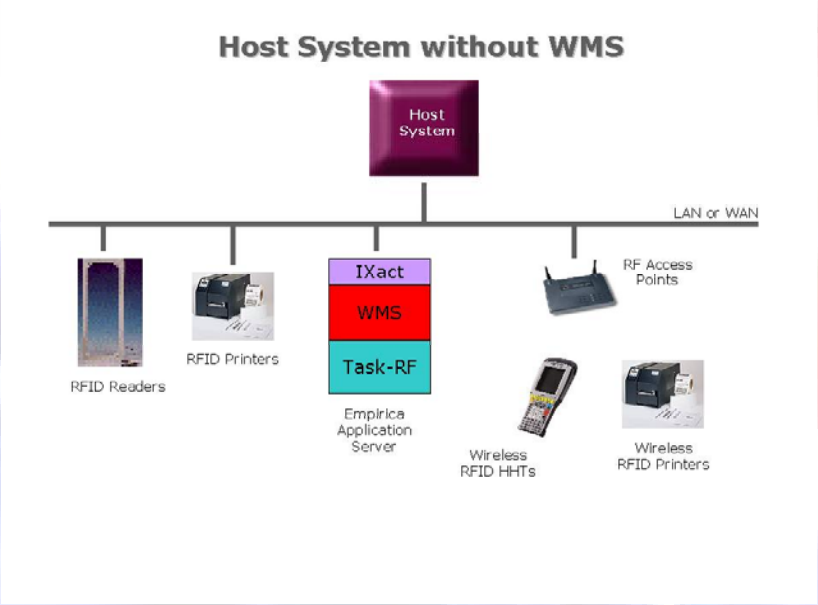



## Basic Summary: Printing RFID Labels

**Printing RFID Labels**

- RFID label print and encode data streams from the host application are sent to the RFID printer(s).
- The RFID printer(s) may be connected directly to the local network or may be RF enabled.
- The RFID printer encodes the smart label chip.
- The RFID printer attempts to read and validate the encoded chip.
- If the validation is successful, the printer will print the human readable and barcode data, if the chip is not validated the printer will void the chip and overstrike the label, preventing its use in the supply chain.
- A correctly validated RFID label is applied to the product or handling media (e.g parcel, case, pallet, roll cage, tote box etc …)

# RFID




## Basic Summary: Reading RFID Labels

**Reading and Writing To RFID Labels**

- RFID readers connected to the network and fixed in position at a number of key locations are used to read and write data to RFID labels.
- In addition, wireless hand held or truck mounted terminals with RFID label-scanning capability can be used to scan RFID labels at any point where there is RF coverage.
- Every time a RFID label is read or data written to it, the host application is updated in real time.
- Empirica Task-RF can be used to extend the functionality of the host application into the hands of the mobile worker operating wireless RFID reader


RFID

# 1. Business Improvement

**Long Term ROI Driven**

- Like the PC, Fax machine, the Internet and Bar Codes in their inception, RFID has the potential to transform the way we do business
- A recent study by IBM estimates that RFID could reduce labour involved in the receipt of goods by 60 to 90%
- RFID can help companies better track, automate the flow of and understand the position and condition of goods in the supply chain
- Ultimately this will lead to companies looking at implementing RFID for business improvement reasons, seeking gains in business efficiencies and a leading edge against competitors
- Freight, Distribution & Materials handling companies will be amongst the early adopters for implementing RFID for gains and efficiencies in moving cases and particularly pallets


RFID
Long Term
ROI Driven

# 1. Compliance Driven

Compliance Driven

**For companies that supply the retail supply chain, the case for implementing RFID may appear straight forward**

**Meeting Compliance**

- **When a customer issues a mandate announcing the intentions to implement RFID and that all or many suppliers have to be comply**
- **The challenge is to Integrate RFID into your case and pallet supply chain with as little downtime and business interruption as possible**
- **The obvious path is to convert your existing bar code labelling stream into EPC Smart Label data streams**

**Risk of non-compliance**

- **You may lose the business from the customer who has issued an RFID mandate**

**Risk of meeting compliance**

- **If the customer who issues a mandate is a relatively small part of your business, the risk of non-compliance may be acceptable when compared to the cost of implementing RFID**

Compliance Driven

# 1. Compliance Driven

## RFID Mandates: Who's Asking and By When?

- WAL★MART: 1/05, 12/06
- Department of Defense: 1/05
- TARGET: Begin late spring '05, completed '07
- Albertsons: Begins 4/05, completed 4/06
- TESCO: Begin 4/04, completed '07
- METRO AG: 11/04, all suppliers by '07
- FDA: 2007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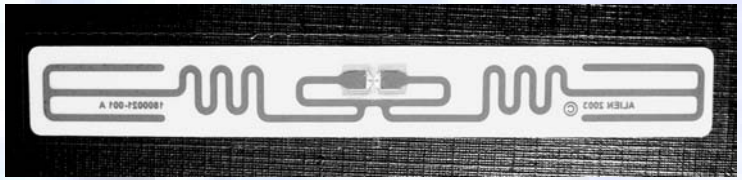
Compliance
Driven

Tags

# 1. RFID TAGS

## 2. TAG Types
## 3. TAG Frequencies
## 4. TAG Selection & Readability



- **The RFID Tag is made up of a microchip and a flexible antenna encased in plastic-coated inlay**
- **Tag design, tag placement, case orientation, and reader location all play a role in achieving consistent performance.**
- **Chips used in RFID tags may become the widely used commercial application of nano- technology**
- **Tag antennas can be made in a variety of configurations to achieve various performance characteristics.**
- **The antenna allows a tag to be read at a distance of up to 10 feet, 3 metres or more,**
- **Antenna size tends to determine the size of an RFID tag.**

- **The following contrasts writing to a tag from reading it**

| | Read | Write |
|---|---|---|
| Initial State of tag | Must have data written to it | Empty or pre-written |
| Process initiated by | Reader command | Reader command |
| Tag internal mechanism | Memory poll circuit | EEPROM circuit |
| Response rate | Hundreds per second | Single tag takes a hundred or so milliseconds |
| Addressing | One to many or one to one | One to one |
| Sequencing | All tags or listed individuals within read area | Serially and individually |
| Distance Sensitivity | Moderate within effective read range | Extremely sensitive to effective read range |
| Validation | Multiple reads | Read synchronised with physical isolation of the tag |
| Error Recovery | Read bar code portion of label | Print overstrike on label and encode next one |

# Tags

1. RFID TAGS
2. TAG Types
3. TAG Frequencies
4. TAG Selection & Readability

- One distinguishing characteristic is whether a tag is active or passive.

- Active RFID Tags broadcast under their own power. An on-board battery run's the microchip's circuitry and transmitter.

- Passive tags have no battery. Instead, they draw power from the reader. Electromagnetic waves transmitted from the reader induces a current in the tags' antenna. The tag uses this energy to talk back to the reader. The "talk back" is known as backscatter reflection.

- Chips in RF tags can be erasable and programmable (EEPROM) or write-one-read-many (WORM) or read only

| Tag Type | Advantages | Disadvantages | Application |
|---|---|---|---|
| Active | Greater read range, memory capacity, continuous signal | Batteries require maintenance. Larger size | Used with high value asset tracking |
| Semi-Active | Greater read range, longer battery life | Battery wear and 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. |
| Passive WORM | Suited for item identification, controllable at the packing source | Limited to a few re-writes, replacing existing data with new data | Case and pallet applications. |
| Passive Read Only | Simplest approach | Identification only, no tracking updates | Case and pallet applications. |

Tags

1. RFID TAGS
2. TAG Types
3. TAG Frequencies
4. TAG Selection & Readability

- The properties of radio waves are frequency dependant.

- At low frequencies, radio waves pass through obstacles well, but the power falls off sharply with distance from the source

- At high frequencies radio waves tend to travel in straight lines and bounce off obstacles. They diffract at corners, sharp edges, and openings.

- Radio waves are subject to interference from a variety of sources, from sun spots to other electrical equipment

| Band | Frequency | Read Range | Application/s |
|---|---|---|---|
| LF | 100-500 kHz | Up to 20 inches (50.8cm) | Access Control, Animal ID, Vehicle Key-locks |
| HF | 13.56 kHz | Up to 3 feet (1 metre) | Access Control, Smart Cards, Item Level Tagging, Libraries, Electronic Article Surveillance |
| UHF | 866-956 MHz | FCC allows over 20 feet (6 metres at 915 MHz. Range at 866 MHz is about 10% less than 916 MHz | Supply Chain Use, Baggage Handling, Toll Collection. Wal-Mart is accepting RFID Tags in this spectrum |
| Microwave | 2.45 GHz | 3 to 10 feet (1 to 3 metres) | Item Tracking, Toll Collections |

Tags

1. RFID TAGS
2. TAG Types
3. TAG Classes
4. TAG Selection & Readability

- Product packaging and supply supply Chain RFID tags must withstand/survive the crushing weight of a load, shipping wear, temperature extremes, and material handling equipment.
- Tag readability is also dependant on characteristics of the UHF spectrum.
- Here is a list ( in no special order ) of considerations when selecting a tag for supply chain use

Tags

1. RFID TAGS
2. TAG Types
3. TAG Classes
4. TAG Selection & Readability

| | |
|---|---|
| Placement | Read rate is affected by the orientation of the tag on the box or pallet relative to the reader |
| Size & Form Factor | Cases often have a specific place for a label, and some companies specify size and format |
| Read Speed | The amount of time the tag is within read range in the case of a tagged carton moving on a conveyor, or a tagged pallet on a truck moving through a dock door portal |
| Read Redundancy | The number of times a given tag can be read while in the reading area. If a tag can respond at least 3 times to read requests whilst it is in the reading area, chances are very good that its data will be captured without error |
| Data Requirements | Tags will contains different information depending on their use (item, case, pallet, returns etc) |
| RF Interference | Read rates will be affected by sources of RF noise, proximity of other tags, and the composition of packaging materials and surrounding surfaces |
| Harsh Environments | Steam, corrosive chemicals or extreme cold will affect the adhesive on tag if nothing else |
| Re-use | Re-use could include use on re-usable containers, or as a way to document returned goods |
| Cross Border Shipping Regulations | Tags may have different read range and sensitivity depending on their frequency range of operation, due to different global standards |
| Read Speed | The speed at which a tag will be expected to move through a reader array or portal |
| Collision avoidance | The number of tags that can be read at once in a given area |
| Readers | Available types that support the tag |
| Progressive Use | Perishable goods, for example, may benefit from a method of logging ambient temperature and expiration |
| Security | Some applications may warrant data encryption and other measures that may not be supported in all tag types |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Tags

Readers

# 1. Readers

2. Reader Commands
3. Reader Operating Modes
4. Reader Antennas
5. Reader Antenna Placement
6. Reader Interference


- RFID readers use backscatter reflection, similar to radar, to energise tags and read their response
- A reader uses its antenna to send digital information encoded in amplitude modulated (AM) waveform
- A receiver circuit on the tag is able to detect the modulated field, decode the information, and use its own antenna to send a weaker AM signal response
- Collision avoidance algorithms are used to allow tags to be sorted and individually selected
- The reader can tell some tags to wake up and others to go to sleep to suppress chatter
- Once a tag is selected, the reader is able to perform a number of operations such as reading the identification number, and writing to the tag
- The reader then proceeds through the list to gather information from all tags

Readers

# 1. Readers

2. Reader Commands
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- **Considerations for selecting the right reader**

| | |
|---|---|
| **Operation Frequency** | **Matched to tag requirements** |
| **Multi-protocol** | **A desirable characteristic if a variety of tags are to be read which may have different air interface protocols** |
| **Meets Local Regulations** | **Power output will be different in the USA and Europe. Frequency hopping is required in the USA and duty cycle in Europe** |
| **Networking Capability** | **Ability to network readers together, and communicate with host computers though common interfaces (cable, twisted pair or wireless), using RS-485, TCP/IP, Ethernet or 802.1.** |
| **Configurable and Upgradeable** | **Through network connection and firmware** |
| **Antenna** | **Adapts to various conditions using dynamic auto-tuning. Can accept multiple antennas for various applications** |
| **Control Interfaces** | **Digital input/output and control circuits for synchronisation with other components on an automated line** |

Readers

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- Current standards describe a number of commands that a reader uses to communicate with a tag. The command set is sure to change over time. Typical commands that a reader uses include:

| | |
|---|---|
| Scroll All | All tags reply by communicating an eight (8)-bit pre-amble, followed by the CRC (Cyclic Redundancy Check). The check sum calculation field in an EPC Class Tag, followed by their EPC (Electronic Product Code) |
| Scroll by ID | Tags matching a specific value reply by communicating an eight (8)-bit pre-amble, followed by the CRC (Cyclic Redundancy Check). The check sum calculation field in an EPC Class Tag, followed by their EPC (Electronic Product Code) |
| Ping | Tags matching a specific value reply by sending eight (8)-bits of the tag identifier. The difference between Ping & Scroll is that Ping tags do not reply with their EPC codes |
| Quiet | Tags matching a specific value enter a quite mode, where they no longer respond to or execute reader commands. This mode of operation is maintained until a proper Talk command is received and correctly interpreted or power has been removed from the tag for at least 1 second, and at most 10 seconds |
| Talk | Tags matching a specific value enter an active mode, where the respond to commands from the reader. This active mode of operation is the same mode that a tag powers up into. This mode of operation is maintained until a proper Quiet command is received and correctly interpreted or power has been removed from the tag for at least 1 second, and at most10 seconds |
| Kill | Tags matching the complete tag identifier, CRC and an eight (8)-bit Password are permanently deactivated and will no longer respond to or execute reader commands. This “self destruct” command renders the tag inactive forever. |

Readers

1. Readers
2. Reader Commands
3. **Reader Operating Modes**
4. Reader Antennas
5. Reader Antenna Placement
6. Reader Interference


- **For most applications, readers will operate in one of two ways, either autonomously or as directed/interactive devices, the air protocol is the same**

| | |
|---|---|
| Autonomous Mode | ➢ A reader can be set to continuously operate, collecting lists of tags in its memory<br>➢ Tag lists represent a dynamic picture of the current tag population in its read window<br>➢ The information available to the host would include the reader location, time read, the size of the tag list, and the ID's of the tags in the list |
| Directed/Interactive Mode | ➢ Readers in this mode will respond to commands from the network host<br>➢ The host can instruct the reader to gather a list of tags within its read window, or look for specific tags.<br>➢ In both cases the reader starts by gathering a list<br>➢ Once it completes the host command, the reader waits until it receives another |

# Readers

1. Readers
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- **Reader antennas are the most sensitive component of an RFID system**
- **Most reader antennas are housed in enclosures that are easy to mount, and tend to look like plain, shallow boxes**
- **Varying the reader antenna placement is usually the easiest adjustment to make when troubleshooting a system, and one of the trickiest things to do as well**
- **The reader antenna must be a placed in position where powering the tag and receiving data can be optimised**

Three characteristics of antennas contribute to tag readability

| | |
|---|---|
| Pattern or footprint | The three-dimensional energy field created by the antenna. This is also known as the reading area |
| Power and attenuation | The maximum power of a reader antenna is fixed in order to meet regulatory requirements. The signal can be decreased or attenuated, to limit the tag read window or aim it only at tags you want to read |
| Polarisation | The orientation of the transmitted electromagnetic field |

# Readers

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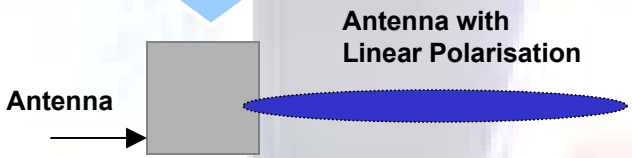


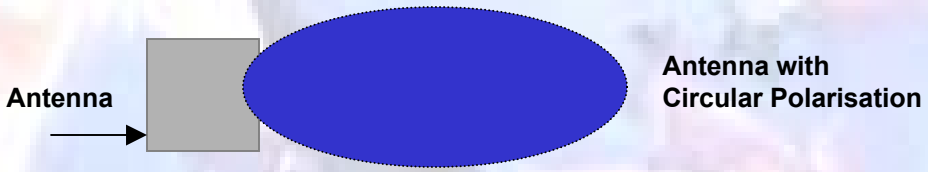


| Linear Polarised Reader Antennas | Circular Polarised Reader Antennas |
|---|---|
| ➢ RF Energy radiates from the antenna in a linear pattern | ➢ RF Energy radiates from the antenna in a circular pattern |
| ➢ The Wave has a single energy field | ➢ The two energy field components are equal in magnitude, 90 degrees out of phase and spatially oriented at 90 degrees from one another |
| ➢ Generally longer range than a circular polarised antenna when tag is optimally oriented | ➢ Designed to increase signal reception in presence of multi-path and high scattering |
| ➢ Can have a narrower beam pattern than a circularly polarised antenna | ➢ Offers more tag orientation insensitivity, slightly reduced from linearly polarised antenna |
| ➢ Best for applications with known tag orientation and location | |

Readers

1. Readers
2. Reader Commands
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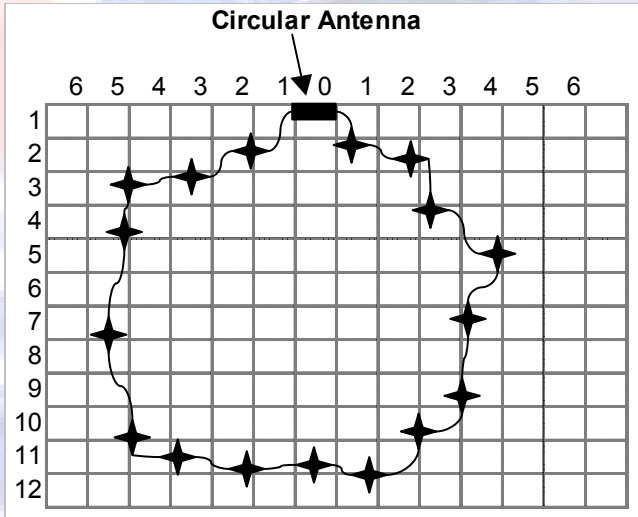
4. Reader Antennas
5. Reader Antenna Placement
6. Reader Interference

- Since power output of a reader is regulated and fixed, antenna design and placement is possibly the most important way to tune the RF signal to an environment
- A useful tool for antenna selection and placement is by mapping its radiation pattern within the operating environment
- This can be done by placing a known good tag at various points in the read area, and attempting to read the tag
- Marking out a grid pattern on a floor diagram, indicating where the tag does and does not read




Example of an antennas baseline pattern mapped out on grid paper or marked on the floor with chalk

Readers

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- Interference creates so-called “dead zones”
- Conveyor apparatus can induce dead zones through vibration or Electromagnetic (EM) discharge from motors or controllers
- Other RFID systems, wireless computers, radios and phones can all create interference

However, most are usually all filtered out through the reader/tag air protocol

•The following are characteristics unique to RF that affect read rates

# Readers

1. Readers
2. Reader Commands
3. Reader Operating Modes
4. Reader Antennas
5. Reader Antenna Placement
6. **Reader Interference**


| | |
|---|---|
| **Translucence** | ➢ Some materials offer little or no barrier to RF energy passing through them. Clothing made of organic and synthetic fibres, paper products, wood, non-conductive plastic and cardboard are translucent to RF. Paper packaging with foil lining, however, may block RF |
| **Absorption** | ➢ Liquids, materials containing liquids such as foods, and liquids and foods containing salts in particular, and Carbon containing compounds, such as graphite in solid or powder form, will all absorb UHF, weakening the electromagnetic field propagating from a reader antenna or back from the tag antenna |
| **Shielding** | ➢ Metals and very thin metal foils particularly can conduct a radio wave away from a target, not allowing it to pass through. Shielding material can behave like an induction coil, moving electrons in parallel with the induced current in a tag antenna. |
| **Detuning** | ➢ Tag antennas, are greatly affected by their immediate surroundings. A tag attached to a case of soda is going to be affected more by its location (top, side or bottom of case etc) than anything else<br>➢ Tags that are placed to close together can capacitively couple to one another, detuning their antennas |
| **Reflection** | ➢ At UHF frequencies, signal reflection is possibly the most fundamental problem for RFID. Because of reflections, a reader may not penetrate a shrink-wrapped pallet.<br>➢ Reflections are due to the surface of the material having a different dielectric constant from that of the surrounding air |
| **RFID Interference** | ➢ A reader signal can interfere with itself because of multiple reflections from surfaces as a signal goes through a narrow opening to reach a tag, or a signal that bounces off a metal object and reaches a tag nearly simultaneously |


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Tags
Readers

Printers/Encoders

# 1. Printer/Encoders

**2. Desktop RFID Printer**

**3. Print & Apply RFID Printer**

- **Passive WORM & EEPROM tags have no data in them. They require an encoding step to prepare them for use**
- **Encoding can be achieved by a reader built into an RFID printer, or any reader that is set up for the task**
- **Writing to a tag is more like printing a bar code than like reading a tag even though both are done by an RFID reader**
- **Smart Label printers make an ideal platform for tag encoding tasks**
- **Isolating the right tag from others around it is very important, to prevent programming the wrong tag.**
- **In the case of the RFID printer, tags are encapsulated in a roll of smart labels, and are a known distance apart from and another**
- **Tag isolation is achieved by the design, positioning and tuning of the reader antenna within the printer**
- **Closed loop data validation and error-recovery mechanisms are also built into an RFID printer, making it instrumental to on-demand tag programming applications.**

## Printers/Encoders

1. Printer/Encoders
2. **Desktop RFID Printer**
3. Print & Apply RFID Printer

- **As the adoption of RFID technology accelerates so must the need for Smart Label printing solutions**
- **Smart Label printers enable encoding and printing of various label sizes**
- **Smart Label Printer Specifications**

| Specification | Description |
|---|---|
| RFID Protocols | ➢ Multi-protocol (Class 0,0+,1) & EPC UHF |
| Print Speed | ➢ Up to 10 inches per second @203 dpi, up to 8 inches per second @ 300 dpi |
| Printing Method | ➢ Direct Thermal & Thermal Transfer |
| Resolution | ➢ 203 and 300 dpi |
| RFID Inlay Labels | ➢ Alien 'squiggle' Class 1: 4 x 2, 4 x 4, 4 x 6, 4 x 8 inches<br>➢ Alien 'm-tag' Class 1: 4 x 4, 4 x 6, 4 x 8 inches<br>➢ Rafsec #313 'psychedelic' Class 1: 3 x 3 inches<br>➢ Matrics 'dual dipole' Class 0, 0+: 3 x 3 inches via software upgrade |
| Encoding Operating Modes | ➢ Write/Verify/Print – writes RFID data to tag and verifies contents are written correctly, while also printing desired image |
| Error Handling Modes | ➢ Overstrike – when a bad RFID tag is detected, overstrikes label and applies the data to the next label<br>➢ Stop – when a bad tag is detected, stops the printer to allow for user intervention |
| Statistics Tracking | ➢ Tracks number of tags written to and number of bad tags detected |

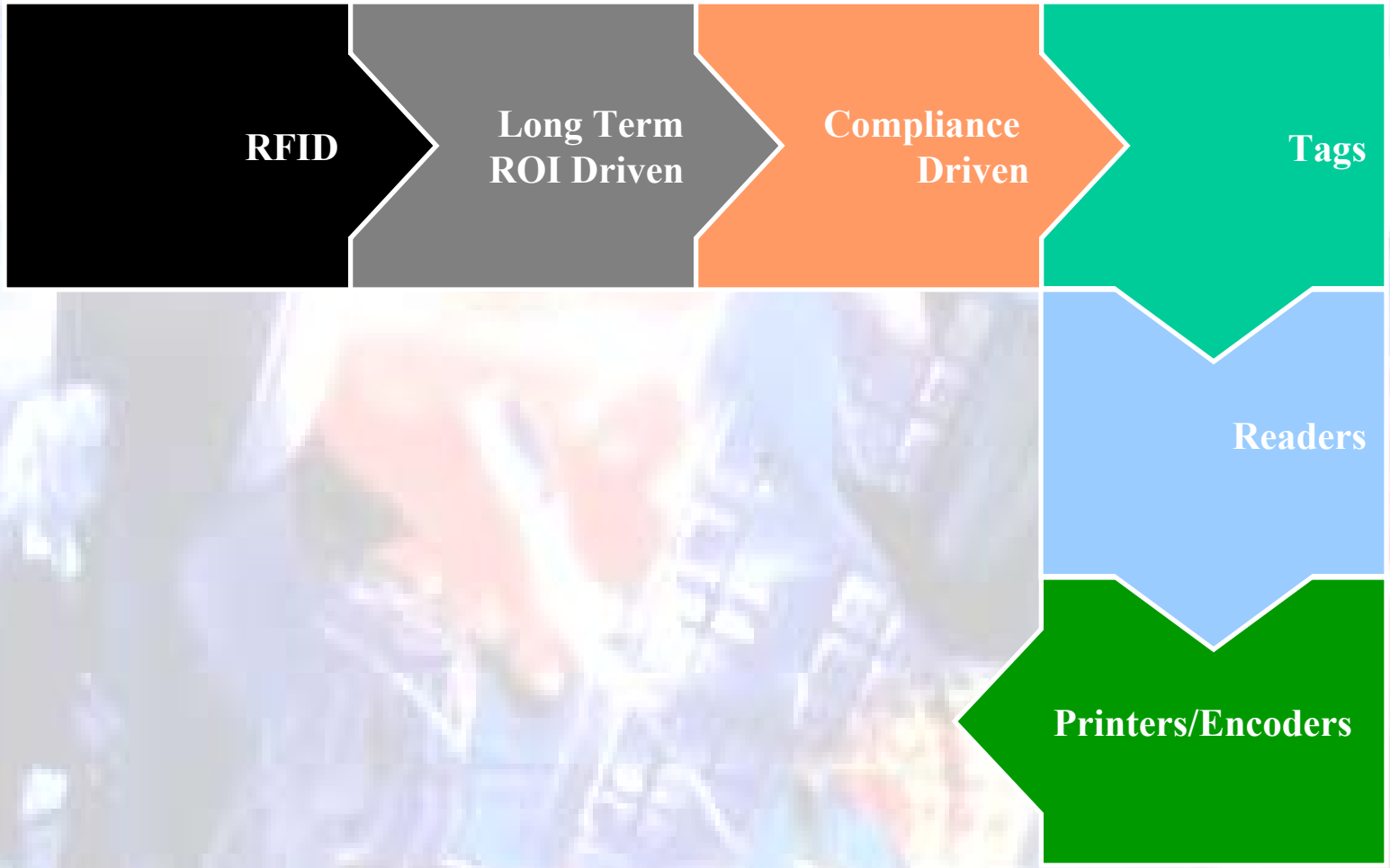
## Printers/Encoders

1. Printer/Encoders
2. Desktop RFID Printer
3. **Print & Apply RFID Printer**

- **The SLPA7000 is smart label printer applicator solution that encodes, prints and applies - all in one unit**
- **Combining RFID smart label printing technology with applicator capabilities, this RFID smart label solution delivers fast, accurate, cost-effective encoding and printing to users with site specific requirements**

Key features

- Enables supply chain operations using encode, print and apply label applicators to automate the RFID smart label application
- A fully integrated RFID printer and applicator is designed for heavy industry environments
- Supported operations include top and side label application and roll-on/front/back applications
- Built in quality control features identify and reject “bad” or “quiet” labels - ensure 100% high performance RFID smart label every time
- Supports multiple label sizes providing flexibility to address different application requirements - reducing the total quantity of print and apply label applicators required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Tags
Readers
Printers/Encoders

# Smart Labels

## 1. Smart Labels
2. Smart Label Validation
3. Reading Smart Labels
4. Smart Label Placement

- Smart Labels are shipping labels with RFID tags
- The surface area is used for standard bar code and label text
- The RFID tag is sandwiched in the middle
- The label consists of six parts:
  - the liner or carrier sheet
  - the liner release coating
  - the tag inlay
  - an adhesive
  - the label material
  - the label topcoat
- Labels are printed using a thermal print process
- Smart labels come in rolls of various sizes, which, along with the thermal ribbon, are mounted in the printer/encoder

**Smart Labels may be:**
**the easiest,**
**least disruptive,**
**least cost,**
**way to implement RFID**

# Smart Labels

## 1. Smart Labels
2. Smart Label Validation
3. Reading Smart Labels
4. Smart Label Placement

• Smart Labels offer the following benefits for supply chain and/or applications including, receiving, routing, stocking, work in process, HAZMAT & asset handling:

- a convenient and economical way to package RFID tags
- a richer data set than either a tag or barcode by itself
- back up and redundancy, by having bar code and human readable text together with electronic data
- can be produced on demand, or pre-printed and pre-coded for batch processes/applications
- labels provide added protection to the tag from heat, dust and humidity

• Existing users of bar code label systems migrating to Smart Label system could involve integration and re-use of established processes:

- on demand printing and application flexibility is maintained
- labelling is done at appropriate times
- RFID integration fits within the small footprint of a Smart Label printer
- Both automated and operator assisted application methods are available
- Tag encoding is done predictably and reliably, without customer engineering
- Validation and error recovery is built in to the system
- Encoding and printing commands share an established host computer and shop floor network
- *system migration and integration can be simplified by using conversion tools, so you don't have to re-write applications*

# Smart Labels

## 1. Smart Labels
## 2. Smart Label Validation
## 3. Reading Smart Labels
## 4. Smart Label Placement

Three basic criteria should drive selection of the right Smart Label

| | |
|---|---|
| Labelling requirement | Customer specifications may dictate everything from size, printable information, placement, EPC information, air protocol and acceptance criteria |
| Application Requirement | Tag readability is a major factor and requires a case analysis. Case analysis should include assessment of package contents, packaging design, label placement, and package label process |
| Compliance requirement | The same as labelling requirement but with acceptance criteria to cover 100% read rates, advanced shipping notice (ASN) integration, validations, record keeping and problem handling |

Label Certification: Some labels may be incompatible with certain printer/encoders. A one percent error rate on labels for example, when production is 40 labels per minute, would result in almost 200 rejects per day. Reasons for incompatibility may include:

- Tag type needs to match the encoder
- Tag position needs to be at a position within the label so that it is correctly oriented to the encoder head
- Label surface material needs to be suitable for high quality production thermal printing
- Adhesive needs to be matched up to the package surface to which it will be applied
- Labels (paper versus synthetic) may be mismatched to ribbon stock (wax versus resin)

# Smart Labels

1. Smart Labels
2. Smart Label Validation
3. Reading Smart Labels
4. Smart Label Placement

- Initially, passive UHF tags have no data in them and require an encoding step to load data into them
- Encoding can be done by a reader built into an RFID printer
- A Smart Label printer makes an ideal platform for tag encoding

- A Smart Label printer works and offers Smart Label Validation in the following way:

1. The printer receives its commands from the host computer. Once a label is positioned the reader does a pre-check. If the tag is quiet during the pre-check, the printer rejects it marking it with a strike over pattern on the label.

2. A single command to the reader programs the tag. The command includes an erase, write, read back and verify sequence, along with specific customer or EPC data to be written to the tag. If the read back and verify is not successful, the command is repeated.

3. The reader then performs an explicit read back, to again match the tag data reply with what it is was expecting to hear.

4. The thermal printer prints the bar code and text characters in the job stream with the customer or EPC data.

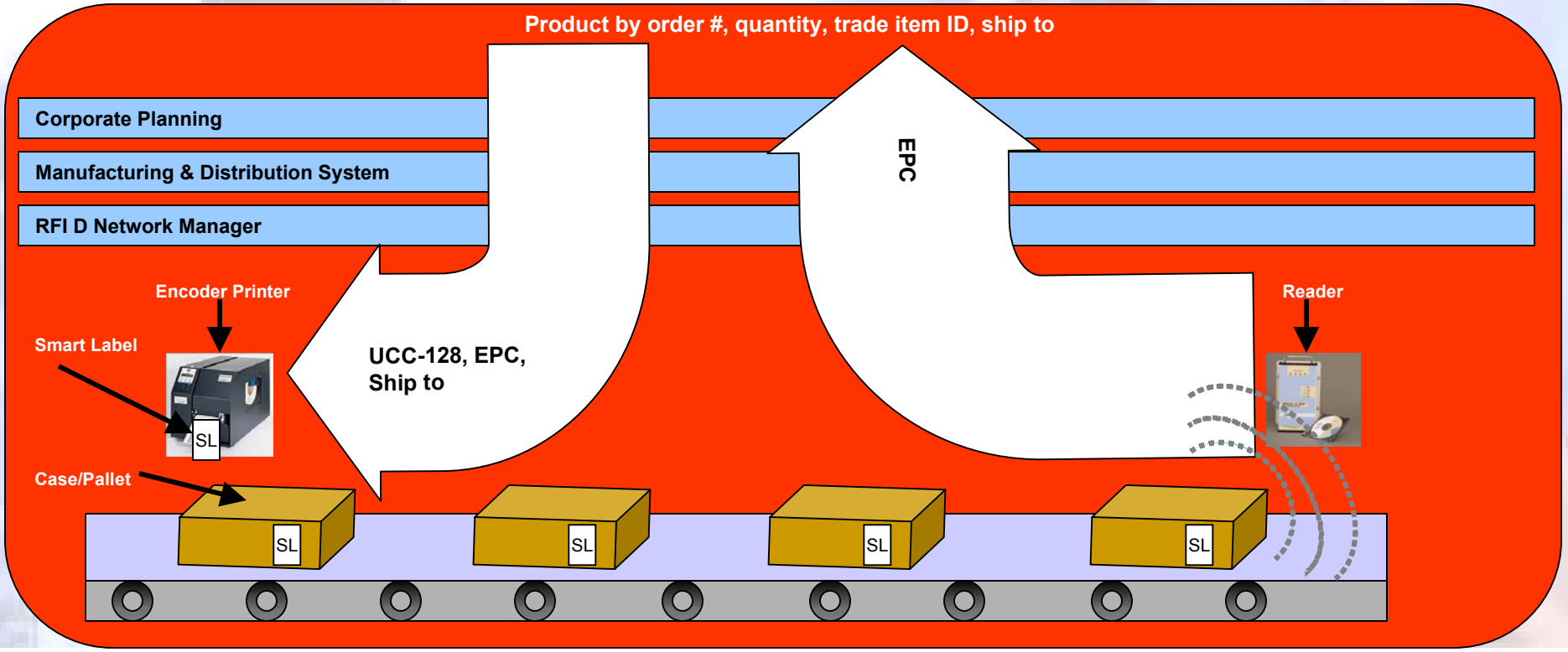
5. A record of the production sequence is sent to the host computer

6. If the printer is integrated with an applicator or other line components with logic controllers it will communicate to sequence next steps in the production line

# Smart Labels

1. Smart Labels
2. Smart Label Validation
3. Reading Smart Labels
4. Smart Label Placement

- Smart Labels are a ready fit format for most RFID implementations
- Customer or EPC data flows down to them through a host computer system and printer/encoder
- Smart Labels are applied to parts, products, cases and pallets, uniquely identifying themselves
- Smart Labelled items are now linked up by radio frequency to the supply chain system

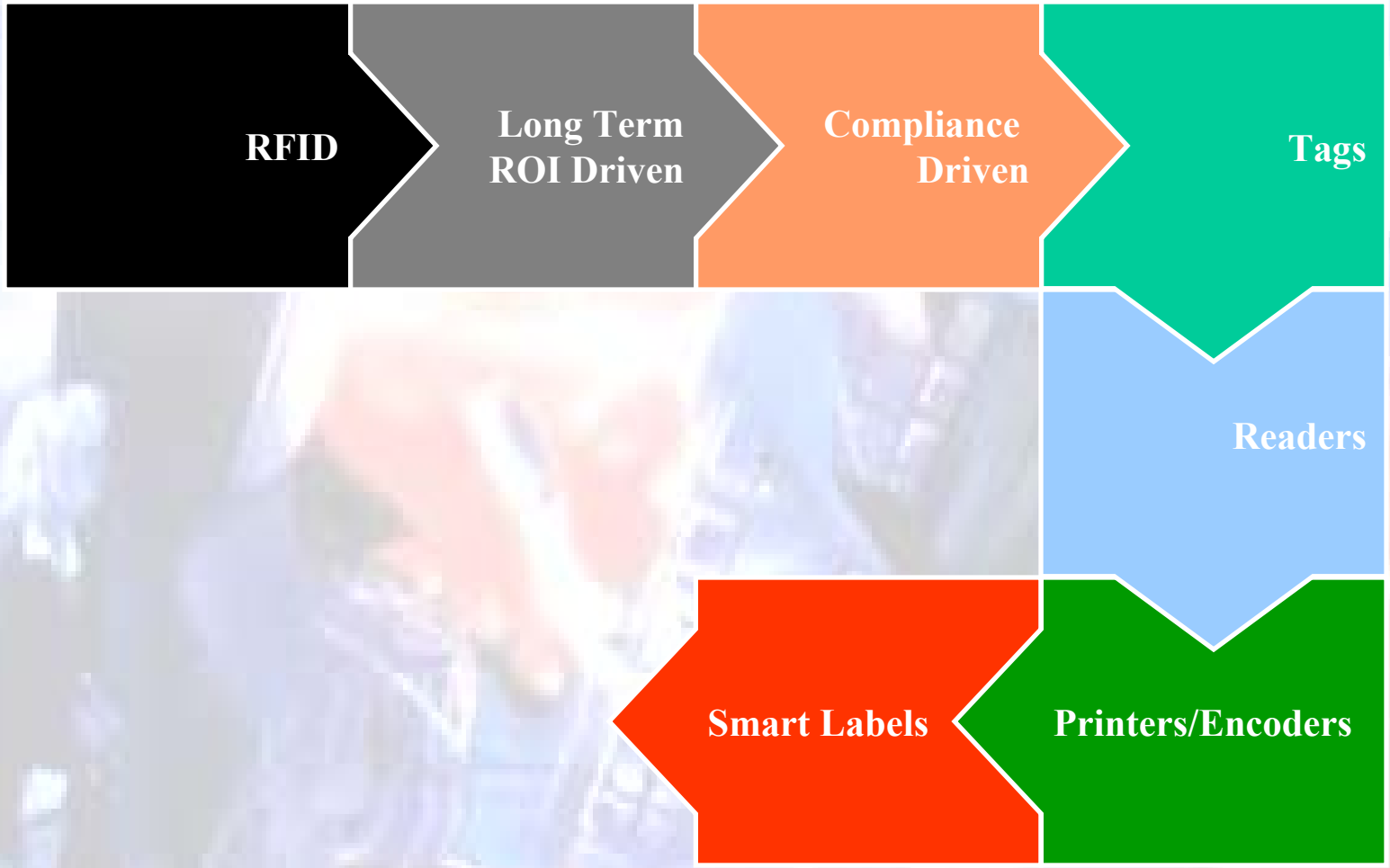


# Smart Labels

1. Smart Labels
2. Smart Label Validation
3. Reading Smart Labels
4. **Smart Label Placement**

- **The location and Orientation of a Smart Label on a case or pallet can be critical**
- **product composition, package geometry, packaging materials, pallet loading, proximity and orientation with respect to antennas are all variables that have to be considered**

| | |
|---|---|
| Tag Presentation | ➢ As a tag passes through the read window it should ideally be in the same plane as the antenna<br>➢ The flat face of the tag should be parallel to the flat of the antenna<br>➢ If a linear antenna is being used, the tag must be orientated vertically or horizontally according to polarisation |
| Tag Coupling | ➢ Tags placed on or very near metal objects, such as cans or foil, may electrically couple with them and may short out the antenna<br>➢ Proper tag selection and placement is very important with packages containing metal |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EPC

# 1. EPC

## 2. EPC Format

EPCglobal

• Electronic Product Codes or EPC's are the lowest level link in the multi-tier information model conceived by EPCglobal.

• EPC's are assigned, catalogued, tracked and managed with a collaborative system associated with the internet

• Using an EPC, a host computer can look via the internet stored information about a specific item, including manufacturer, product classification, handling, use and status in the supply chain

• The EPC ranges from 64 to 256 bits, with four distinct fields:

  • Header
  • EPC manager
  • Object Class
  • Serial Number

• The EPC Type 1 number, at 96 bits in length, will accommodate as many as 268 million companies, each having 16 millions classes, with 68 billion serial numbers in each class

• In Class 1 tags, an additional 32 bits of the EPC are for unique item information such as: item description, ultimate destination, special handling instructions etc that can be reused at any point in the supply chain

EPC

1. EPC

## 2. EPC Format

Electronic Product Code Type 1 96-BIT

| 02 | 000A68 | 00010D | 00112DED |
|---|---|---|---|
| Header 8-bits | EPC Manager 28-bits | Object Class 24-bits | Serial Number 36-bits |

- **The general format for EPC tag data includes these sections:**

| | |
|---|---|
| Header | ➢ The 8-bit header identifies the version number of the code itself |
| EPC Manager | ➢ Identifies an organisational entity (e.g. a company) that is responsible for maintaining the number in the following fields: Object Class and Serial Number<br>➢ EPCglobal assigns the General Manager Number to an entity, and ensures that each General manager Number is unique |
| Object Class | ➢ Refers to the exact type of product, similar to a SKU (stock keeping unit)<br>➢ The object class is used by an EPC managing entity to identify trade items<br>➢ These object class numbers, of course must be unique within each General Manager domain |
| Serial Number | ➢ A unique identifier for the item within each object class<br>➢ The managing entity is responsible for assigning unique, non-repeating serial numbers for every instance within each object class |


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EPC

# Applications

## 1. Slap & Ship
**2. Slap & Ship with EPC Management**
**3. Print & Apply**

- **Slap & Ship is distribution centre language for separating a label from its adhesive backing and affixing it by hand to a case or pallet**
- **This approach can be labour intensive and slow**
- **Slap & Ship is where some RFID applications start to help pilot systems identify Smart label placement, antenna placement, read coverage read rates & read speeds**

| Advantages | Disadvantages |
|---|---|
| Most flexible approach | Labour intensive |
| Least engineering content and cost | Not integrated with process |
| Allows tagging at distribution centre just before shipment | Does not provide upstream benefits of RFID |
| Fast start up | Low volume |
| Back-up for methods that are brought on-line | Does not scale |
| Achieves initial compliance labelling requirements | Lengthens investment period |
| Potentially least disruptive approach | May require separate staging area |
| On-demand | Potential for operator error |
| Allows company to learn about RFID | Long-term competitive disadvantages |

## Applications

1. Slap & Ship
2. Slap & Ship with EPC Management
3. Print & Apply

- **A Slap & Ship approach can help a company get started with compliance labelling in a productive way**
- **Products to be shipped with RFID labels would be separated and diverted to a staging area, especially if production line speeds prohibit Slap & Ship**
- **If you look at the RFID adoption curve as a conservative 7-10 year timeline, a Slap & Ship approach may be in use in various parts of your company for a number of years**

Typical Slap & Ship with EPC Management operation

| | |
|---|---|
| 1. Pallets of cases are de-palletised manually, or a number of cases are collected as per the picking list | 5. Each is manually applied to a predetermined position on the case |
| 2. The bar code for each unique case type is scanned | 6. Once all cases have been labelled, the cases are (re-)palletised |
| 3. The number of cases is entered into a PC. A series of EPC's are generated and stored in the local database | 7. A pallet label is then encoded, printed then manually applied |
| 4. RFID labels for each case are encoded and printed with EPC's | 8. As a final check the pallet is read and compared with the pallets original pick list |

## Applications

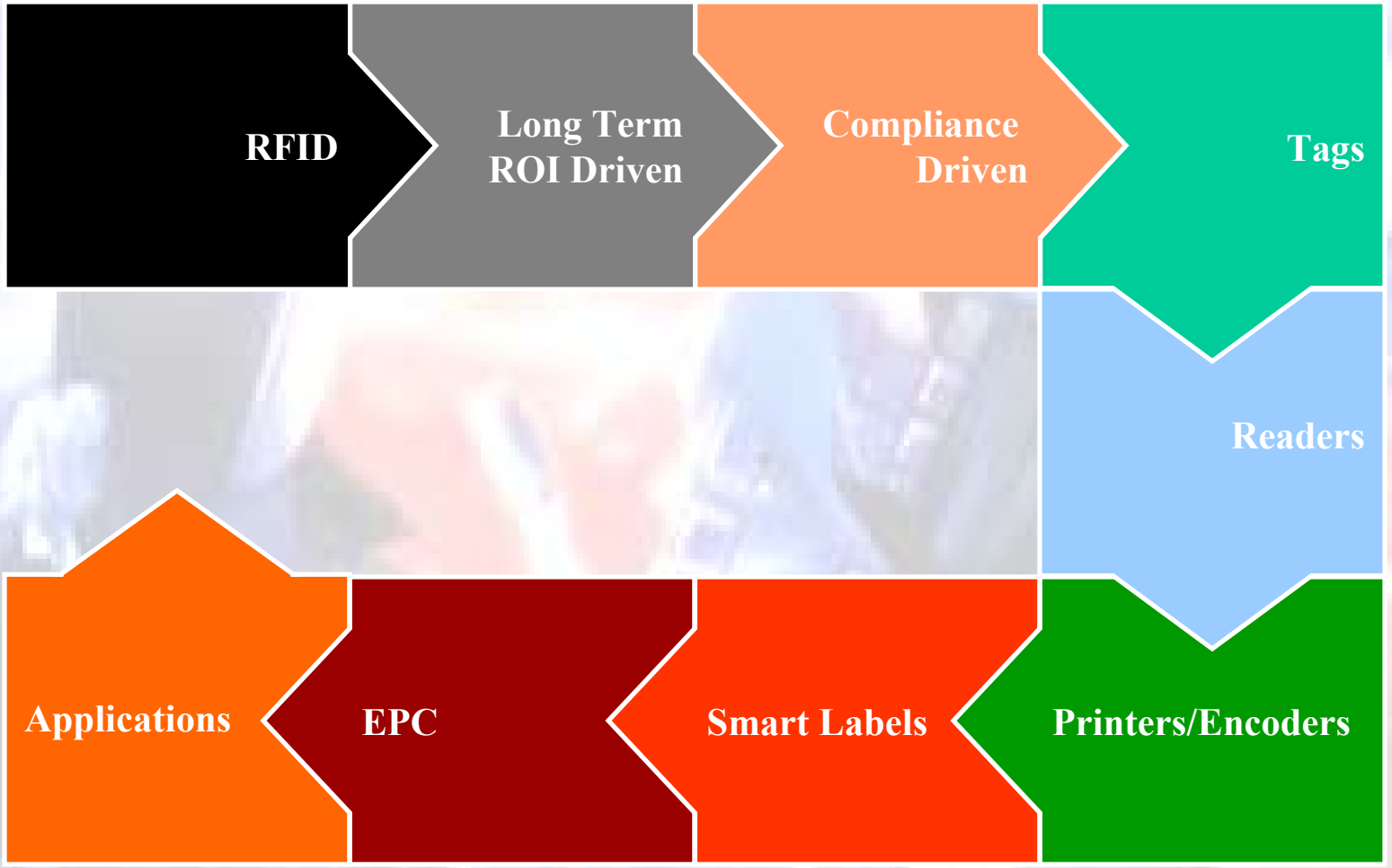
1. Slap & Ship
2. Slap & Ship with EPC Management
3. **Print & Apply**

- **Print & Apply is the term used for semi- or fully automated labelling process**

- **Smart label print & apply requires a label applicator integrated with a RFID printer which can be synchronised with moving cases on a conveyor**

The time to transition from Slap & Ship to a more automated approach depends on a number of factors

| | |
|---|---|
| 1. Product Portfolio | ➢ High value items subject to lots of shrinkage justify RFID investment |
| 2. Technology maturity & reliability | ➢ Automation require heavy investment and a longer period to re-coup costs<br>➢ Automation usually requires building in more rigidity in order to achieve reliability |
| 3. Competitive landscape | ➢ What your competitors do to meet RFID mandates will affect your decision to automate<br>➢ You should be developing a business case for automation well in advance of having to react to competitors |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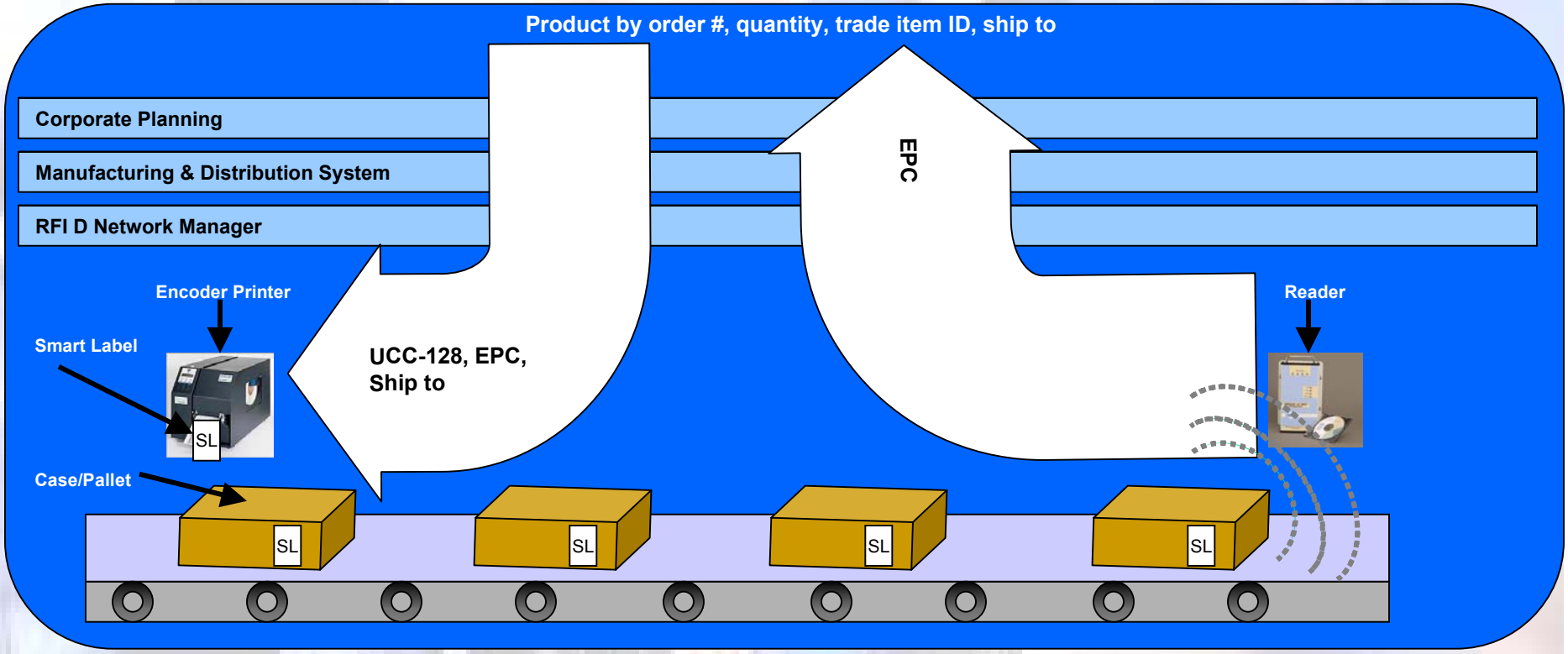
Applications

Operational Data

# 1. Operational Data Flow

## 2. Global Exchange of Supply Chain Data

- The picture below illustrates the probable flow of RFID data



# 1. Operational Data Flow

## 2. Global Exchange of Supply Chain Data

**Operational Data**

- **Layers of RFID data**

| | |
|---|---|
| Corporate Planning | ➢ At the top of the information model are the human, financial, procurement, customer relations and product development resources of a company<br>➢ The corporate planning system would be the keeper of the product order numbers, SKU's, trade item identification, customer information and delivery requirements. |
| Manufacturing & Distribution | ➢ A Master schedule sequences product manufacturing, packaging and shipping<br>➢ A forecasting system may drive case builds and inventory anticipation of the receiving customer orders<br>➢ Product & order information converge at the point where the labelling takes place |
| RFID Network | ➢ EPC numbers may be passed down and converted to text, barcode and RFID data and translated into a command language that the printer encoder understands<br>➢ The network manager also manages RFID reader arrays, filtering reads and lists of tags, passing them to the other layers of the system |

Operational Data

1. Operational Data Flow

## 2. Global Exchange of Supply Chain Data

• EPC in partnership with VeriSign, the company that manages the Internet Domain Name Service (DNS) has begun laying the ground work of what will be called the EPC Network

• EPC Data architecture not only allows for faster identification of product, but supports movement of information through the supply

• The EPC Network information concept and system architecture will include the following system components

  • Object Name Service (ONS)
  • Information Services
  • EPC Discovery Service
  • Physical Mark-up Languages (PML)

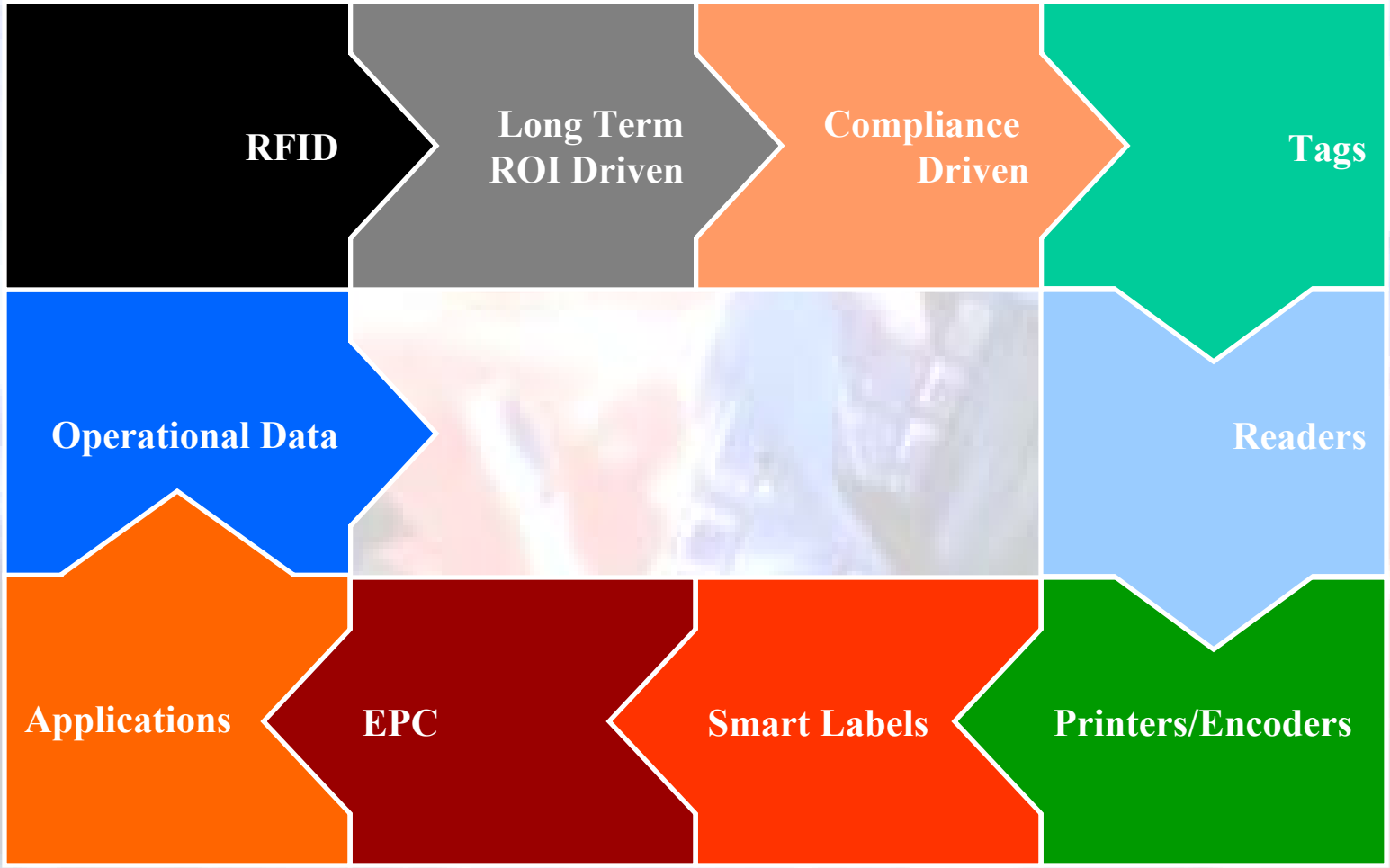
• Ultimately this will lead to business efficiencies

## Operational Data

### 1. Operational Data Flow

# 2. Global Exchange of Supply Chain Data

| | |
|---|---|
| Object Name Service (ONS) | ➢ ONS serves as a registry for distributed EPC Information Services Database<br>➢ ONS will link an EPC with an IP address of a database that stores relevant information |
| Information Services | ➢ EPC Information Services are the actual repositories used to store unique item data<br>➢ These are distributed databases maintained by companies, and referred through ONS, like how DNS points to web sites on the internet |
| EPC Discovery Service | ➢ The directory service stores EPC history<br>➢ It serves as a chain of custody service providing tracking information as a product moves through the supply chain |
| Physical Mark-up Language (PML) | ➢ PML will extend EPC to include associated information of value to the supply chain<br>➢ PML pages for each EPC can be set-up, maintained and shared by the EPC product manufacturer, or owner<br>➢ PML descriptors can include the following kind of information<br>Expiry date<br>Handling instructions<br>Ingredients and composition<br>Procedural information, such as processing, packaging and quality control steps |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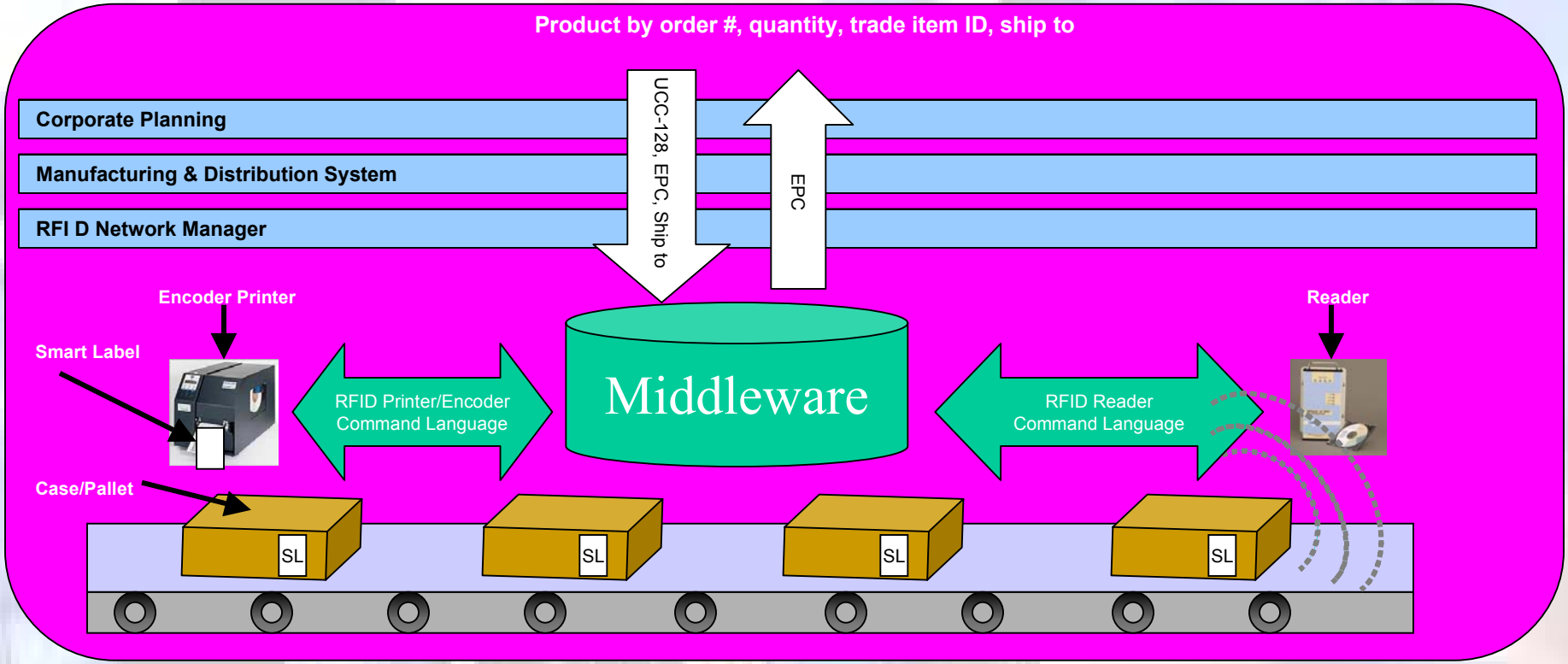
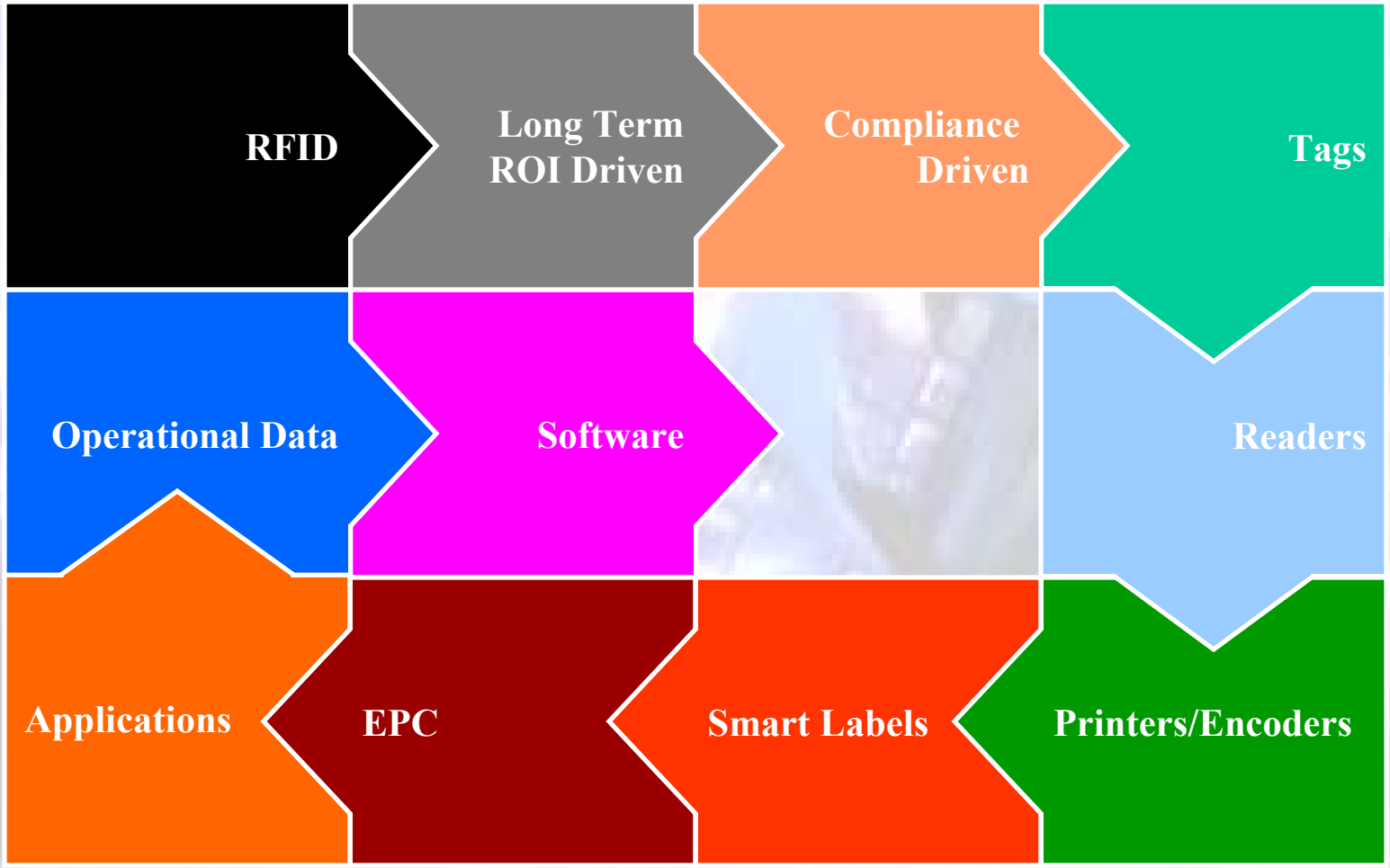
Software

# 1. Middleware

- **Middleware intercepts the data being passed through the layers of the Warehouse Management Systems (WMS) or Enterprise Resource Planning (ERP) systems and converts it into a command language that would be accepted by an encoder/printer or reader set up for the task of encoding**

- **Middleware intercepts the tag data available from local readers and rationalises it into information for use with Warehouse Management Systems (WMS) or Enterprise Resource Planning (ERP) systems.**

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**Getting Started**

## 1. Fast Tracking Smart Label Pilot Requirements

***The objective of a pilot program is to develop a predictable and scaleable system***

Fast tracking your Smart Label pilot will requires knowledge of the following:

1. Is the application or need for RFID for business improvement or for customer compliance

2. What type of tag is required
   - this could be determined by the need for the RFID ( I.e. EPC for customer compliance)
   - this will determine the frequency support required by the printer/encoder and readers

3. What data needs to be encoded on the tag and collected by the reader

4. How will you encode/read the tag
   - q. by printer/encoder commands written/programmed into your systems/application
   - q. by reader commands written/programmed into your systems/application
   - q. by adding a layer of middleware removing the conflict of modifying complete systems

   *middleware is the lowest risk form of data conversion, especially during pilots*

5. Smart Label and Reader/Antenna choice and placement for optimum read rates/read speeds

6. A vendor like Newbury Data with support to offer all of the above!!

**Getting Started**

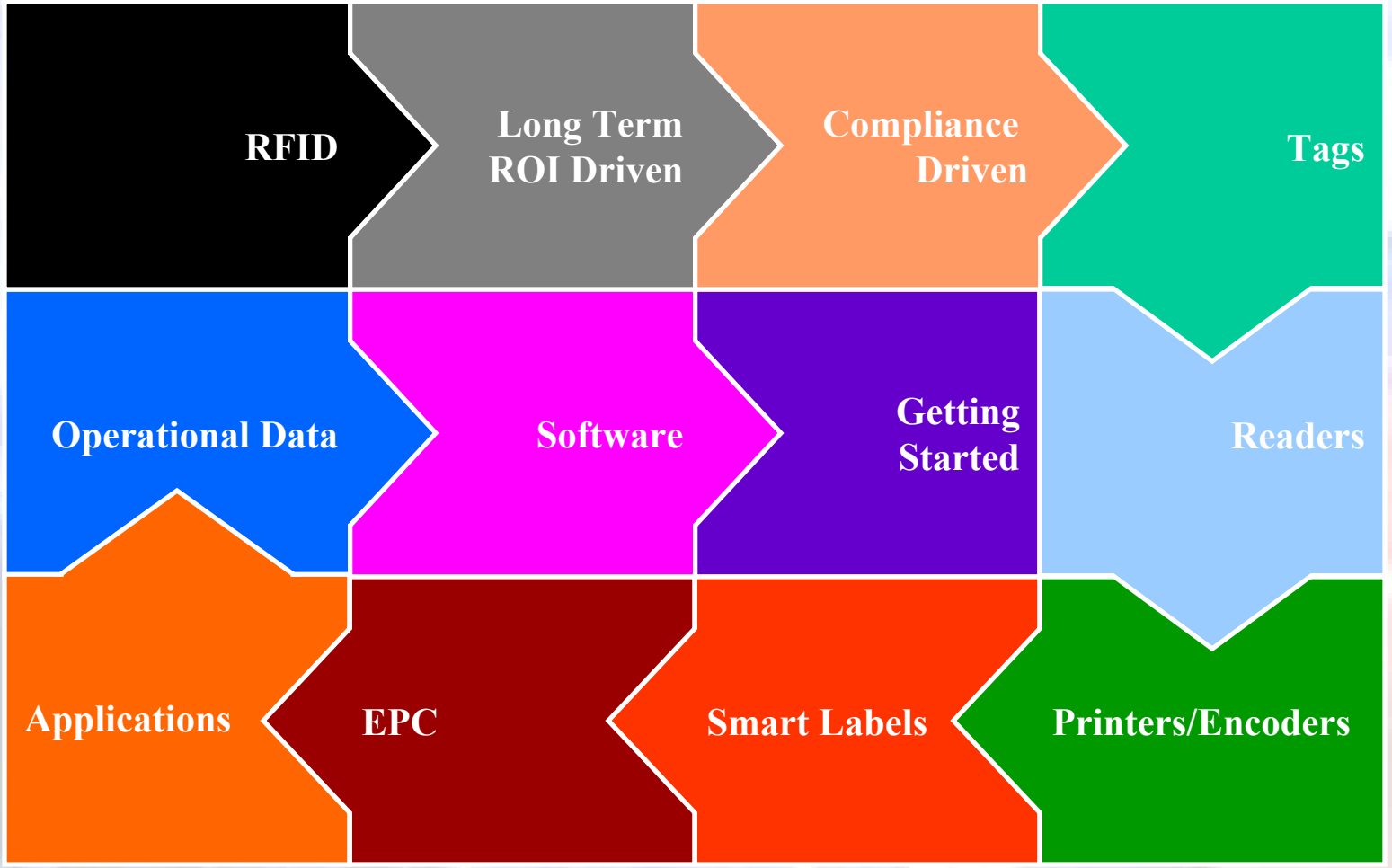
## 1. Fast Tracking Smart Label Pilot Requirements

***The objective of a pilot program is to develop a predictable and scaleable system***

RFID Implementation Process

| 1: Getting Started | 2: Test & Validate | 3. Pilot | 4: Implementation |
|---|---|---|---|
| ➢ Assemble your lab<br>➢ Set up development environment<br>➢ Focus on technology and solution based smart labels | ➢ Evaluate software applications & middleware requirements<br>➢ Evaluate/test with printer/encoder/reader<br>➢ Evaluate/Test Label & Reader/Antenna placement for read ranges, read speeds and data capture | ➢ Set up equipment in facility<br>➢ Capture test/specific data<br>➢ Measure results | ➢ Explore opportunities for new efficiencies<br>➢ Capture and manage data<br>➢ Implement RFID network & device management<br>➢ Deploy smart media |

# RFID Puzzle Solved



# RFID Proof of Concept / Test Equipment Available

- Printronix 869.5 Mhz Smart Ready Thermal Printer
- SAMsys Multi-Protocol Reader
- SAMsys Circular Antenna
- Middleware Demo Program (create and read smart labels)
- Smart Labels (limited number)